

## Status of Rice Germplasm – Its Collection and Conservation in India

**BN Singh, SR Dhua, RK Sahu, BC Patra and BC Marndi**

*Central Rice Research Institute, Cuttack-753006, Orissa*

The cultivated rice of Asia (*Oryza sativa* L.) is supposed to have originated in the South and/or South-East Asia. India forms a major part of this region. Thus, it is traditionally rich in the diversity of rice including the wild progenitors of cultivated rice.

During the first quarter of the twentieth century and more specifically in the years between 1910 and 1920 Madras Presidency, Bengal and Central Province initiated collection of rice germplasm in the country. At the same time (in 1911) the first Agricultural Research Station devoted to rice research, was established in Dacca (now in Bangladesh) and the Paddy Breeding Station was established in Coimbatore in 1912. Subsequently, more and more research stations were established in different agro-climatic zones of the country. These rice research stations collected traditional rice varieties from their respective localities, practiced pure line selection to identify higher yield potential lines and recommend them for general cultivation.

The Central Rice Research Institute was established at Cuttack in the year 1946 with Dr K Ramiah as its first Director. He brought with him a duplicate set of about 2,000 accessions of rice germplasm, which was being maintained at Coimbatore at that time. This became the starting point of the national genebank for rice at CRRI. Subsequently, many explorations, collection, introduction and exchange activities have helped to enrich this genebank.

The Institute undertook its first planned exploration and collection mission of rice germplasm in the Jeypore tract (now Koraput District of Orissa) during 1955-60.

Govindaswami and Krishnamurthy explored about 27,000 sq km area during this mission and a total of 1,745 accessions were collected. During 1956, Dr RH Richharia initiated the exploration and collection of rice germplasm from Manipur. This mission was spread over a period of five years and a total of 874 accessions were collected.

Simultaneously, a PL-480 project on collection of rice germplasm was operative during 1967-72 with Dr MS Swaminathan and Dr SVS Shastri. In this

programme, during a period of five years, Dr SD Sharma and his associates collected a total of 6630 accessions from all the districts of Arunachal Pradesh, Nagaland, Manipur, Tripura, Meghalaya, and only North Lakhimpur, Guwahati and Goalpara districts of Assam. This collection is popularly known as Assam Rice Collection (ARC). During 1970-79, a special programme was undertaken to collect rice germplasm from all the rice growing districts of Madhya Pradesh by Dr RH Richharia. He covered 42 districts and collected a total of 19,226 accessions.

In 1975, a comprehensive exploration and collection programme was drawn for the whole country especially for the traditional rice growing areas of Karnataka, Maharashtra, Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal and Orissa covering 30 districts. This programme resulted in collection of 1,038 accessions.

During 1978-80, a collaborative programme was operative in CRRI with the Agricultural Universities, State Department of Agriculture and ICAR centres for collection of rice germplasm all over the country. The materials were collected from all 100 districts of 14 States and a total of 6,349 accessions were collected.

During 1986-89 a total of 3,697 accessions of cultivated rice and 167 accessions of four wild species of rice were collected from Northern Orissa, South Bihar, West Bengal, Sikkim and Mizoram.

At present, the NBPGR has been coordinating the exploration and collection of rice germplasm from all over the country and is also supporting operational facilities for the explorations. In 1984, a Division of Genetic Resources was established in CRRI to look after all the aspects of rice germplasm. This is recognized as the National Active Collection Centre by the NBPGR. With the introduction of a mission mode NATP project on plant Biodiversity (by the NBPGR as its lead centre), a new thrust has been applied on the exploration and collection of rice germplasm with special reference to wild rice. Now, the total number of rice accessions maintained by various Research Stations in the country might exceed 80,000.

During the maintenance, germplasm may lose their identity because of random and non-random processes of sampling. Also, loss due to unforeseen natural calamity of the type of super-cyclone that affected Orissa during the year 1999 or devastating flood, which destroyed all the germplasms, maintained at Chinsurah, West Bengal in the year 2000, can not be ruled out.

Realizing the potential danger of such genetic erosion, the effort of developing a medium-term cold storage system for rice germplasm was initiated at CRRI in 1984. During 1986, it was decided by Dr RS Paroda, the then Director, NBPGR and Dr SD Sharma, the then Head, Genetic Resources Division, CRRI to accommodate all the germplasm of CRRI at the genebank of NBPGR. Since then, a total of 22,137 accessions had been deposited in the long-term storage of the NBPGR. These materials in a small quantity were deposited as a stop-gap arrangement, till the development of a dependable storage system at CRRI. Under the Indo-USAID collaborative project a cold module was installed in the

CRRI, which has been operative since 1998 and found to be rather dependable.

Thus, now a stage has come to streamline and systematize the conservation of rice germplasm in the country. In this endeavour, the first step would be to assign a National Accession Number to all these collections. This has to be followed by seed increase in sufficient quantity for further deposit in the long-term storage and also in the medium-term storage of the active collection site in a phase-wise manner. At the same time they need to be characterized. Further evaluation and utilization has to be followed up for the purpose of crop improvement.

In the past, the scientists involved with genetic resources undertook the evaluation and characterization of germplasm. However, in the absence of a National Numbering System and proper conservation of such evaluated materials, the information generated often suffered from deficient identification and thus under-utilization of such information.

## Farmers and Breeders – Better Partners for Management of Plant Genetic Resources

**Elsy CR, R Gopinathan, VV Radhakrishnan and S Estellita**

*Kerala Agriculture University, Vellanikkara, Thrissur-680656, Kerala*

**Key Words: Rice, Intellectual Property Rights, Participatory Plant Breeding**

Development of locally adapted varieties and conservation of plant genetic resources play a key role in augmenting agricultural productivity especially when Intellectual Property Rights are introduced in the areas of new plant varieties and genetic resources. Besides the agro-ecological factors of each locality, social and economic factors also decide the acceptability and adaptability of new varieties. Many of the HYVs of crops evolved from centralized breeding programmes are poorly accepted by the farmers. Jayathy (Ptb 47) a HYV of rice released in Kerala was poorly accepted by the farmers even though the variety was the best genotype in the International Rice Testing Programme (IRRI, 1984). Contrary to this, many of the local rice cultivars, not released and notified as varieties had attained higher level of acceptance and spread in the rice growing tracts. This situation had

motivated the concept of Farmer Participatory Plant Breeding (FPB), and in Kerala a FPB programme was launched to evolve rice varieties suited to specific agro-ecological situations of Palakkad – the rice granary of Kerala. The project was implemented as the research component of GALASA (Group Approach for Locally Adapted and Sustainable Agriculture), a programme for the development of locally adapted technologies and their demonstration utilizing indigenous knowledge and local manpower. Palakkad District Panchayath is providing financial support to the project, whereas State Agricultural University, State Department of Agriculture and the farming communities of Palakkad district collaborate in the project with technical know-how.

In FPB, farmers demanded for a spectrum of rice varieties to cater the needs of home consumption and

During the maintenance, germplasm may lose their identity because of random and non-random processes of sampling. Also, loss due to unforeseen natural calamity of the type of super-cyclone that affected Orissa during the year 1999 or devastating flood, which destroyed all the germplasms, maintained at Chinsurah, West Bengal in the year 2000, can not be ruled out.

Realizing the potential danger of such genetic erosion, the effort of developing a medium-term cold storage system for rice germplasm was initiated at CRRI in 1984. During 1986, it was decided by Dr RS Paroda, the then Director, NBPGR and Dr SD Sharma, the then Head, Genetic Resources Division, CRRI to accommodate all the germplasm of CRRI at the genebank of NBPGR. Since then, a total of 22,137 accessions had been deposited in the long-term storage of the NBPGR. These materials in a small quantity were deposited as a stop-gap arrangement, till the development of a dependable storage system at CRRI. Under the Indo-USAID collaborative project a cold module was installed in the

CRRI, which has been operative since 1998 and found to be rather dependable.

Thus, now a stage has come to streamline and systematize the conservation of rice germplasm in the country. In this endeavour, the first step would be to assign a National Accession Number to all these collections. This has to be followed by seed increase in sufficient quantity for further deposit in the long-term storage and also in the medium-term storage of the active collection site in a phase-wise manner. At the same time they need to be characterized. Further evaluation and utilization has to be followed up for the purpose of crop improvement.

In the past, the scientists involved with genetic resources undertook the evaluation and characterization of germplasm. However, in the absence of a National Numbering System and proper conservation of such evaluated materials, the information generated often suffered from deficient identification and thus under-utilization of such information.

## Farmers and Breeders – Better Partners for Management of Plant Genetic Resources

**Elsy CR, R Gopinathan, VV Radhakrishnan and S Estellita**

*Kerala Agriculture University, Vellanikkara, Thrissur-680656, Kerala*

**Key Words: Rice, Intellectual Property Rights, Participatory Plant Breeding**

Development of locally adapted varieties and conservation of plant genetic resources play a key role in augmenting agricultural productivity especially when Intellectual Property Rights are introduced in the areas of new plant varieties and genetic resources. Besides the agro-ecological factors of each locality, social and economic factors also decide the acceptability and adaptability of new varieties. Many of the HYVs of crops evolved from centralized breeding programmes are poorly accepted by the farmers. Jayathy (Ptb 47) a HYV of rice released in Kerala was poorly accepted by the farmers even though the variety was the best genotype in the International Rice Testing Programme (IRRI, 1984). Contrary to this, many of the local rice cultivars, not released and notified as varieties had attained higher level of acceptance and spread in the rice growing tracts. This situation had

motivated the concept of Farmer Participatory Plant Breeding (FPB), and in Kerala a FPB programme was launched to evolve rice varieties suited to specific agro-ecological situations of Palakkad – the rice granary of Kerala. The project was implemented as the research component of GALASA (Group Approach for Locally Adapted and Sustainable Agriculture), a programme for the development of locally adapted technologies and their demonstration utilizing indigenous knowledge and local manpower. Palakkad District Panchayath is providing financial support to the project, whereas State Agricultural University, State Department of Agriculture and the farming communities of Palakkad district collaborate in the project with technical know-how.

In FPB, farmers demanded for a spectrum of rice varieties to cater the needs of home consumption and

**Table 1. Duration, yield parameters and grain qualities of *Kunjukunju* cultures (kharif 2000)**

| Culture number          | Total duration (days) | Number of grains/panicle | 1000-grain weight (g) | Mean yield | Milling % | *Farmer's preference (%) |
|-------------------------|-----------------------|--------------------------|-----------------------|------------|-----------|--------------------------|
| K.6                     | 112-115               | 140                      | 27.2                  | 5448       | 71.5      | 55                       |
| K.10.2                  | 110-115               | 118                      | 24.5                  | 5022       | 67.5      | —                        |
| K.10.3                  | 110-115               | 139                      | 26.3                  | 4109       | 70.5      | 33                       |
| K.67.5                  | 108-112               | 119                      | 25.4                  | 4999       | 65.5      | —                        |
| K.68.4                  | 108-112               | 118                      | 25.4                  | 4676       | 70.5      | —                        |
| K.68.6                  | 108-112               | 115                      | 25.5                  | 4726       | 69.5      | 33                       |
| Local <i>Kunjukunju</i> | 110-115               | 101                      | 27.5                  | 5281       | 68.5      | —                        |
| Matta Triveni           | 115-118               | 98                       | 25.6                  | 5007       | 69.5      | —                        |

\* Some farmers expressed equal preference to cultures K.6 and K.10.3

market demand. Two approaches viz. -Participatory Varietal Selection (PVS) and Participatory Plant Breeding (PPB) were practiced to select/evolve best suited rice hybrids/varieties with local adaptability and consumer acceptance. In this project farmers are 'farmer-breeders' and 'farmer-fields' are "on farm research stations". In PVS, rice hybrids released from our country were raised on farm and the members of farming community evaluated them to select the best hybrid for the area. In PPB, projects were designed to achieve two objectives viz. -purification of the local rice cultivar '*Kunjukunju*' and combination breeding to combine red kernel colour and yield potential of Ponmany (CR 1009), utilizing the genetic variability existing in farmers' fields.

In PVS, 32% of the farmers selected PA 6201 as the best hybrid whereas 24% of the farmers selected APHR-2 as the most preferred one. It was interesting to note that 22% of the farmer selected Aiswarya (Ptb 52) the local check variety as their choice variety. High market demand for red bold rice, simple seed production techniques and timely availability of seed material are the factors that favoured the selection of Aiswarya.

Pureline selection conducted in '*Kunjukunju*' had led to the evolution of 14 promising rice cultures. Of these, six short duration cultures with red kernel colour were selected for advanced trials to assess yield potential, pest and disease reaction, grain quality and farmers' acceptance. The results of farmer's evaluation trials conducted at 7 locations during kharif 2000 are presented in (Table 1). The cultures had recorded an yield potential

of 4.6–5.4 t/ha, red bold grains, and good grain qualities. Culture K.6, K.10.3 and K.68.6 that had recorded maximum farmer's acceptance are now tested from trials and demonstration trials.

Segregating material from breeding programme to combine red kernel colour and yield potential of CR 1009 are in the 4<sup>th</sup> generation of selection.

Understanding the significance of PPB, IRRI has launched a project for rice in Eastern India. Participatory Plant Breeding Programme implemented in Kerala had led to the evolution of promising rice cultures with local adaptability and farmer acceptance. Survey conducted in the project area had revealed the cultivation of many high yielding rice genotypes that are not released or notified as varieties. Farmer Participatory Breeding is the best choice for the utilization of such genetic variability available with each farming community. Moreover, in the era of Intellectual Property Rights, through FPB each farming community can have their "own" varieties on which they can enjoy the benefits of Plant Breeders' Rights and Farmers' Rights. Identification of most suited varieties to each locality can also be best achieved through PVS. Other prospects and problems related to such FPB, especially in the areas of genetic resources management, 'fare and equitable benefits sharing', seed production links etc. also should be discussed.

## References

IRRI (1984) *Annual Progress Report of International Rice Research Institute*, Manila, Philippines.

## Plants of Tribal Importance from Rajasthan

**SS Katewa**

Laboratory of Ethnobotany and Agrostology, Department of Botany, College of Science, ML Sukhadia University, Udaipur-313001, Rajasthan

Rajasthan is one of the largest states of the Indian Union having an area of 3,42,274 sq kms. Many tribes are scattered in different parts of the state. The main tribes of the state are Bhil, Garasia, Damor, Kathodi and Meena. Living close to nature, these tribals have acquired knowledge about the use of wild flora most of which are not known to the outside world. This rich knowledge system if subjected to scientific scrutiny could benefit the humankind in many ways. The inroads of modernization are presently posing imminent danger for this rich and varied expertise and wisdom of ages and it is likely that this will be lost to the humankind for all times to come. The habitats where the tribal and hill communities lived and the environment in which the folklore evolved on the uses of wild plants are fast disappearing on account of the interference of outsiders. In Rajasthan considerable work has been done on ethnobotany. The notable contributions are those of Bhandari (1974), Sebastian and Bhandari (1984, 88, 90), Singh and Pandey (1980, 96); Joshi (1982, 87, 91, 93, 95); Katewa and Arora (1997); Katewa and Guria (1997); Katewa and Sharma (1998) and Katewa and Chaudhary (2000).

An ethnobotanical survey was conducted repeatedly during 1995-2000 in different seasons and areas. The local informants were medicine men, men and women working in the field, village headman and priests. People mostly above the age of 60 have accurate information regarding their traditions. Participating in their feasts, festivals other social events *etc.*; was of great use in collecting information on plants and observing how they are used. Ethnobotanical investigation has led to the documentation of wild plants used by tribal for meeting their multifarious requirements. Application of most of the plants recorded in the present study are either lesser known or hitherto unknown to the outside world.

The present study records use of 73 wild growing plants as food and medicine by the tribals of Rajasthan (Table 1). Tribals have a traditionally self-managed system of folk medicine. They have perfected simple but effective remedies to treat various ailments. Recent changes brought about in tribal attitude due to habitat displacement; deforestation *etc.* have led to the decline and even disappearance of this rich knowledge system. Many wild plants used in the traditional medicines of

**Table 1. Ethno-food plants of Rajasthan**

| Botanical name                 | Local name   | Plant part used   | Uses                                                                                                                                                                                   |
|--------------------------------|--------------|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Amaranthus gangeticus</i>   | Kangni       | Seeds             | Seeds are cooked like rice and are relished by the tribals.                                                                                                                            |
| <i>Amorphophallus bulbifer</i> | Jangli suran | Tubers            | As vegetable.                                                                                                                                                                          |
| <i>Annona squamosa</i>         | Sitaphal     | Fruits            | Ripe fruits are eaten raw by the tribals.                                                                                                                                              |
| <i>Asparagus racemosus</i>     | Satavar      | Tubers            | Tuberous roots are eaten raw for vitality.                                                                                                                                             |
| <i>Brachiaria ramosa</i>       | Salki        | Grain             | Grains are eaten during famines.                                                                                                                                                       |
| <i>Capparis decidua</i>        | Ker          | Fruits            | Unripe fruits are used as vegetable. Ripe fruits are eaten raw. Unripe fruits are also pickled.                                                                                        |
| <i>Ceropegia bulbosa</i>       | Khadula      | Leaves and Tubers | Tubers are eaten raw for vitality and are considered as refrigerant whereas leaves are cooked as vegetable.                                                                            |
| <i>Chlorophytum tuberosum</i>  | Safed Musli  | Tubers            | Tubers are eaten raw for vitality and are also used in various preparations.                                                                                                           |
| <i>Citrus medica</i>           | Bijaura      | Fruits            | Ripe fruits are edible. They are sweet refrigerant, digestive and anthelmintic.                                                                                                        |
| <i>Coix lacryma-jobi</i>       | Garelo       | Grains            | Grains are eaten after boiling. Grains of this grass are mixed with the grains of <i>Zea mays</i> and are also used for making porridge.                                               |
| <i>Cordia dichotoma</i>        | Gunda        | Fruits            | Fruits are edible.                                                                                                                                                                     |
| <i>Dioscorea bulbifera</i>     | Varaikand    | Tubers            | Tubers are edible.                                                                                                                                                                     |
| <i>Echinochloa crusgalli</i>   | Batda/Batti  | Grains            | The grains are eaten mostly by poorer classes.                                                                                                                                         |
| <i>Eleusine coracana</i>       | Maduo/Mall   | Grains            | Grains are eaten largely by tribals and the plant is used for making country liquor. Tribals of South Rajasthan take the crop of this grass and grains are eaten during summer months. |

Contd.

Table 1. Contd.

| Botanical name                | Local name          | Plant part used                | Uses                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------------------------|---------------------|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Ensete superbum</i>        | Jungli Kela         | Fruits                         | Fruits are palatable. Form shaft, leaf sheaths are removed and then it is made into pieces (Chaun), these are then chewed. Flower buds are cooked as vegetable.                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <i>Ficus bengalensis</i>      | Vadlo/Bad           | Receptacles                    | Fresh receptacles are eaten raw. Dried receptacle powder mixed with kangni ( <i>Setaria italica</i> ) flour is used as famine food.                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <i>Ficus racemosa</i>         | Gular/Umbra         | Fruits                         | Fruits (receptacles) are used as a vegetable and also eaten raw. The stem bark is crushed into powder and mixed with flour to prepare bread during famine.                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <i>Grewia orientalis</i>      | Gengchi             | Fruits                         | Ripe fruits are eaten raw. Good source of vitamin C.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <i>Iphigenia indica</i>       | Dholi Musli         | Corms                          | Underground corms are eaten raw.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <i>Lagenaria siceraria</i>    | Tumbo               | Fruits                         | Fresh fruits are used as vegetable.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <i>Leptadenia reticulata</i>  | Jhumka              | Fruits                         | Unripe fruits are eaten raw with salt.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <i>Leucas cephalotes</i>      | Kubhi               | Leaves                         | Leaves are cooked as vegetable.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <i>Madhuca indica</i>         | Mahua/<br>Mahuro    | Flowers/Fruits                 | The flowers and fruits are eaten raw or cooked. The flowers are compressed into laddoos. The seeds locally called as "Dolma" are also eaten and edible oil called as "Ghee" is also extracted from them, which is used for cooking purposes. During famine the bark is boiled in water to make "Rab" and consumed locally. Special dishes are prepared of the flowers and fruits. Tribals can be seen picking the fallen ones from the ground, which keep on dribbling. They are sun-dried and stored in earthen pots. Tribals distill liquor from the fleshy corollas, which is locally called "mahuri". |
| <i>Mimusops elengi</i>        | Maulsari/<br>Khirni | Fruits                         | Ripe fruits are eaten raw and also sold in the market.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <i>Nelumbo nucifera</i>       | Kamal-<br>Kakri     | Petiole/<br>Rhizome/<br>Flower | The petiole, rhizome and flowering scape are cooked as vegetable and often sold in the market by the tribals. The seeds are also eaten raw or roasted.                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <i>Panicum miliaceum</i>      | Samalai             | Grains                         | Grain flour is used for making bread. The grains serve as the poorman's stand-by and famine reserve.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <i>Panicum paludosum</i>      | —                   | Grains                         | The grains are used as famine food.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <i>Paspalidium flavidum</i>   | Kuri                | Grains                         | The grains used as staple food by most of the tribals of the area.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <i>Paspalum scrobiculatum</i> | Kodra               | Grains                         | Grains are cooked like rice. Grain flour is used for making bread. The grass is cultivated by the tribals. On fifth day of child-birth (Panchora), the newly born child is given a liquid food of pounded seeds with milk.                                                                                                                                                                                                                                                                                                                                                                                |
| <i>Prosopis cineraria</i>     | Khejra              | Pods                           | Unripe pods are used as vegetable. They are dried and preserved for future use as vegetable. Gum is used in preparation of sweets.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <i>Rhus mysurensis</i>        | Dansaria            | Fruits                         | Ripe fruits are eaten raw especially by children and ladies while collecting firewood from the forests. They are dried and preserved for future consumption.                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <i>Salvadora oleioides</i>    | Pilu                | Fruits                         | The sweet edible fruits are very much liked by the tribals. They are dried and preserved for future use also.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <i>Setaria glauca</i>         | Kutta/Kukarva       | Grains                         | The grains are powdered and mixed with flour of cultivated cereals to make the breads.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <i>Setaria paniculifera</i>   | —                   | Grains                         | Grains are used as famine foods.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <i>Tribulus terrestris</i>    | Boodiya/<br>Gokhru  | Seeds                          | The seeds are powdered and mixed with the flour of grains of cultivated crops to make breads during famine. Fruits when young are sweet in taste and are eaten raw. The fruit powder is also used as remedy for urinary disorders and impotence by the tribals.                                                                                                                                                                                                                                                                                                                                           |
| <i>Urginea indica</i>         | Jangli kanda        | Bulbs                          | Detoxified pieces of bulbs (after washing in water repeatedly) are used as a vegetable. In urgent need, slices are detoxified by boiling in water for some time.                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <i>Urochloa panicoides</i>    | Sanwal/Kuri         | Grains                         | Grains are used as famine food.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <i>Zizyphus trinervia</i>     | Jungli ber          | Fruits                         | The ripe fruits are eaten and sold in the tribal market.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

Table 2. Ethno-medicinal plants in Rajasthan

| Botanical name                  | Local name   | Uses                                                                                                                                                                                                                                                                                                                     |
|---------------------------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Alloteropsis cimicina</i>    |              | Root paste is used in toothache.                                                                                                                                                                                                                                                                                         |
| <i>Apluda mutica</i>            |              | Poultice of whole plant is used to cure mouth sores of cattle. It is also given to cattle with small fishes to cure flatulence.                                                                                                                                                                                          |
| <i>Arundo donax</i>             |              | Decoction of rhizome is used to stop the secretion of milk and to increase menses.                                                                                                                                                                                                                                       |
| <i>Capillipedium heugelli</i>   |              | Essential oil is extracted from this grass and used for massage in rheumatism.                                                                                                                                                                                                                                           |
| <i>Cenchrus ciliaris</i>        | Dhaman       | Decoction of root is given to children suffering from intestinal worms.                                                                                                                                                                                                                                                  |
| <i>Cenchrus setigerus</i>       | Dhaman       | Decoction of root is given to children suffering from intestinal worms.                                                                                                                                                                                                                                                  |
| <i>Chloris virgata</i>          |              | Decoction of root is used in the treatment of cold and rheumatism.                                                                                                                                                                                                                                                       |
| <i>Coix lacryma-jobi</i>        | Garelo       | The seeds are boiled in water and then eaten to cure dysentery. The leaf juice is given orally in urinary complaints.                                                                                                                                                                                                    |
| <i>Cymbopogon martinii</i>      | Rohida       | Paste of leaves is warmed with mustard oil ( <i>Brassica campestris</i> ) and then used in massage to relieve rheumatic pain. Oil extracted from leaves is used to cure skin diseases. Decoction of leaves is given in cold and fever. Its smoke is used as rodent and mosquito repellent.                               |
| <i>Cynodon dactylon</i>         | Doob ghass   | Aqueous extract of plant with sugar is given to persons suffering from nostril haemorrhage. Young leaves paste with sugar is used to stop bleeding from cuts and wounds. Leaf juice with a pinch of common salt is taken orally in stomachache. Decoction of whole plant is given orally to cure menstrual problem.      |
| <i>Dactyloctenium aegyptium</i> | Makro        | Grain powder is used to cure stomachache.                                                                                                                                                                                                                                                                                |
| <i>Dactyloctenium indicum</i>   | Makro        | Whole plant extract is taken orally in rheumatism.                                                                                                                                                                                                                                                                       |
| <i>Digitaria adscendens</i>     |              | Decoction of inflorescence of <i>Digitaria</i> and fruits of <i>Tribulus terrestris</i> is given to children suffering from fever.                                                                                                                                                                                       |
| <i>Echinochloa crusgalli</i>    | Batda/Batti  | Juice of whole plant is taken orally to cure nostril haemorrhage.                                                                                                                                                                                                                                                        |
| <i>Eleusine coracana</i>        | Maduo/Mall   | Grains and whole plant are used in measles, small pox pneumonia, pleuro-pneumonia, in blood diseases, in burning sensation, leprosy, skin diseases, general debility.                                                                                                                                                    |
| <i>Panicum antidotale</i>       | Karad/Kangni | Paste of whole plant is tied over wounds.                                                                                                                                                                                                                                                                                |
| <i>Paspalum scrobiculatum</i>   |              | Paste of whole plant is used for skin diseases. It is also effective on boils and scores.                                                                                                                                                                                                                                |
| <i>Pennisetum americanum</i>    | Bajra        | Grains are employed in cold season as food to get rid of cold and sexual debility.                                                                                                                                                                                                                                       |
| <i>Phragmites karka</i>         |              | The leaf juice is used for the body cooling.                                                                                                                                                                                                                                                                             |
| <i>Saccharum bengalense</i>     | Munj ghass   | About 100 gms fresh leaves are taken and cut into small pieces. Leaves are then boiled in about 2 cups of water till it is reduced to half cup and then filtered. This filtrate is taken orally for 3 days to cure menstrual complaints. It is also a good remedy for abortion. The leaf juice is taken orally in fever. |
| <i>Setaria italica</i>          | Kangni       | Grains are used externally in rheumatism and as a domestic remedy for alleviating the pain of parturition. It is sedative to gastric ulcers, useful in burning sensation, in healing fracture, causes flatulence.                                                                                                        |
| <i>Sorghum halepense</i>        | Baru         | Juice of whole plant is taken orally with a pinch of common salt in fever.                                                                                                                                                                                                                                               |
| <i>Themeda quadrivalvis</i>     |              | Paste of whole plant is warmed and used to cure the septic wounds. Small fishes moulded in this grass are used to cure flatulence in cattle especially buffaloes.                                                                                                                                                        |
| <i>Vetiveria zizanioides</i>    | Khas         | Root paste is taken orally in anthelmintic problem.                                                                                                                                                                                                                                                                      |
| <i>Zea mays</i>                 | Makka        | Juice of leaves is taken orally to cure renal disorders.                                                                                                                                                                                                                                                                 |
| <i>Abrus precatorius</i>        | Chirmi       | The root decoction is also useful in ulcers and blood diseases. Fresh leaves are used as ingredient in cough mixtures and also chewed to cure mouth boils. During field studies it was quoted by tribals, that seeds of this plant are used as an antifertility drug both in male as well as female.                     |

Contd.

Table 2. Contd.

| Botanical name                     | Local name       | Uses                                                                                                                                                                                                                                                                                      |
|------------------------------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Celastrus paniculatus</i>       | Mali/Malkangni   | Seed oil is applied over scalp for promotion of hair growth. It is also applied in skin inflammations, gout and rheumatism. Infusion of bark is used in bronchitis, seeds are stimulant.                                                                                                  |
| <i>Cocculus villosus</i>           | Khangro          | A jelly like material is formed by soaking the leaves in water for 24 hrs. This material is used to cause infertility in males.                                                                                                                                                           |
| <i>Costus speciosus</i>            | Maha lakdi       | Two or three drops of filtered rhizome extract is poured into ear to check pus formation and severe earache. Infusion of rhizome is taken early in the morning for about 45-50 days for the treatment of asthma. Poultice of rhizome is used in dropsy and oedema.                        |
| <i>Curculigo orchoides</i>         | Kali moosli      | Root decoction is used as a tonic for children and also to remove impotency and to check filaria.                                                                                                                                                                                         |
| <i>Gloriosa superba</i>            | Kariharo/Kathari | Root paste is heated and applied on the forehead and neck for seven days to cure asthma in children. Leaf paste is applied over irritations, piles and leprosy.                                                                                                                           |
| <i>Helicteris isora</i>            | Hatri/Marodfali  | Root decoction is used in asthma. Infusion of fruits is used to check vomiting.                                                                                                                                                                                                           |
| <i>Holoarrhena antidysenterica</i> | Koorwa/Kadwa     | Latex is used for instant curding of milk. Powdered leaves and flowers are taken orally in dysentery. Root bark is crushed with stem bark of <i>Diospyros melanoxylon</i> and infusion of this mixture is taken orally in malaria.                                                        |
| <i>Tinospora cordifolia</i>        | Gloya/Neemgloya  | In Piles, the swollen portion of rectum is first washed with leaf extract of 'Neem' ( <i>Azadirachta indica</i> ) and then smeared with bark paste of gloya. Stem pieces are eaten raw in rheumatism. Decoction of whole plant is considered as a wonderful medicine in hepatic diseases. |
| <i>Typha angustata</i>             | Ara              | Decoction of whole plant is used to cure madness.                                                                                                                                                                                                                                         |

tribal and other such communities are important sources of biodynamic compounds. Chemical and pharmacological investigations of such plants are important not only for the discovery of new therapeutic agents, but also for new sources of economic materials and precursors for the synthesis of complex chemicals of biological or industrial importance.

Primitive cultivars of wild plants used by tribal communities may hold the genetic key to many important agricultural breakthrough. Many tribal communities still continue to grow such plant species that are of great economic utility but are being threatened by changes in the style of these communities. These genetic resources have to be urgently preserved.

## References

- Bhandari MM (1974) Famine foods of Rajasthan desert. *Econ. Bot.* **28**: 73-81.
- Joshi P (1982) An Ethnobotanical Study of Bhils-A Preliminary Survey. *J. Econ. Tax. Bot.* **3**: 257-266.
- Joshi P (1987) Weather indicating plants of tribals in Southern Rajasthan. *Bull. Bot Surv. India* **27**: 100-104.
- Joshi P (1991) Herbal drugs used in guinea worms disease by the tribals of Southern Rajasthan (India). *Int. J. Pharmacognosy* **29**: 33-38.
- Joshi P (1993) Ethnomedicine of Kathodias-A monkey eating tribe in Rajasthan. *Glimpses in Plant Res.* **10**: 75-95.
- Joshi P (1995) *Ethnobotany of the primitive tribes in Rajasthan*. Printwell, Jaipur.
- Sebastian MK and MM Bhandari (1984) Medico-ethnobotany of Mt. Abu, Rajasthan. *J. Ethnopharmacology* **12**: 223-230.
- Sebastian MK and MM Bhandari (1988) Medicinal plant-lore in Udaipur district, Rajasthan. *Bull. Medic. Ethno. Bot. Res.* **5**: 133-134.
- Sebastian MK and MM Bhandari (1990) Edible wild plants of the forest areas of Rajasthan. *J. Econ. Tax. Bot.* **14**: 689-694.
- Singh V and RP Pandey (1980) Medicinal plant-lore of the tribals of eastern Rajasthan. *J. Econ Tax. Bot.* **1**: 137-147.
- Singh V and RP Pandey (1996) Ethno-medicinal plants used for venereal and gynaecological diseases in Rajasthan, India. *J. Econ. Tax. Bot. (Addl. Series)* **12**: 154-165.
- Katewa SS and A Arora (1997) Some plants in folk medicine of Udaipur district, Rajasthan. *Ethnobotany* **9**: 48-51.
- Katewa SS and BD Guria (1997) Ethnobotanical observations on certain wild plants from Southern Aravalli hills of Rajasthan. *Vasundhara* **2**: 85-86.
- Katewa SS and R Sharma (1998) Ethnomedicinal observations from certain watershed areas of Rajasthan. *Ethnobotany* **10**: 46-49.
- Katewa SS and BL Chaudhary (2000) Ethnoveterinary survey of plants of Rajsamand district, Rajasthan. *Vasundhara* **5**: 95-99.

**Table 3. Local and traditional rice germplasm collected from Barak Valley**

| Ahu varieties (8)                                                                                       | Sali varieties (81)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Boro varieties (26)                                                                                                                                                                                                                                                            |
|---------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ahu berocin,<br>Birashi,<br>Golkimurali,<br>Kachal,<br>Kartica,<br>Mayamoti,<br>Nagamurali,<br>Sunamuki | Agirghalberocin, Agnisail, Amuhail, Asra terabail, Badaya,<br>Badshabhug, Baluchoriasra, Bangonbitchi, Bethi, Bherapowa<br>long awned, Bherapowa short awned, Bherapowa Finegrain,<br>Bodosoyamora, Bothuasra, Borhail, Chabrasail, Chatoki, Chandmoni,<br>Chandramoni, Damdiberoein, Dandaberocin, Doloo berocin,<br>Doomasail, Dolmadhi, Dumay, Godhasail, Eri, Gondhiberocin, Guaroi,<br>Harinarayan, Hasbadalasra and Insanberocin, Jhumberocin red, White,<br>Jhumsoyamora, Joria, Juthaberocin, Kachalo, Kaizuri, Kakhiberocin,<br>Kakirjaliberocin, Kalakura asra, Kalakura asra awned, Kalimakuri,<br>Kalimuki, Kalizera, Kamrang, Koimurali, Khetrasail, Lakhiasra, Lalberocin,<br>Lalpani, Lalsheet, Latha, Lathiberocin, Latma, Laoti, Lanza, Majlasoyamora,<br>Madhumala, Moinasail, Mokhajurya, Moniram, Monthathoi, Mouberoein,<br>Mulahail, Murali, Munshimurali, Mydhani, Naga berocin, Nagasail,<br>Painoili, Pakhiberoein, Paniberocin, Paninoliasra, Parichakasra awnless and<br>awned, Puthiberocin Shabail, Sunasrs, Terabail. | Agrical, Agnisail, Aubera, Auhuga,<br>Atsathi, Balambarua, Basphul,<br>Baruaberoein, Bangonbitchi,<br>Birashi, Chatoki, Chocklat,<br>Gopalari, Gorsibarua, Gosabarua,<br>Gusibarua, Jamilal, Kaiya, Kewla,<br>Koibarua, Lenzabarua, Lahai,<br>Nimoria, Ratha, Sikoibarua, Tufa |

**References**

- Das GR, T Ahmed, HC Bhattacharaya and BC Borthakur (1981)  
Evaluation of rice germplasm I. Characterization and evaluation  
of ahu rice for important quantitative characters in relation  
to yield. *J. Res. Assam Agric Univ.* 2: 156-164.
- Das GR, T Ahmed, HC Bhattacharaya and BC Borthakur (1983)  
Evaluation of rice germplasm II Characterization and  
evaluation of traditional sali rice. *J. Res. Assam Agric. Univ.*  
4: 92-97.

**Collection and Evaluation of Kartoli (*Momordica dioica* Roxb. ex. Willd.)**

**D Ram, MK Banerjee, Sudhakar Pandey and Umesh Srivastava\***

*Indian Institute of Vegetable Research, 1, Gandhi Nagar (Naria), P.B. 5002, Varanasi-221005, Uttar Pradesh*

**Key words : *Momordica dioica*, Landraces, Genetic diversity, Superior genotype**

Kartoli, family Cucurbitaceae, genus *Momordica* is also known as spine gourd, sweet gourd, kankad and kheksa. Sixty species are reported worldwide of which 7 species occur in India. Kartoli is dioecious in nature and has a wide range of adaptability. It is a rich source of protein and minerals. It possesses several medicinal and curative properties like decoction of leaves reduces fever; tuberous roots help in relieving headache, sweating, stone formation, migraine while fruit is quite helpful in controlling diabetes and blood pressure. It contains aliphatic compounds (Ali and Srivastava, 1998). This prized vegetable has its importance mainly in the areas of their occurrence due to climatic change, physiographic diversity and adaptation. In the Indian sub-continent, it has tremendous scope of acclimatization. It has not only contributed towards food but also is a rich wild gene pool for several important traits. With drastic increase in the world population and

fast depletion of natural resources, there is a great need to explore newer sources of vegetables and diversity in the vegetable cultivation to meet the present days' demand.

Kartoli is mainly grown in Orissa, Bihar and West Bengal as a crop and kitchen garden plant but occurs as wild in Punjab, Uttar Pradesh, Rajasthan, Madhya Pradesh, Kerala and Maharashtra under custody of tribals. Kartoli shows enormous diversity in shape, size of the leaf, fruit shape and colour which occurs in semi-domesticated and wild types in local pockets and such types have been selected by native people as a part of their vegetable requirement. Its commercial cultivation is meagre due to unavailability of improved varieties, difficulties in propagation by seeds due to dormancy, low multiplication rate of tubers, dormancy of tubers and unpredictable sex ratio in seedling progeny (Ali *et al.* 1991). An attempt was made to collect and evaluate locally available genetic diversity of Kartoli germplasm.

\* National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012

A programme for survey, collection and evaluation of natural diversity available in Kartoli (*Momordica dioica*) was initiated during 1997 to 1999. Eighteen female genotypes of diverse nature and two male lines were collected from Vindhyachal hills of Mirzapur in the month of July-August. Collections were made in the form of mature seeds, tuberous roots and parts of the stem (above the ground) for multiplication. The collected seeds/roots/plant material were sown/planted in the month of August-September in the medium for sprouting. The experiments were conducted in RBD considering two replications for two consecutive years. Observations were recorded for 5 randomly selected plants in each replication. The agromorphological characters considered for this study are: tuber size (g), plant height (cm), number of branches/plant, days taken to rooting of soft cutting, days to 50% flowering, days to first fruit set and to edible maturity, days taken from edible maturity to seed maturity, number of fruits/plant, average fruit weight (g) and yield/plant (kg). As a rooting medium "Rootex No-1" was used which is suitable for induction of roots in soft wood cuttings. The study was conducted at the experimental farm, IIVR, Varanasi (U.P.)

On the basis of experimental results, considerable range of variation was recorded for all the characters. Some sampled populations were morphologically similar. Considerable variability were recorded in fruit morphological traits including fruits shape (round, oblong), base (roundish, broad, conical), apex (narrowly round, roundish, conical round), colour at edible maturity (dark greenish, light yellowish) and taste (sweet). It was observed during the exploration that the edible maturity differs greatly from plant to plant.

It may be probably due to new plant development by seed cuttings or newly sprouted tubers or due to geographical variation. Table 1 reveals that under-weight tubers (10 g) start sprouting quite late (20-25 days) and sprouts were weak and slender. Medium-size tubers (11-15 g) took 18-20 days for sprouting but plant stand

**Table 1. Categorization of Kartoli on the basis of tuber size and sprouting**

| Tuber size  | Tuber weight (g) | Days taken to sprouting of tubers after planting | Growth                           | Accessions                 |
|-------------|------------------|--------------------------------------------------|----------------------------------|----------------------------|
| Low size    | <10              | 20-25                                            | Sprouts are weak and cylindrical | MD-1, 13,14,16             |
| Medium size | 11-15            | 18-22                                            | Vigorous                         | MD-4, 8,9,11,15            |
| Big size    | >16              | 15-16                                            | Very vigorous but growth is poor | MD-2,3,5,6, 7,10,12, 17,18 |

was quite vigorous. Over-size tubers in general sprout within 15-16 days and sprouts were quite vigorous but showed poor root development. Promising genotypes were MD-4, 8, 9, 11 and 15.

In Kartoli, seed germinates 30-35 days after sowing. Flowering occurs after 56 (male flower) and 54 (female flowers) days after sowing/planting. It attains the edible fruit maturity in 88 days and seeds mature after 98-105 days of sowing. Tuberous roots sprout very early (16-20 days) and start flowering within 40 days, which attain the edible fruit maturity within 72 days. Findings indicate that medium size tuberous roots are the best planting material. In cuttings, only 36% plants survived. With respect to yield potential, maximum yield was recorded by tuber raised crop (3.3 kg/plant) followed by cuttings (2.8 kg/plant). Minimum yield was recorded in seed propagated crop (Table 2).

Quantitative characterization of the Kartoli germplasm (Table 3) Line MS-15 and MD-18 yielded maximum, i.e. 2.85 and 2.80 kg/plant, respectively, with an average yield of 1.94 kg/plant. Shaw *et al.* (1998) isolated one genotype "RMF 37" for maximum fruit yield from this collection, which was less affected by damaging insect.

Maximum number of fruits/plant recorded is MD-16 (120) followed by MD-17(110). Individual fruit

**Table 2. Yielding ability and morphological variation in the context of propagation**

| Method of propagation               | Yield (kg) | Days taken to germination/ sprouting/rooting | Days to first male flowering | Days to first female flowering | Days to first fruit set | Days to edible fruit maturity (days) | Days to seed maturity (days) |
|-------------------------------------|------------|----------------------------------------------|------------------------------|--------------------------------|-------------------------|--------------------------------------|------------------------------|
| Seed                                | 1.45       | 30-35                                        | 56                           | 54                             | 61                      | 88                                   | 98-105                       |
| Tubers                              | 3.30       | 16-20                                        | 46                           | 40                             | 55                      | 72                                   | 85-90                        |
| Cutting (treated with rootex no.-1) | 2.80       | 28-30                                        | 50                           | 45                             | 50                      | 80                                   | 93-95                        |

**Table 3. Characterization of collected germplasm**

| Accession | Plant height (cm) | No. of fruits/plant | Individual fruit weight (g) | No. of seed/fruit | Branches/plant | Yield/plant (kg) |
|-----------|-------------------|---------------------|-----------------------------|-------------------|----------------|------------------|
| MD-1      | 2.80              | 95                  | 18.00                       | 16                | 9              | 2.33             |
| MD-2      | 1.95              | 72                  | 13.60                       | 22                | 10             | 1.50             |
| MD-3      | 2.45              | 98                  | 15.00                       | 20                | 8              | 1.97             |
| MD-4      | 2.60              | 88                  | 12.20                       | 15                | 11             | 1.45             |
| MD-5      | 3.30              | 105                 | 16.20                       | 23                | 16             | 2.85             |
| MD-6      | 1.50              | 45                  | 19.40                       | 18                | 12             | 1.65             |
| MD-7      | 3.50              | 102                 | 14.00                       | 20                | 10             | 2.22             |
| MD-8      | 3.95              | 87                  | 13.00                       | 12                | 14             | 2.38             |
| MD-9      | 2.20              | 48                  | 10.50                       | 19                | 8              | 1.85             |
| MD-10     | 1.54              | 32                  | 8.20                        | 23                | 13             | 1.20             |
| MD-11     | 1.68              | 55                  | 10.50                       | 21                | 14             | 1.85             |
| MD-12     | 2.95              | 101                 | 11.65                       | 14                | 15             | 2.43             |
| MD-13     | 3.00              | 95                  | 12.42                       | 17                | 12             | 2.00             |
| MD-14     | 2.25              | 80                  | 9.30                        | 10                | 8              | 1.20             |
| MD-15     | 1.65              | 90                  | 8.20                        | 16                | 6              | 1.00             |
| MD-16     | 3.40              | 120                 | 13.00                       | 22                | 14             | 2.30             |
| MD-17     | 3.00              | 110                 | 11.00                       | 17                | 10             | 2.00             |
| MD-18     | 3.10              | 105                 | 12.00                       | 26                | 19             | 2.80             |
| Mean      | 2.59              | 84.88               | 12.68                       | 18.38             | 11.61          | 1.94             |
| Range     | 1.50-3.95         | 32-120              | 8.20-19.4                   | 10-23             | 6-19           | 1.00-2.85        |

weight, which determines the yield, fruit varies greatly (8.20–19.4). Seeds of Kartoli are round and differ greatly from other species of *Momordica*. More number of seeds/fruit was counted in MD-6 and MD-10 each of 23. More number of seeds in a fruit is not a desirable character in Kartoli. So, less-seeded genotypes *i.e.* MD-14(10) and MD-8(12) were considered as best genotypes. Both the selected genotypes were soft-seeded and more fleshy. It is true that more number of fruits were born on thinner branches. For this trait MD-18(19) and MD-5(16) were considered best genotypes among the accessions available. MD-5 genotype yielded poor due to less number of branches.

### References

- Ali M, H Okubo, T Fujii and K Fujieda (1991) Techniques for propagation and breeding of Kakrol (*Momordica dioica* Roxb.). *Sci. Hort.* **47**: 335-343.
- Ali M and V Srivastava (1998) Characterization of phytoconstituents of the fruits of *M. dioica*. *Indian J. Pharmaceutical Sci.* **60**: 287-289.
- Shaw SS, SC Mukherjee, AK Tripathi, V Mahajan, S Bhandarkar and SK Sinha (1998) Incidence of insect pest on genotypes of spine gourd in Madhya Pradesh. *Pest Manage. Hortic. Ecosys.* **4**: 133-134.

## Interception of Insect and Mite Pests in Germplasm under Exchange during the Year 2000

**Shashi Bhalla, Kavita Gupta, B Lal, Manju Lata Kapur, Charan Singh, Naresh Kumar, Meenakshi and RS Baloda**

*Division of Plant Quarantine, National Bureau of Plant Genetic Resources, New Delhi-110012*

**Key Words:** Insect, Mites, Interceptions, Germplasm, Quarantine

Exchange of planting material has a significant role in diversifying and stabilizing agricultural production but involves an inherent risk of introduction of exotic pests in a given geographical area. The role of quarantine is important in preventing the possible entry of exotic pests, which may accompany the incoming and planting material. It is on record that distribution of several pests and pathogens have resulted from the movement of infested germplasm and the introduced pests have proved more dangerous in the new areas as they can flourish unchecked by their natural enemies. The importance of plant quarantine is indicated in the number of

interceptions of insects and mites made during previous years, which include *Bruchidius glycyrrhizae* (Fab) in *Glycyrrhiza uralensis* from USSR, *Bruchophagus mellipes* in *Sesbania* spp. from Philippines and *Megastigmus aculeatus* in *Rosa* spp. from N. Arctic Region (Mathur and Lal, 1996).

A total of 1,22,365 samples (1,22,183 imported and 182 exported) comprising seeds, tubers, bulbs, suckers, rhizomes, cuttings, seedlings and rooted plants of different crops and their wild relatives were received for quarantine clearance in the year 2000. These samples were examined visually, under high magnification and the seeds of plant

## Collection of Rice Germplasm from Barak Valley, Assam

**Atiqur Rahman Barbhuiya and GD Sharma**

*Department of Life Science, Assam University, Silchar-788011, Assam*

**Key Words: Biodiversity, Rice germplasm**

Rice (*Oryza sativa*) is the staple food of the people of North-Eastern region of India. Various traditional as well as improved varieties have been cultivated by different tribes and communities. Since, there is no systematic work available on the diversity of rice and their conservation in Barak Valley (*i.e.* the three districts of Assam *viz.*-Cachar, Hailakandi and Karimganj). It was planned to carry out an investigation to record the diversity of rice and their conservation. Since time immemorial local people of Barak Valley mainly depend on rice crop of diverse type. Hence, this region has been known for the higher paddy germplasm (Das *et al.* 1981, 1983). Due to socio-economic compulsion, unfavourable agroclimatic conditions *i.e.* high rainfall, sometime drought, warm, humid climate, frequent floods-water logging condition and with the improvement in the Green Revolution, farmers of Barak Valley are introducing more of the hybrid varieties which are resistant to various adverse climatic conditions, as well as to diseases and thus putting pressure on the cultivation of the traditional varieties. However, still traditional varieties for their various qualities like scented, glutinous, high yield potentiality, profuse tillering, flood resistant, straw quality, fitness of grain *etc.* are in cultivation. These traditional varieties may serve as valuable material for future breeding work, as these are the source of many genetic information.

Cachar, Karimganj and Hailakandi districts of South Assam constitute Barak Valley with a geographical area of about 7000 sq km and a population of about 30 lakhs. Among the population of Barak Valley majority of them are Bengali (Hindu and Muslim), alongwith Manipuri, Kuki, Naga, Barman, Dimasa, Mizo, Rieng, Hmar, Vaipai and Tea-garden community.

Geographically, the Barak Valley as a whole is younger than the Brahmaputra Valley and it is surrounded by North-Cachar Hills and Jaintia Hills in the North, by the hills of Manipur in the East, by Mizoram in

the South and by Tripura and Sylhet district of Bangladesh in the West. The area has an altitude of 26-27 m above MSL and falls under 24°8' and 25°8' N latitude and 92°15' and 93°15' E longitude. The districts consist of small hillocks, plain areas, bheels and extreme low lying flood prone areas and the river Barak flows across the three districts and has a length of nearly 74.564 km (120 miles). Barak Valley is entirely alluvial in origin and is composed of pebbles, sand, silt, clay and sometimes a mixture of sand and clay containing decomposed matter. The climate of Barak Valley is Tropical humid type. The annual average rainfall of the valley is 670.9 mm. Rainfall increases from March to September with apprehension of flood but December and January months are generally dry. The valley experiences a humid weather with frequent rainfall. The annual range of temperature ranged from 8.5°C-36.2°C. The relative humidity remains high throughout the year in the morning hours, although it may drop to low during the afternoon hours in the months of February and April. The soil of the area is a mixture of alluvial, sandy-loam, muddy loam, loam, clay, superimposed upon stones, grants and conglomerates. The muddy soil rich in humus content is mostly confined to river bank. The tillah lands of many areas is mostly lateric (reddish colour) and the pH of the soil ranges from 4.5 to 8.5.

The collection and evaluation of traditional Ahu Sali and Boro Rice germplasms of Barak Valley were done by block wise categorization during the specific growing season of each variety through regular visits in the farmers' field (Table 1 and Table 2). Interaction with old men/women farmers of the villages to get information on the cultivation practice, yield and utility were also carried out.

Specific growing seasons of rices in Barak Valley for Ahu-rices is May-October, Sali-rice is June-December and Boro-rice is from November to May. During collection and evaluation and interaction with farmers the following information was collected for

**Table 1. Details of the blocks of Barak Valley for study**

The following blocks of Barak Valley are under study

| Cachar         | Karimganj          | Hailakandi          |
|----------------|--------------------|---------------------|
| Silchar-01     | North Karimganj-16 | Hailakandi-23       |
| Sonai-02       | South Karimganj-17 | South-Hailakandi-24 |
| Salchapra-03   | Patherkandi-18     | Algapur-25          |
| Norsingpur-04  | Ramkrishnanagar-19 | Lala-26             |
| Palong ghat-05 | Badarpur-20        | Katlichera-27       |
| Udharbond-06   | Louirpua-21        |                     |
| Tapang-07      | Durlavchera-22     |                     |
| Borjalenga-08  |                    |                     |
| Banskandi-09   |                    |                     |
| Binnakandi-10  |                    |                     |
| Borkhola-11    |                    |                     |
| Katigora-12    |                    |                     |
| Kalain-13      |                    |                     |
| Lakhipur-14    |                    |                     |
| Rajabazar-15   |                    |                     |

The numerical values as suffix are the code of blocks

**Table 2. Details of the districts for collection of rice germplasm**

| Cachar Distt.                                                                                   | Karimganj Distt.                                                              | Hailakandi Distt.                                                             |
|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Traditional Ahu-Rice<br>Germplasm collected in 2000:<br>01, 02, 04, 09.                         | —                                                                             | —                                                                             |
| Traditional Sali-Rice<br>Germplasm collected in<br>2000-2001:<br>01, 02, 04, 05,<br>06, 09, 11. | Traditional Sali-Rice Germplasm<br>collected in 2000-2001:<br><br>16, 17, 20. | Traditional Sali-Rice Germplasm<br>collected in 2000-2001:<br><br>23, 24, 25. |
| Traditional Boro-Rice<br>Germplasm collected in 2001:<br>01, 02, 03, 10, 11, 14.                | Traditional Boro-Rice<br>Germplasm collected in 2001:<br>17, 20.              | Traditional Boro-Rice<br>Germplasm collected in 2001:<br>23, 26.              |

The numerical values are the codes of the blocks

each specific variety (a) duration of span *i.e.* seed to seed duration (day), (b) average plant height (cm), (c) average yield (kg/ha), (d) average flag leaf length and width (cm), (e) flag leaf angle ( $^{\circ}$ ) (f) panicle length (cm), (g) no. of grains/panicle, (h) the weight of 100 grains, (i) seed characters *i.e.* length and width of grain (mm); length width ratio; colour of seed kernel, outer glume, inner glume, apiculus tip, grain, endosperm and pericarp colour, seeds awn character, flavour (scent) and glutinous quality of the grain (data not presented).

After conducting a survey of different blocks of Barak Valley 8, 81, and 26 local varieties of Ahu, Sali and Boro-Rice were collected, respectively (Table 3).

Results reveal that there is a great variation within the different local, traditional rice varieties in respect of their yield, duration of maturity and other qualities like height, flood resistance, drought resistance, seed quality *etc.* This indicates that a very rich source of traditional rice germplasm exists in Barak Valley and it needs a thorough investigation for their future improvement, breeding and ultimately conservation.

**Table 3. Local and traditional rice germplasm collected from Barak Valley**

| Ahu varieties (8)                                                                                       | Sali varieties (81)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Boro varieties (26)                                                                                                                                                                                                                                                            |
|---------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ahu berocin,<br>Birashi,<br>Golkimurali,<br>Kachal,<br>Kartica,<br>Mayamoti,<br>Nagamurali,<br>Sunamuki | Agirghalberocin, Agnisail, Amuhail, Asra terabail, Badaya,<br>Badshabhug, Baluchoriasra, Bangonbitchi, Bethi, Bherapowa<br>long awned, Bherapowa short awned, Bherapowa Finegrain,<br>Bodosoyamora, Bothuasra, Borhail, Chabrasail, Chatoki, Chandmoni,<br>Chandramoni, Damdiberoein, Dandaberocin, Doloo berocin,<br>Doomasail, Dolmadhi, Dumay, Godhasail, Eri, Gondhiberocin, Guaroi,<br>Harinarayan, Hasbadalasra and Insanberocin, Jhumberocin red, White,<br>Jhumsoyamora, Joria, Juthaberocin, Kachalo, Kaizuri, Kakhiberocin,<br>Kakirjaliberocin, Kalakura asra, Kalakura asra awned, Kalimakuri,<br>Kalimuki, Kalizera, Kamrang, Koimurali, Khetrasail, Lakhiasra, Lalberocin,<br>Lalpani, Lalsheet, Latha, Lathiberocin, Latma, Laoti, Lanza, Majlasoyamora,<br>Madhumala, Moinasail, Mokhajurya, Moniram, Monthathoi, Mouberoein,<br>Mulahail, Murali, Munshimurali, Mydhani, Naga berocin, Nagasail,<br>Painoili, Pakhiberoein, Paniberocin, Paninoliasra, Parichakasra awnless and<br>awned, Puthiberocin Shabail, Sunasrs, Terabail. | Agrical, Agnisail, Aubera, Auhuga,<br>Atsathi, Balambarua, Basphul,<br>Baruaberoein, Bangonbitchi,<br>Birashi, Chatoki, Chocklat,<br>Gopalari, Gorsibarua, Gosabarua,<br>Gusibarua, Jamilal, Kaiya, Kewla,<br>Koibarua, Lenzabarua, Lahai,<br>Nimoria, Ratha, Sikoibarua, Tufa |

**References**

- Das GR, T Ahmed, HC Bhattacharaya and BC Borthakur (1981)  
Evaluation of rice germplasm I. Characterization and evaluation  
of ahu rice for important quantitative characters in relation  
to yield. *J. Res. Assam Agric Univ.* 2: 156-164.
- Das GR, T Ahmed, HC Bhattacharaya and BC Borthakur (1983)  
Evaluation of rice germplasm II Characterization and  
evaluation of traditional sali rice. *J. Res. Assam Agric. Univ.*  
4: 92-97.

**Collection and Evaluation of Kartoli (*Momordica dioica* Roxb. ex. Willd.)**

**D Ram, MK Banerjee, Sudhakar Pandey and Umesh Srivastava\***

*Indian Institute of Vegetable Research, 1, Gandhi Nagar (Naria), P.B. 5002, Varanasi-221005, Uttar Pradesh*

**Key words : *Momordica dioica*, Landraces, Genetic diversity, Superior genotype**

Kartoli, family Cucurbitaceae, genus *Momordica* is also known as spine gourd, sweet gourd, kankad and kheksa. Sixty species are reported worldwide of which 7 species occur in India. Kartoli is dioecious in nature and has a wide range of adaptability. It is a rich source of protein and minerals. It possesses several medicinal and curative properties like decoction of leaves reduces fever; tuberous roots help in relieving headache, sweating, stone formation, migraine while fruit is quite helpful in controlling diabetes and blood pressure. It contains aliphatic compounds (Ali and Srivastava, 1998). This prized vegetable has its importance mainly in the areas of their occurrence due to climatic change, physiographic diversity and adaptation. In the Indian sub-continent, it has tremendous scope of acclimatization. It has not only contributed towards food but also is a rich wild gene pool for several important traits. With drastic increase in the world population and

fast depletion of natural resources, there is a great need to explore newer sources of vegetables and diversity in the vegetable cultivation to meet the present days' demand.

Kartoli is mainly grown in Orissa, Bihar and West Bengal as a crop and kitchen garden plant but occurs as wild in Punjab, Uttar Pradesh, Rajasthan, Madhya Pradesh, Kerala and Maharashtra under custody of tribals. Kartoli shows enormous diversity in shape, size of the leaf, fruit shape and colour which occurs in semi-domesticated and wild types in local pockets and such types have been selected by native people as a part of their vegetable requirement. Its commercial cultivation is meagre due to unavailability of improved varieties, difficulties in propagation by seeds due to dormancy, low multiplication rate of tubers, dormancy of tubers and unpredictable sex ratio in seedling progeny (Ali *et al.* 1991). An attempt was made to collect and evaluate locally available genetic diversity of Kartoli germplasm.

\* National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012

**Table 3. Characterization of collected germplasm**

| Accession | Plant height (cm) | No. of fruits/plant | Individual fruit weight (g) | No. of seed/fruit | Branches/plant | Yield/plant (kg) |
|-----------|-------------------|---------------------|-----------------------------|-------------------|----------------|------------------|
| MD-1      | 2.80              | 95                  | 18.00                       | 16                | 9              | 2.33             |
| MD-2      | 1.95              | 72                  | 13.60                       | 22                | 10             | 1.50             |
| MD-3      | 2.45              | 98                  | 15.00                       | 20                | 8              | 1.97             |
| MD-4      | 2.60              | 88                  | 12.20                       | 15                | 11             | 1.45             |
| MD-5      | 3.30              | 105                 | 16.20                       | 23                | 16             | 2.85             |
| MD-6      | 1.50              | 45                  | 19.40                       | 18                | 12             | 1.65             |
| MD-7      | 3.50              | 102                 | 14.00                       | 20                | 10             | 2.22             |
| MD-8      | 3.95              | 87                  | 13.00                       | 12                | 14             | 2.38             |
| MD-9      | 2.20              | 48                  | 10.50                       | 19                | 8              | 1.85             |
| MD-10     | 1.54              | 32                  | 8.20                        | 23                | 13             | 1.20             |
| MD-11     | 1.68              | 55                  | 10.50                       | 21                | 14             | 1.85             |
| MD-12     | 2.95              | 101                 | 11.65                       | 14                | 15             | 2.43             |
| MD-13     | 3.00              | 95                  | 12.42                       | 17                | 12             | 2.00             |
| MD-14     | 2.25              | 80                  | 9.30                        | 10                | 8              | 1.20             |
| MD-15     | 1.65              | 90                  | 8.20                        | 16                | 6              | 1.00             |
| MD-16     | 3.40              | 120                 | 13.00                       | 22                | 14             | 2.30             |
| MD-17     | 3.00              | 110                 | 11.00                       | 17                | 10             | 2.00             |
| MD-18     | 3.10              | 105                 | 12.00                       | 26                | 19             | 2.80             |
| Mean      | 2.59              | 84.88               | 12.68                       | 18.38             | 11.61          | 1.94             |
| Range     | 1.50-3.95         | 32-120              | 8.20-19.4                   | 10-23             | 6-19           | 1.00-2.85        |

weight, which determines the yield, fruit varies greatly (8.20–19.4). Seeds of Kartoli are round and differ greatly from other species of *Momordica*. More number of seeds/fruit was counted in MD-6 and MD-10 each of 23. More number of seeds in a fruit is not a desirable character in Kartoli. So, less-seeded genotypes *i.e.* MD-14(10) and MD-8(12) were considered as best genotypes. Both the selected genotypes were soft-seeded and more fleshy. It is true that more number of fruits were born on thinner branches. For this trait MD-18(19) and MD-5(16) were considered best genotypes among the accessions available. MD-5 genotype yielded poor due to less number of branches.

### References

- Ali M, H Okubo, T Fujii and K Fujieda (1991) Techniques for propagation and breeding of Kakrol (*Momordica dioica* Roxb.). *Sci. Hort.* **47**: 335-343.
- Ali M and V Srivastava (1998) Characterization of phytoconstituents of the fruits of *M. dioica*. *Indian J. Pharmaceutical Sci.* **60**: 287-289.
- Shaw SS, SC Mukherjee, AK Tripathi, V Mahajan, S Bhandarkar and SK Sinha (1998) Incidence of insect pest on genotypes of spine gourd in Madhya Pradesh. *Pest Manage. Hortic. Ecosys.* **4**: 133-134.

## Interception of Insect and Mite Pests in Germplasm under Exchange during the Year 2000

**Shashi Bhalla, Kavita Gupta, B Lal, Manju Lata Kapur, Charan Singh, Naresh Kumar, Meenakshi and RS Baloda**

*Division of Plant Quarantine, National Bureau of Plant Genetic Resources, New Delhi-110012*

**Key Words:** Insect, Mites, Interceptions, Germplasm, Quarantine

Exchange of planting material has a significant role in diversifying and stabilizing agricultural production but involves an inherent risk of introduction of exotic pests in a given geographical area. The role of quarantine is important in preventing the possible entry of exotic pests, which may accompany the incoming and planting material. It is on record that distribution of several pests and pathogens have resulted from the movement of infested germplasm and the introduced pests have proved more dangerous in the new areas as they can flourish unchecked by their natural enemies. The importance of plant quarantine is indicated in the number of

interceptions of insects and mites made during previous years, which include *Bruchidius glycyrrhizae* (Fab) in *Glycyrrhiza uralensis* from USSR, *Bruchophagus mellipes* in *Sesbania* spp. from Philippines and *Megastigmus aculeatus* in *Rosa* spp. from N. Arctic Region (Mathur and Lal, 1996).

A total of 1,22,365 samples (1,22,183 imported and 182 exported) comprising seeds, tubers, bulbs, suckers, rhizomes, cuttings, seedlings and rooted plants of different crops and their wild relatives were received for quarantine clearance in the year 2000. These samples were examined visually, under high magnification and the seeds of plant

genera (suspected to carry hidden infestation) were exposed to X-ray radiography or rendered transparent to detect the infestation. Details of detection techniques used are as follows:

**Visual examination:** Seeds/planting materials were examined by naked eye or with the help of magnifiers. The external infestation was detected by presence of external symptoms of insect damage *i.e.* holes, rotting, swelling or any other deformity *etc.* or presence of dead or live insects/mites, eggs/egg shells, immature stages, exuviae or excreta thereof.

**X-ray radiography:** A total of 2,741 exotic seed samples of the plant genera known to carry hidden infestation of bruchids, chalcids and others were subjected to X-ray radiography. Seeds were arranged on paper and exposed to soft X-rays at 22 Kv, 3 mA for 15 seconds at the distance of 30 cm.

**Transparency technique:** Small seeds like grasses which are difficult to salvage through X-ray radiography, were rendered transparent by heating in lactophenol-acid fuchsin (phenol 2 parts, lactic acid 2 parts, glycerine 1 part, distilled water (hot) 2 parts, little acid fuchsin for detection of internal infestation (Kaura, 1959).

A thorough examination revealed that 1,746 samples were found infested with various insects and mites by using detection techniques *viz.*-visual examination (1,413), and X-ray radiography (333). The infested material was salvaged using one or more of the following treatments. **X-ray radiography:** On developing the X-ray film the infested seeds were distinguished and were hand-picked from the seed geometry and only healthy seeds were released (Wadhi, *et al.* 1967).

**Fumigation:** The seed material infested with external/surface feeding and most common stored grain insect pests was fumigated in an airtight container at normal air pressure. Ethylene dichloride carbon tetra chloride (EDCT) mixture @ 320 mg/l for 48 h or 640 mg/l for 24 h at 30°C and some specific fumigation schedules were used for effective eradication (Anonymous, 1985).

**Pesticidal dip/spray treatments:** Infested rooted plants, cuttings, tubers and other vegetatively propagated material were given dip/spray treatment with suitable insecticide/acaricide or a combination of both.

**Mechanical cleaning:** The seeds were cleaned mechanically by removing plant debris, deformed and shrivelled seeds by handpicking. Number of samples salvaged by various techniques given below.

**Table 1. Pests intercepted in the germplasm under exchange during 2000**

| Pest                         | Host                        | Source                                                                                   |
|------------------------------|-----------------------------|------------------------------------------------------------------------------------------|
| * <i>Bruchus ervi</i>        | <i>Lens culinaris</i>       | Syria, Chile, Greece, Iran, Lebanon, Italy, Germany, Morocco, Turkey, Russian Federation |
| <i>Bruchus dentipes</i>      | <i>Vicia faba</i>           | Syria                                                                                    |
| <i>Bruchus lentis</i>        | <i>Lens culinaris</i>       | Azerbaijan, Spain, Syria, Afghanistan                                                    |
| * <i>Bruchophagus gibbus</i> | <i>Medicago sativa</i>      | USA                                                                                      |
| <i>Bruchophagus mellipes</i> | <i>Sesbania</i> spp.        | Philippines                                                                              |
| <i>Sitophilus zeamais</i>    | <i>Zea mays</i>             | Philippines                                                                              |
| <i>Sitotroga cerealella</i>  | <i>Oryza sativa</i>         | Nepal                                                                                    |
| <i>Tribolium castaneum</i>   | <i>Pennisetum typhoides</i> | Nepal                                                                                    |
|                              | <i>Gypsophylla</i> spp.     | Israel                                                                                   |
| Aphids                       | <i>Punica</i> sp.           | USA                                                                                      |
| Bugs                         | <i>Punica</i> sp.           | USA                                                                                      |
|                              | <i>Prunus</i> sp.           |                                                                                          |
| Scales                       | <i>Juglans regia</i>        | USA                                                                                      |
| Mites                        | <i>Cassava</i> plants       | Vietnam                                                                                  |
|                              | <i>Gypsophylla</i>          | Israel                                                                                   |
|                              | <i>Juglans regia</i>        | USA                                                                                      |
| Immature forms               | <i>Acacia</i> spp.          | Australia                                                                                |

\* Pests not reported from India

Infested material was salvaged by employing the suitable disinfestation techniques/procedures *viz.*- X-ray radiography (333), fumigation (479), pesticidal dip/spray treatment (766) and mechanical cleaning (168).

In addition to salvaging of infested samples, 30092 samples were given prophylactic treatments *viz.*- 7707 seed samples were given prophylactic fumigation and 22385 samples of vegetative propagules were given pesticidal dip/spray.

The advantages of effective implementations of plant quarantine are clearly indicated by the number of important interceptions made during the period (Table 1). *Bruchus ervi*, (Coleoptera: Bruchidae) an important quarantine pest, not yet reported from India was intercepted in *Lens culinaris* from 11 countries and had been repeatedly intercepted from these countries. *Bruchophagus gibbus* (Hymenoptera: Chalcididae) is not yet known to occur in India was intercepted in *Medicago sativa* from USA. The quarantine significance of these two pests is further highlighted due to hidden nature of infestation. Other bruchids as *Bruchus dentipes*, *B. lentis*, and a chalcid, *Bruchophagus mellipes* also present a real quarantine risk being carried as latent infestation. Some of the serious pests *viz.*- *Sitophilus zeamais*, *Sitotroga cerealella* and

*Tribolium castaneum* though already known to occur from the country are important from quarantine viewpoint as of their being different strains.

#### References

- Anonymous (1985) *Plant Quarantine Treatment Manual*. USDA, USA.
- Ka'ra (1959) A new transparency method for detecting internal infestation in grains. *Grain Storage Newslett.* 1: 12.
- Mathur VK and Arjun Lal (eds.) (1996) *Plant Quarantine Activities at NBPGR 1976-1996*; *NBPGR Sci. Monogr.* 6: 96
- Wadhi SR, BR Verma, S Thomas and Rattan Lal (1967) Detection of *Phytophagous chalcidoids* in seeds for quarantine purpose. *Indian J. Ent.* 29: 197-199.

## Location-Specific Suitable Cultivars of Life-Supporting Crops

**DK Mishra, Vimla Sharma, BS Phogat and GD Sharma**

National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012

**Key Words:** Pseudo-cereals, Small millets, Ricebean, Horsegram, Niger

In spite of near food (rice and wheat) self sufficiency in the country, people living in tribal, hilly and backward areas do not have easy access to food and suffer from food and nutritional insecurity. On the other hand, pseudo-cereals, small millets, indigenous pulses, and oilseeds are the major source of sustenance to people in such areas. The tribal, hilly and backward areas are encapsulated with several physical, socio-economic and technical constraints. These include remoteness of the area, low economic viability and, in turn, low risk bearing capacity of the farmers. Small holding size, non-availability of location specific cultivars as well as techniques further add to the problems of farmers living in such areas. All these have been contributing to low productivity of crops. As a result, food and feed continues to be in short supply.

In view of an urgent need to enhance the production and productivity of different life support crop species, various activities viz.-varietal verification trials, quality seed production and front line demonstrations were undertaken under Programme-1 (Life supporting crops) of the Jai Vigyan National Science and Technology Mission on Household Food and Nutritional Security under NATP (National Agricultural Technology Project) in order to select location-specific suitable cultivars, make available quality seeds and also to popularize the improved cultivation techniques of crops under cultivation.

The programme is in operation at 11 selected centres namely – Palampur (Himachal Pradesh), Rudrapur, Almora (Uttaranchal), Imphal (Manipur), Umiam (Meghalaya), Ranchi (Jharkhand), Madhubani (Bihar),

Banswara (Rajasthan), Akola, Sangliwadi (Maharashtra) and Raipur (Chhatisgarh). Performance of crops viz.- grain amaranth, buckwheat (pseudocereals), finger millet, foxtail millet, kodo millet, proso/little millet (small millets), rice bean, horsegram (indigenous pulses) and niger (oilseeds) was studied during *kharif* season of year 2000, and based on the findings (grain yield data), two to three top ranking suitable varieties for each centre/location were selected, which are presented in this paper.

A total of 83 evaluation trials were conducted during *kharif* 2000, that included, grain amaranth (12), buckwheat (5), rice bean (11), horse gram (14), finger millet (18), foxtail millet (5), proso millet (5), little millet (4), kodo millet (4) and niger (5). In general, trials were allotted to each centre in pairs, so that one may be conducted on the research station and another in farmers' field for better exposure and participation of farmers from the initial stage itself. Trials were conducted in randomized block design (RBD) with three replications and recommended package of practices were adopted for each crop, details of which are presented in Table 1.

Grain yield data obtained from varietal trials conducted at different locations were analysed to find the suitability of cultivars for a particular location. Centre-wise performance of crops/varieties are as follows:

**Palampur:** In grain amaranth, Annapurna (11.67 q/ha) at Salooni and PRA 9401 (9.33 q/ha) at Sangla were found more suitable than other varieties. Sangla B-1 (29.40 q/ha) variety of buckwheat recorded the highest

*Tribolium castaneum* though already known to occur from the country are important from quarantine viewpoint as of their being different strains.

#### References

- Anonymous (1985) *Plant Quarantine Treatment Manual*. USDA, USA.
- Ka'ra (1959) A new transparency method for detecting internal infestation in grains. *Grain Storage Newslett.* 1: 12.
- Mathur VK and Arjun Lal (eds.) (1996) *Plant Quarantine Activities at NBPGR 1976-1996*; *NBPGR Sci. Monogr.* 6: 96
- Wadhi SR, BR Verma, S Thomas and Rattan Lal (1967) Detection of *Phytophagous chalcidoids* in seeds for quarantine purpose. *Indian J. Ent.* 29: 197-199.

## Location-Specific Suitable Cultivars of Life-Supporting Crops

**DK Mishra, Vimla Sharma, BS Phogat and GD Sharma**

National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012

**Key Words:** Pseudo-cereals, Small millets, Ricebean, Horsegram, Niger

In spite of near food (rice and wheat) self sufficiency in the country, people living in tribal, hilly and backward areas do not have easy access to food and suffer from food and nutritional insecurity. On the other hand, pseudo-cereals, small millets, indigenous pulses, and oilseeds are the major source of sustenance to people in such areas. The tribal, hilly and backward areas are encapsulated with several physical, socio-economic and technical constraints. These include remoteness of the area, low economic viability and, in turn, low risk bearing capacity of the farmers. Small holding size, non-availability of location specific cultivars as well as techniques further add to the problems of farmers living in such areas. All these have been contributing to low productivity of crops. As a result, food and feed continues to be in short supply.

In view of an urgent need to enhance the production and productivity of different life support crop species, various activities viz.-varietal verification trials, quality seed production and front line demonstrations were undertaken under Programme-1 (Life supporting crops) of the Jai Vigyan National Science and Technology Mission on Household Food and Nutritional Security under NATP (National Agricultural Technology Project) in order to select location-specific suitable cultivars, make available quality seeds and also to popularize the improved cultivation techniques of crops under cultivation.

The programme is in operation at 11 selected centres namely – Palampur (Himachal Pradesh), Rudrapur, Almora (Uttaranchal), Imphal (Manipur), Umiam (Meghalaya), Ranchi (Jharkhand), Madhubani (Bihar),

Banswara (Rajasthan), Akola, Sangliwadi (Maharashtra) and Raipur (Chhatisgarh). Performance of crops viz.- grain amaranth, buckwheat (pseudocereals), finger millet, foxtail millet, kodo millet, proso/little millet (small millets), rice bean, horsegram (indigenous pulses) and niger (oilseeds) was studied during *kharif* season of year 2000, and based on the findings (grain yield data), two to three top ranking suitable varieties for each centre/location were selected, which are presented in this paper.

A total of 83 evaluation trials were conducted during *kharif* 2000, that included, grain amaranth (12), buckwheat (5), rice bean (11), horse gram (14), finger millet (18), foxtail millet (5), proso millet (5), little millet (4), kodo millet (4) and niger (5). In general, trials were allotted to each centre in pairs, so that one may be conducted on the research station and another in farmers' field for better exposure and participation of farmers from the initial stage itself. Trials were conducted in randomized block design (RBD) with three replications and recommended package of practices were adopted for each crop, details of which are presented in Table 1.

Grain yield data obtained from varietal trials conducted at different locations were analysed to find the suitability of cultivars for a particular location. Centre-wise performance of crops/varieties are as follows:

**Palampur:** In grain amaranth, Annapurna (11.67 q/ha) at Salooni and PRA 9401 (9.33 q/ha) at Sangla were found more suitable than other varieties. Sangla B-1 (29.40 q/ha) variety of buckwheat recorded the highest

**Table 1. Varieties of selected crops and their cultivation practices adopted**

| Crops          | Plot size (m <sup>2</sup> ) | Manuring<br>NPK kg/ha | Spacing (cm) | Varieties                                                                                                  |
|----------------|-----------------------------|-----------------------|--------------|------------------------------------------------------------------------------------------------------------|
| Grain amaranth | 2.50 x 4.0                  | 40:40:20              | 50 x 15      | Annapurna, Suvarna, GA-1, GA-2, PRA-1, PRA-9401 and Local (Check)                                          |
| Buckwheat      | 3.0 x 3.0                   | 40:40:20              | 30 x 10      | Himpriya, VL Ugal-7, Sangla B-1, OC-2, Kuppa, Kamroo and Local (Check)                                     |
| Finger millet  | 2.25 x 3.0                  | 50:40:25              | 22.5 x 7.5   | VL-146, VL-149, VL-204, Pant Madua 3, HR 374, RAU-8, PRR-202, A-404 and Local (Check)                      |
| Foxtail millet | 2.25 x 3.0                  | 40:40:0               | 22.5 x 7.5   | SR 11, SR 15, SR 16, PRK-1, SIA-326, PS 4 and Local (Check)                                                |
| Kodo millet    | 2.25 x 3.0                  | 40:40:0               | 22.5 x 7.5   | GPUK-3, JK 76, JK 41, RBK-155 and Local (Check)                                                            |
| Proso millet   | 2.25 x 3.0                  | 40:40:0               | 22.5 x 7.5   | K-1, GPUP-15, GPUP-16, RAUM 14 and Local (Check)                                                           |
| Little millet  | 2.25 x 3.0                  | 40:40:0               | 22.5 x 7.5   | CO-2, PRC-3, JK 8, BG-1 and Local (Check)                                                                  |
| Rice bean      | 3.0 x 3.0                   | 40:40:0               | 30 x 15      | RBL-1, RBL-6, PRR-1, PRR-2, MNPL-1, MNPL-2, MNPL-3, Naini, BRS-2, Chaukhamba and Local (Check)             |
| Horsegram      | 4.0 x 2.50                  | 40:40:10              | 25 x 10      | Birsa Kulthi-1, BGM-1, Maru Kulthi, VL Gehat-1, PHG-9, AK 21, Bastar black, Bastar white and Local (Check) |
| Niger          | 3.6 x 4.0                   | 20:40:20              | 30 x 10      | Ootakamund, IGP 76, GA-5, GA-10 and Local (Check)                                                          |

grain yield. In case of rice bean, RBL-6 (10.89 q/ha) and BRS-2 (10.44 q/ha) at Palampur and Chaukhamba (8.52 q/ha) at Salooni were found to be high yielding varieties. Experimental findings at HPKV Farm, Palampur revealed that VL Gehat-1 (4.43 q/ha) variety of horsegram is suitable under Palampur conditions.

**Rudraprayag:** Grain amaranth varietal trial conducted in the farmers' field at Budhna revealed that Annapurna (16.11 q/ha) is the most suitable variety, followed by Suvarna (15.45 q/ha). In case of buckwheat, Sangla B-1 (17.37 q/ha) was found to be superior over rest of the varieties at Rudraprayag. PRK-1 (11.70 q/ha) and SR 15 (10.71 q/ha) varieties of foxtail millet recorded higher grain yield than the local check (10.56 q/ha).

Out of the 11 varieties of rice bean tested, PRR-2 (8.08 q/ha) was found to be superior to other varieties, however, the yield of other varieties differ non-significantly (6.0 to 8.08 q/ha). In case of horsegram, the highest grain yield (7.27 q/ha) was recorded from Birsa Kulthi-1.

**Almora:** Experimental findings revealed that Annapurna variety of grain amaranth is suitable for both the locations i.e. Hawalbagh and Souni, whereas Suvarna at Hawalbagh and PRA-1 at Souni was found to be also equally suitable. In case of buckwheat variety VL Ugal-7 (3.89 q/ha) at Hawalbagh; and Sangla B-1 (10.66 q/ha) and Himpriya

(9.76 q/ha) at Souni were found to be superior over rest of the varieties. Finger millet varieties VL-146 (43.33 q/ha) and VL-149 (18.87 q/ha) was found to be suitable for Hawalbagh and Karikhet locations, respectively. VL Gehat-1 and local check of horsegram was found to be equally suitable for both the locations.

**Imphal:** Varietal trial of finger millet conducted at Langol hill revealed that PR 202 (12.20 q/ha) is the most suitable variety followed by VL-149 (9.73 q/ha). In case of rice bean, the local selections namely MNPL-1, KNPL-2 and MNPL-3, proved to be high yielding than rest of the varieties.

**Umiam:** In finger millet, local varieties recorded highest grain yield at two locations namely Umiam (29.15 q/ha) and Uden Mission (28.87 q/ha), whereas at Jorhat Pant Madua 3 (21.13 q/ha) and VL 149 (21.08 q/ha) were found to be higher grain yielders. At Umiam, varieties HR-374, RAU-8 and PRR 202 recorded similar yields i.e. 28.04 q/ha. In rice bean, a local selection namely RCRB-1-6 recorded the highest yields (23.70 to 27.88 q/ha) among the varieties under trial.

**Ranchi:** Finger millet varieties PR 202 and A-404 were found to be suitable at both the locations namely - Ranchi and Dumka. BG-1 (1.90 q/ha) variety of little millet and Birsa Kulthi-1 (11.33 q/ha) of horsegram was found to be suitable at Ranchi location. In case of niger, varieties

Ootakamund (3.99 q/ha) and IGP 76 (3.71 q/ha) were found to be superior at Ranchi and Dumka locations respectively.

**Madhubani:** Grain yield data of grain amaranth varieties were recorded at Simarkon and Chanpura locations. PRA 9401 (5.15 q/ha) and Suvarna (7.40 q/ha) was found to be suitable at Simarkon and Chanpura, respectively. In case of finger millet, variety A-404 (15.80 q/ha) and RAU 8 (14.98 q/ha) was found suitable at both the locations. PRR-1 (10.21 q/ha) and SR 11 (9.33 q/ha) variety of foxtail millet recorded higher grain yield than other varieties. In proso millet, variety K-1 (10.65 q/ha) and GPUP 15 (10.59 q/ha) at Simarkon and GPUP 15 (10.70 q/ha) and K-1 (10.48 q/ha) at Chanpura were found to be high yielding varieties. Bastar white and Bastar black varieties of horsegram performed better than other varieties.

**Banswara:** Experimental findings on varietal trials of finger millet revealed that HR 374 (20.92 q/ha) and Pant Madua (20.87 q/ha) at Pratapgarh and PR 202 (6.91 q/ha) and HR 374 (6.67 q/ha) at Banswara are suitable varieties. In foxtail millet varieties such as SR 16 (11.46 q/ha) at Banswara and SR 11 (11.35 q/ha) and SR 16 (10.71 q/ha) were found to be high yielding. At Banswara location K-1 (7.41 q/ha) and RAUM 14 (7.16 q/ha) varieties of proso millet were found to be suitable, whereas at Pratapgarh local cultivar gave higher grain yield (16.03 q/ha) than other varieties. In horsegram, AK-21 (7.50 q/ha) proved its superiority over rest of the varieties.

**Akola:** Trials conducted at Agricultural Research Station, Achalpur, revealed that varieties Suvarna (4.50 q/ha) of Amaranth, VL-146 (18.49 q/ha) of finger millet, GPUK-3 (19.08 q/ha) and JK 76 (17.85 q/ha) of kodo millet, GPUP-16 (6.87 q/ha) and K-1 (6.42 q/ha) of proso millet and CO-2 (8.15 q/ha) of little millet are suitable under Achalpur conditions. In farmers' field similar trends were observed in finger millet VL 146 (0.69 q/ha) at Chandpur and kodo millet [GPUP-3 (0.21 q/ha); JK 76 (0.15 q/ha)] at Daramdoh, but the yields were very low, which might be attributed to acute water stress conditions. In case of grain amaranth, Annapurna (4.17 q/ha) was found to be superior over rest of the varieties.

**Sangliwadi:** In grain amaranth PRA 9401 (14.03 q/ha),

RBL 6 (20.46 q/ha) of ricebean AK 21 (7.44 q/ha) of horsegram at Wajegaon; finger millet variety RAU 8 (14.81 q/ha) and GA-10 (4.53 q/ha) of niger at Panchgani were found to be suitable.

**Raipur:** Little millet variety BG-1 recorded higher yield and Ambikapur (5.29 q/ha) as well as Jagdalpur (4.54 q/ha) locations. Similarly JK 41 (Kodo millet) was equally suitable for both the locations. In case of horsegram, Birsa Kulthi-1 at Ambikapur and Bastar black at Jagdalpur was found high yielding than other varieties but the yields were very low. GA-5 (2.55 q/ha) of niger recorded higher yield at Ambikapur, whereas at Jagdalpur, local check yielded higher than other varieties.

In grain amaranths, variety Annapurna and Suvarna were found suitable for most of the locations. Buckwheat varieties Sangla B-1 and VL-Ugal-7 had wider adaptation. Finger millet varieties VL-146 and VL-149 were found to be suitable in the hills whereas PR 202, A-404, RAU-8 etc. in the plains. In foxtail millet SR-16, recorded the best average yield, whereas JK-41 in kodo millet GPUP-15 in proso millet and BG-1 in little millet were found to be superior varieties.

In rice bean local cultivars namely RCRB-1-6 at Umiam and MNPL cultivars in the high rainfall areas of Manipur (Imphal), were found to be superior. Horsegram varieties, VL-Gehat-1, AK-21, and Bastar white performed equally well when the overall mean yield was taken into account.

Finally, it can be concluded that performance of varieties differs from one location to another, hence for increasing the production and productivity of crops in tribal, hilly and backward areas such location-specific trials are highly useful for selecting improved varieties suitable for a particular location.

**Acknowledgements:** The authors are highly thankful to the CCPIs and others involved in conduct of trials at all the 11 centres. Financial support received from Jai Vigyan National Science and Technology Mission (NATP) is also duly acknowledged.

## Reference

Annual Progress Report (2000-01) Jai Vigyan-NATP-Project on Household Food and Nutritional Security "Increasing Production and Productivity of Life Support Crop Species and Allied Enterprises of Tribal, Backward and Hilly Areas" (Programme-1-Crop Science), NBPGR, New Delhi.

## Eradication of Corn Cyst Nematode (*Heterodera zae*) from Vetiver Germplasm for its Safe Exchange

**Rajan and Arjun Lal**

Nematology Unit, Division of Plant Quarantine, National Bureau of Plant Genetic Resources, New Delhi-110012

**Key Words:** Corn Cyst Nematode, *Heterodera zae*, Hot Water Treatment, Quarantine Treatment, *Vetiveria zizanioides*

Vetiver (*Vetiveria zizanioides* L.), popularly known as Khas is a tall perennial grass cultivated in several parts of North and South India. Its spongy, much branched fine rootlets contain fragrant oil, which is in great demand by the perfumery industry. The dried aromatic roots are also used to make curtains and mats for desert air coolers. The roots emit scented aroma along with the cool air when moistened. Due to these qualities vetiver is in great demand and exported to several countries in the form of rooted cuttings (saplings) for cultivation. It has been reported to be a good host of *Heterodera zae* (Arjun Lal and Mathur, 1982). Because of this, there had been persistent problem in exchanging "nematode free" planting material.

So far no treatment has been reported to completely eliminate *H. zae* from infested vetiver roots. Therefore, the present study was undertaken with the objective of finding a treatment (thermal or chemotherapeutic), which would be effective from quarantine point of view.

Vetiver plants infested with *H. zae* were collected from NBPGR experimental farm, Issapur, Delhi. Roots were gently washed under running water to remove adhering soil. After cutting about 2/3 of the shoots all the rooted cuttings were thoroughly mixed and then six of these were picked randomly for each of the treatments and associated checks. Randomly drawn root sample showed nematode inoculum @ six nematodes/gram of root (including second and third juvenile stages).

For hot water treatment, the root systems were immersed in a thermostatically controlled hot water bath for 15 and 30 min. at 47, 50 and 53°C. For associated check, the rooted cuttings were dipped in tap water at room temperature (23°C). For nematicidal dip treatment, the roots were dipped in aqueous solutions of Dimethioate, Rogor, Formalin, Nemagon, Nema-cur, Sodium hypochlorite in concentrations of 500, 1000 and 1500 ppm except in sodium hypochlorite for 15 and 30 min. Concentrations of sodium hypochlorite used were 10, 20 and 40 ml/litre of water. In control, the roots were

dipped in tap water. At completion of the dip treatment, the roots were pressed between filter papers so that excess of pesticide on the roots is removed.

Following hot water or nematicidal dip treatments, the cuttings were planted in plastic pots having nematode-free soil. The pots were maintained in open. After four months of transplanting the root system of each plant and the soil around was examined for cysts and second stage juveniles. Roots were also stained to confirm the absence of juveniles wherever required.

Following the treatments of vetiver roots, all the leaves turned yellow and drooped immediately. Only during the rainy season (two months after the treatment) new green leaves started emerging in between the dead leaves. Even the highest tested temperature 53°C for 30 min. was not deleterious to revival under the experimental conditions. Immersion of vetiver plant root system for 15 min. in a water bath maintained at 50°C eradicated *H. zae* and did not adversely affect subsequent plant growth. The ability of plant roots to withstand temperatures that are lethal to *H. zae* provides a means of nematode elimination from the germplasm.

An exposure of roots to 1500 ppm of Dimethioate was effective in eradicating nematodes and dipping them for 30 min. resulted in death due to phytotoxicity. Treatment-wise detailed results are presented in Table 1. Bare root dips for 15 or 30 min. in 500 ppm Formalin or Nemagon were not injurious to plants and at the same time not effective in eliminating *H. zae*. Higher concentrations or longer exposure period of the same chemicals were phytotoxic except Nemagon-1000 ppm for 15 min. which was effective and non-phytotoxic. Only highest concentration tested for Nema-cur (30 min.) and sodium hypochlorite for 15 or 30 min. was effective.

The number of *H. zae* cysts in roots was significantly reduced with different tested treatments, when compared with control. The purpose of the present study was to achieve complete nematode control without any damage

**Table 1. Effect of different treatments on the survival and multiplication of *H. zae* on vetiver roots**

| Treatment                      | Number of cysts formed |       |
|--------------------------------|------------------------|-------|
|                                | A                      | B     |
| Hot water treatment at 47 °C   | 29.75                  | 7.75  |
| Hot water treatment at 50 °C   | 0                      | 0     |
| Hot water treatment at 53 °C   | 0                      | 0     |
| Dimethioate-500 ppm            | 24.25                  | 6.25  |
| Dimethioate-1000 ppm           | 6.5                    | 4.00  |
| Dimethioate-1500 ppm           | 0                      | P     |
| Rogor-500 ppm                  | 34.75                  | 26.00 |
| Rogor-1000 ppm                 | 17.25                  | 6.50  |
| Rogor-1500 ppm                 | 2.00                   | 0     |
| Formalin-500 ppm               | 19.0                   | 6.50  |
| Formalin-1000 ppm              | P                      | P     |
| Formalin-1500 ppm              | P                      | P     |
| Nemagon-500 ppm                | 40.25                  | 18.00 |
| Nemagon-1000 ppm               | 0                      | P     |
| Nemagon-1500 ppm               | P                      | P     |
| Nemacur-500 ppm                | 40.50                  | 31.75 |
| Nemacur-1000 ppm               | 36.00                  | 12.5  |
| Nemacur-1500 ppm               | 3.75                   | 0     |
| Sodium hypochlorite-10 ml/l    | 43.50                  | 33.50 |
| Sodium hypochlorite-20 ml/l    | 32.25                  | 32.0  |
| Sodium hypochlorite-40 ml/l    | 32.0                   | 31.25 |
| Sodium hypochlorite-commercial | 0                      | 0     |
| Check                          | 50.00                  | —     |

Each figure under the number of cysts formed is average of six replicates.

A=After 15 min. of treatment; B=After 30 min. of treatment; P=Phytotoxic

to vetivers, therefore statistical analysis was not necessary to compare efficiency of different treatments.

Soaking bare roots for 15 or 30 min. in commercially available sodium hypochlorite, resulted in eradication of nematode without any adverse effect on the plants. The disruptive effects of sodium hypochlorite on many nematode genera, including effects on cysts of soybean

and potato cyst nematode are known (Esser, 1972; Wood and Foot, 1975). At very low concentrations, the chemical has been used to disperse eggs from egg masses and to surface sterilize eggs of root knot nematode (McClure *et al.* 1973; Hussey and Barker, 1973).

The results from the dip treatments tested indicate that eradication can be achieved with a thermotherapy as low as 50°C for 15 min. or with 1000 ppm Formalin, Nemagon for 15 min. or with 1500 ppm Dimethioate, Nemacur for 15 or 30 min., respectively. No phytotoxic injuries resulted from any of these treatments.

From the foregoing observations it can be concluded that the corn cyst nematode, *Heterodera zae* was completely eliminated from infested vetiver (*Vetiveria zizanioides*) roots by giving either of the following treatments viz.-hot water treatment at 50°C for 15 min. or dipping the roots for 15 min. in Dimethioate (1500 ppm) or Nemagon (1000 ppm) or sodium hypochlorite (commercial) or for 30 min. in Rogor (1500 ppm). In all the treated plants, including check, new leaves emerged showing establishment of plants after 60 days of transplanting in sterilized soil. Examination of the roots and soil after four months of some of the treatments did not reveal any cyst or juvenile thus making it safe from quarantine point of view to exchange vetiver germplasm.

## References

- Arjun Lal and VK Mathur (1982) Occurrence of *Heterodera zae* on *Vetiveria zizanioides*. *Indian J. Nematol.* **12**: 405-407.
- Esser RP (1972) Effect of sodium hypochlorite concentration on selected genera of nematodes. *Proc. Helminth. Soc. Washington* **8**: 185-190.
- Hussey RS and KR Barker (1973) A comparison of methods of collecting inocula of *Meloidogyne* spp. including a new technique. *Plant Disease Reporter* **57**: 1025-1028.
- McClure MA, TH Kruk and Misaghi (1973) A method for obtaining quarantines of potato cyst nematode: a note. *New Zealand J. Exp. Agric.* **3**: 349-350.
- Wood FH and MA Foot (1975) Treatment of potato cyst nematode: a note. *New Zealand. J. Exp. Agric.* **3**: 349-350.

## Chilli and Cucurbits Germplasm Collection from Barak Valley, Assam

Atiqur Rahman Barbhuiya and GD Sharma

Department of Life Science, Assam University, Silchar-788011, Assam

Barak Valley of Southern Assam is very rich in chilli and cucurbits germplasm. Chillies and cucurbits are commercially grown in winter and summer seasons respectively. Besides, these two crop groups are also grown in small scale in home gardens throughout the year. Cachar, Karimganj and Hailakandi districts of South Assam constitute Barak valley. The soil of the area is mixture of alluvial, sandy loam, muddy-loam, loam, clay, superimposed upon stones, grands and conglomerates and the soil pH ranges from 4.5 to 8.5.

The collection and study of chillies and cucurbits of Barak valley were done by block wise categorisation during the specific growing season through regular visits in the farmers' fields and interaction with farmers, housewives of the villages of the blocks Silchar, Sonai, Lakhimpur, Banskandi, Udharbond, Binnakandi, Borjalenga under Cachar District, South Karimganj and North Karimganj of Karimganj District and Algapur and Hailakandi of Hailakandi District to get information on the cultivation practice, yield, fruit size variation, fruiting behaviour, fruit colour, etc.

An exploration for the collection of local diversity in chillies and cucurbits were taken in Barak Valley in 2000-2001. Sixty-eight and 92 accessions of chillies and cucurbits, respectively were collected. A wide range of variability was observed. In case of chillies considerable variability was observed for plant height (short creeping type to 1.5m height), leaf-colour (green to pinkish and black), fruiting behaviour (single or clustered and upwards and downwards), immature fruit colour (white, green, black, pink, milky etc.), mature fruit colour (green, red, rough-red etc.), fruit length (0.7 cm to 7.3 cm), fruit circumference (0.9 cm to 23.6 cm), very heavy fruiting to very few and less pungent to very highly pungent types. In cucurbits, mainly fruit size variation *i.e.* length, breadth and circumference was observed along with the other characteristics like plant stem character – plain stem/squared stem, etc. leaf colour, fruit colour, number of ridges in fruits etc. In both the crop-groups very high incidence of viral disease (fruit rot) has been observed at most of the sites of collection.

Table 1. Germplasm of curcubits and chilli collected from Barak Valley

| Crop         | Local name           | Botanical name                   | No. of germplasm collected |
|--------------|----------------------|----------------------------------|----------------------------|
| Cucurbits    | Chalkodu/Panilau     | <i>Lagenaria vulgaris</i>        | 20                         |
|              | Aukodu/Misthilau     | <i>Cucurbita moschata</i>        | 31                         |
|              | Chalkumra/Jara Kumra | <i>Cucurbita pepo</i>            | 10                         |
|              | Sasha/Khira          | <i>Cucumis sativus</i>           | 07                         |
|              | Tita Karela          | <i>Momordica charantia</i>       | 04                         |
|              | Kakrol               | <i>Momordica cochinchinensis</i> | 03                         |
|              | Purol                | <i>Luffa cylindrica</i>          | 01                         |
|              | Jhinga               | <i>Luffa acutangula</i>          | 03                         |
|              | Chirchinga           | <i>Trichosanthes anguina</i>     | 03                         |
|              | Chinar               | <i>Cucurbita</i> sp.             | 06                         |
|              | Sareash              | <i>Sechium edule</i>             | 02                         |
|              | Pyarilau             | <i>Cucurbita</i> sp.             | 02                         |
| Chilli       | Gul Morich           | <i>Capsicum frutescens</i>       | 27                         |
|              | Lamba Morich         | <i>Capsicum annum</i>            | 41                         |
| <b>Total</b> |                      |                                  | <b>160</b>                 |

## Exploration for the Collection of Niger (*Guizotia abyssinica* (L.f.) Cass) Germplasm from Patalkoat and Satpura Vallies in Madhya Pradesh

**KMS Raghuvanshi and SS Duhoon**

All India Coordinated Research Project on Sesame and Niger, Jawaharlal Nehru Krishi Vishwa Vidyalaya Campus, Jabalpur-482004, Madhya Pradesh

**Key Words:** Collection, Niger, Madhya Pradesh

Niger (*Guizotia abyssinica* L.f. Cass) has been grown mostly in Ethiopia and India for millennia as an oilseed crop. The genus *Guizotia*, family Compositae (Syn. *Asteraceae*), tribe Helianthae, subtribe *Coreopsidinae*, is native of tropical Africa (Baagoe, 1974) and the cultivated niger may have been taken from Ethiopia to India by traders probably in the third millennium BC along with other crops such as finger millet (Doggett, 1987). India is also considered as the centre of diversity and origin of niger. Baagoe (1974) raised four points about the origin of niger; first the highest concentration of *Guizotia* species is in Ethiopia; second, *G. abyssinica* can also be collected from the natural habitat; third, the similarity of the distribution of niger with that of other cultivated crops and fourth, the historical trade between Ethiopia and India. This would suggest that niger is not native to India and may have been taken from Ethiopia to India by traders.

India is the largest producer and exporter of niger. It is cultivated in Andhra Pradesh, Madhya Pradesh, Orissa, Maharastra, Bihar, Karnataka, Nagar Haveli and West Bengal states of India of which Madhya Pradesh is the largest. Several authors have reported the variability of Niger in India. Immense variability for important traits existed in the surveyed area of Satpura valley. Local native types of niger still constitute a rich reservoir of under-utilized diversity awaiting exploitation. The collection maintained in the germplasm repositories in India, do not represent the wide genetic diversity and some pockets of the country are not represented. Many of these collections are either sporadic or confined to roadsides.

Under NATP on Plant Biodiversity, the collection of niger germplasm was made from so far unexplored tribal pockets in Patalkoat vallley and parts of Satpura valley in Betul and Chhindwara districts of Madhya Pradesh, by the Project Coordinating Unit (Sesame and Niger), Jawaharlal Nehru Krishi Vishwa Vidyalaya Campus, Jabalpur (MP) from 14<sup>th</sup> to 25<sup>th</sup> December

2000. A total of 103 germplasm samples of niger were collected from about the same number of sites in different habitats ranging from undulating plains to hill slopes, valley (like Patalkoat) and tops (like Kalapaharh) lying between 77.2° to 79.1°E longitude and 21.3 to 22.9°N latitude. Niger is the most suitable crop for hill regions of high rainfall and humidity in India.

In all, 103 samples included the diversity in niger, 70 of which represented from Chhindwara and 33 from Betul district of Madhya Pradesh. Random method of sampling with coarse grid survey was followed for the collection of samples mainly from farmers' field, threshing yards and farm stores which represented mainly the primitive local types. The variability in germplasm was represented mainly by the small capitulate and small seeded types varying in plant height, stem colour (purple, green and intermediate types with and without blotches), number of branches and number of capitula/plant, number of seed/capitulum, leaf size and shape. The small seeded type is vernacularly known as *jagni* and the bold seeded type is *jagna* in the surveyed area.

The surveyed area is inhabited by *Gond*, *Korku*, *Gwali*, *Bharia* and other tribes who are growing niger as an oilseed crop, from the ancient times for their domestic requirement. In Patalkot valley niger is the only source for the tribes to earn some money. The crop is grown during July to January. Generally sowing starts with the onset of monsoon in July and continues up to September depending upon the availability of moisture. In Patalkot valley the sowing is mainly done after the completion of rainy season with the retained moisture on the hill slopes and tops to prevent the seed to drain out with the rain. Most of the fields are full of stones and the only way of sowing is broad casting. Due to this kind of late sowing in the valley the crop stands in the minimum day length period. The maximum height of the niger plant is of about 2 feet. Before 3-4 years, only shifting cultivation was in practice in

the valley but not so now. By and large the cultivation is done with very low inputs and rarely with proper inputs and care, generally in those fields where other crops cannot be grown. Because of this reason, niger has great significance for the tribal people who can hardly afford the costly inputs.

The surveyed area is the highly dense forest of Satpura valley. This year the valley is facing a severe drought because of which the farmers' fields are affected severely. Niger oil is used for cooking, lighting, anointing, painting, cleaning machinery, pharmaceutical purposes

and soap making. In Patalkot valley niger is the main cash crop. It is also a major part of their diet. With corn or mahua the niger is dry fried and after mixing thoroughly the tribals use this as a unique dish.

#### References

- Baagoe J (1974) The genus *Guizotia* (*compositae*) A taxonomic revision. *Bot. Tidsskrift*. **69**: 1-39.
- Doggett H (1987) Niger/Noug research methodology in oil crops: Niger and Rapeseed/Mustard. In *Proceed. Third Oil Crops Network Workshop, Addis Ababa, Ethiopia*, A. Omran (ed.). IDRC-MR 153e.

## Development and Management of DNA Fingerprinting Database

**Madhu Bala**

National Research Centre (NRC) on DNA Fingerprinting, National Bureau of Plant Genetic Resources, New Delhi-110012

**Key Words:** Database, Storage, Retrieval, DNA fingerprinting

DNA Fingerprinting technique provides unequivocal evidences for identification of specific genotypes. Enormous amount of DNA characterization data is generated during fingerprinting experimentation, which is difficult to manage manually. Large amount of molecular data is being generated at NRC on crop varieties and genetic stocks. But, there is no relevant computer software available to store and retrieve the data for comparison and analysis. Thus, it was found necessary to develop an application software to store this valuable information and to develop a retrieval system to access the information from the database.

Information Retrieval System is developed at NRC on DNA fingerprinting. This system is made in MS-Access 2000. The system can store as well as retrieve information from the data. Presently, this database is having data on banana, tomato, chillies and barley.

Following profile tables are available with this database.

1. Banana crop with AFLP technique. It has 107 varieties with 9 primers.
2. Chillies crop with ISSR technique. It has 38 varieties with 4 primers.
3. Tomato crop with RAPD technique. It has 30 varieties with 42 primers.

4. Barley crop with RAPD technique. It has 50 varieties with 20 primers.

**Storage system:** (1) Data entry form : This option is put in the database to enter new data. The various fields of the data entry form are – crop, family technique genus, species, subspecies variety, source, accession number, primer, NRC-id number, pedigree, and other details, (2) profile table of each crop, (3) morphological trait, (4) various gel pictures of different markers.

**Retrieval system:** Retrieval system of the database has six different choice options. They can be used to submit the choice of user in the database. These choice options are crop, technique, primer, variety, accession number and source.

1. *Open and modify profile table:* This option can be used to view profile table and also to modify it.
2. *Search:* This option is used to get detailed information of particular variety. Search option will present all the necessary information regarding the variety. This option can also inform about the presence, absence and total number of bands of particular variety.
3. *Jaccard's coefficients:* This is the most important option of the database. Jaccard's coefficients is able to give us report showing number of bands matched

the valley but not so now. By and large the cultivation is done with very low inputs and rarely with proper inputs and care, generally in those fields where other crops cannot be grown. Because of this reason, niger has great significance for the tribal people who can hardly afford the costly inputs.

The surveyed area is the highly dense forest of Satpura valley. This year the valley is facing a severe drought because of which the farmers' fields are affected severely. Niger oil is used for cooking, lighting, anointing, painting, cleaning machinery, pharmaceutical purposes

and soap making. In Patalkot valley niger is the main cash crop. It is also a major part of their diet. With corn or mahua the niger is dry fried and after mixing thoroughly the tribals use this as a unique dish.

#### References

- Baagoe J (1974) The genus *Guizotia* (*compositae*) A taxonomic revision. *Bot. Tidsskrift*. **69**: 1-39.
- Doggett H (1987) Niger/Noug research methodology in oil crops: Niger and Rapeseed/Mustard. In *Proceed. Third Oil Crops Network Workshop, Addis Ababa, Ethiopia*, A. Omran (ed.). IDRC-MR 153e.

## Development and Management of DNA Fingerprinting Database

**Madhu Bala**

National Research Centre (NRC) on DNA Fingerprinting, National Bureau of Plant Genetic Resources, New Delhi-110012

**Key Words:** Database, Storage, Retrieval, DNA fingerprinting

DNA Fingerprinting technique provides unequivocal evidences for identification of specific genotypes. Enormous amount of DNA characterization data is generated during fingerprinting experimentation, which is difficult to manage manually. Large amount of molecular data is being generated at NRC on crop varieties and genetic stocks. But, there is no relevant computer software available to store and retrieve the data for comparison and analysis. Thus, it was found necessary to develop an application software to store this valuable information and to develop a retrieval system to access the information from the database.

Information Retrieval System is developed at NRC on DNA fingerprinting. This system is made in MS-Access 2000. The system can store as well as retrieve information from the data. Presently, this database is having data on banana, tomato, chillies and barley.

Following profile tables are available with this database.

1. Banana crop with AFLP technique. It has 107 varieties with 9 primers.
2. Chillies crop with ISSR technique. It has 38 varieties with 4 primers.
3. Tomato crop with RAPD technique. It has 30 varieties with 42 primers.

4. Barley crop with RAPD technique. It has 50 varieties with 20 primers.

**Storage system:** (1) Data entry form : This option is put in the database to enter new data. The various fields of the data entry form are – crop, family technique genus, species, subspecies variety, source, accession number, primer, NRC-id number, pedigree, and other details, (2) profile table of each crop, (3) morphological trait, (4) various gel pictures of different markers.

**Retrieval system:** Retrieval system of the database has six different choice options. They can be used to submit the choice of user in the database. These choice options are crop, technique, primer, variety, accession number and source.

1. *Open and modify profile table:* This option can be used to view profile table and also to modify it.
2. *Search:* This option is used to get detailed information of particular variety. Search option will present all the necessary information regarding the variety. This option can also inform about the presence, absence and total number of bands of particular variety.
3. *Jaccard's coefficients:* This is the most important option of the database. Jaccard's coefficients is able to give us report showing number of bands matched

and number of bands unmatched between two varieties. It also informs about the presence and absence of marker in a particular profile table. It informs about the primer and its variety showing minimum coefficient in comparison with all the other primers in the list.

**Functions:** (1) Calculates Jaccard's coefficients between two varieties; (2) calculates Jaccard's coefficients primer wise. In this case all the varieties of one primers are compared with all the varieties of other primer; (3) calculates Jaccard's coefficients with total markers.

In this case one variety is compared with other variety irrespective of primer.

The report generated by Jaccard's coefficient has following fields: crop, technique, variety, primer, total number of records compared, field 1, field 2, availability of field1, availability of field2, matched bands, unmatched bands, Jaccard's coefficients.

**Print report:** This option is used to get the detailed report. It can be used to get crop-wise, technique-wise, primer-wise, variety-wise information. It could also give report, if the choice is in combination.

## Exploration for the Collection of Sesame (*Sesamum indicum* L.) Germplasm from Central Narmada Valley in Madhya Pradesh

**KMS Raghuwanshi and SS Duhoon**

All India Coordinated Research Project on Sesame and Niger, Jawaharlal Nehru Krishi Vishwa Vidyalaya Campus, Jabalpur-482004, Madhya Pradesh

**Key Words:** Collection, Sesame, Madhya Pradesh

Sesame (*Sesamum indicum* L. syn. *S. orientale* L.) is one of the oldest oilseed crops and is under cultivation from ancient times (Joshi, 1961; Weiss, 1971). It is regarded as the "queen of oilseeds". probably because of its oil (about 50% of seed weight) resistant, to oxidation and rancidity when stored at ordinary ambient temperatures (Bedigrain and Harlan, 1986). The centre of origin of sesame is not certain. East Indies, India, the Middle East and Africa have been suggested as possible centres of origin (Nayar and Mehta, 1968). However there is no doubt about its antiquity in the Indian sub-continent. The charred *Sesamum* seeds have been recorded from Harappa (Ca. 3500-1700 BC) the oldest archeological site in the region.

Exploration for the collection of sesame (*Sesamum indicum* L.) germplasm from Central Narmada Valley or Bundelkhand region of Madhya Pradesh was undertaken by the Project Coordinating Unit (Sesame and Niger), Jawaharlal Nehru Krishi Vishwa Vidyalaya Campus, Jabalpur (MP) in October 2000. Random method of sampling with coarse grid survey was followed for the collection of samples mainly from farmers' field, threshing yards and farm stores. Mostly the emphasis was given for the collection of local types from the

interior/remote areas far away from the main roads. Due care was taken to avoid the repetition of samples. Mostly one sample was collected from a specific site or a village until and unless warranted by the apparent distinct types.

A total of 120 samples of divergent types of sesame were collected from about 120 sites in different habitats ranging from undulating plains of Narmada valley to hill tops and slopes of Satpura mountains. This region is known for its richness in diversity in both flora and fauna and lie between 77° to 80°E longitude and 21.9 to 23.6°N latitude. During the course of exploration, it has been observed that sesame is a typical crop of small holders, often grown under marginal or stress conditions. Due to change in the cropping pattern the sesame crop by and large, has been replaced by soybean in the surveyed area, mainly because of its low yield and high susceptibility to diseases and insect pests.

The collected germplasm represented variability in most of the important plant characteristics such as plant height, number of branches (from highly branched to mono stem type), number of locules/capsule, seed colour ranging from white, light brown to dark black, seed size (small to bold types). White seeded types are vernacularly known as *Tilli* or *Tili* and black seeded

and number of bands unmatched between two varieties. It also informs about the presence and absence of marker in a particular profile table. It informs about the primer and its variety showing minimum coefficient in comparison with all the other primers in the list.

**Functions:** (1) Calculates Jaccard's coefficients between two varieties; (2) calculates Jaccard's coefficients primer wise. In this case all the varieties of one primers are compared with all the varieties of other primer; (3) calculates Jaccard's coefficients with total markers.

In this case one variety is compared with other variety irrespective of primer.

The report generated by Jaccard's coefficient has following fields: crop, technique, variety, primer, total number of records compared, field 1, field 2, availability of field1, availability of field2, matched bands, unmatched bands, Jaccard's coefficients.

**Print report:** This option is used to get the detailed report. It can be used to get crop-wise, technique-wise, primer-wise, variety-wise information. It could also give report, if the choice is in combination.

## Exploration for the Collection of Sesame (*Sesamum indicum* L.) Germplasm from Central Narmada Valley in Madhya Pradesh

**KMS Raghuwanshi and SS Duhoon**

All India Coordinated Research Project on Sesame and Niger, Jawaharlal Nehru Krishi Vishwa Vidyalaya Campus, Jabalpur-482004, Madhya Pradesh

**Key Words:** Collection, Sesame, Madhya Pradesh

Sesame (*Sesamum indicum* L. syn. *S. orientale* L.) is one of the oldest oilseed crops and is under cultivation from ancient times (Joshi, 1961; Weiss, 1971). It is regarded as the "queen of oilseeds". probably because of its oil (about 50% of seed weight) resistant, to oxidation and rancidity when stored at ordinary ambient temperatures (Bedigrain and Harlan, 1986). The centre of origin of sesame is not certain. East Indies, India, the Middle East and Africa have been suggested as possible centres of origin (Nayar and Mehta, 1968). However there is no doubt about its antiquity in the Indian sub-continent. The charred *Sesamum* seeds have been recorded from Harappa (Ca. 3500-1700 BC) the oldest archeological site in the region.

Exploration for the collection of sesame (*Sesamum indicum* L.) germplasm from Central Narmada Valley or Bundelkhand region of Madhya Pradesh was undertaken by the Project Coordinating Unit (Sesame and Niger), Jawaharlal Nehru Krishi Vishwa Vidyalaya Campus, Jabalpur (MP) in October 2000. Random method of sampling with coarse grid survey was followed for the collection of samples mainly from farmers' field, threshing yards and farm stores. Mostly the emphasis was given for the collection of local types from the

interior/remote areas far away from the main roads. Due care was taken to avoid the repetition of samples. Mostly one sample was collected from a specific site or a village until and unless warranted by the apparent distinct types.

A total of 120 samples of divergent types of sesame were collected from about 120 sites in different habitats ranging from undulating plains of Narmada valley to hill tops and slopes of Satpura mountains. This region is known for its richness in diversity in both flora and fauna and lie between 77° to 80°E longitude and 21.9 to 23.6°N latitude. During the course of exploration, it has been observed that sesame is a typical crop of small holders, often grown under marginal or stress conditions. Due to change in the cropping pattern the sesame crop by and large, has been replaced by soybean in the surveyed area, mainly because of its low yield and high susceptibility to diseases and insect pests.

The collected germplasm represented variability in most of the important plant characteristics such as plant height, number of branches (from highly branched to mono stem type), number of locules/capsule, seed colour ranging from white, light brown to dark black, seed size (small to bold types). White seeded types are vernacularly known as *Tilli* or *Tili* and black seeded

types as *Til*. Black seeded types are mostly used in Havan/Poojas and other rituals. In all, 25 samples represented diversity from Narsinghpur, 1 from the adjoining district of Sehore, 32 from Hosangabad and 62 from Raisen district in Narmada valley of Madhya Pradesh. Besides, some very good single plant selections were made for plant types and other devisable traits. Some of the samples were collected from old stocks of the farmers, which are likely to be of primitive type.

In the surveyed area sesame cultivation is done for various uses other than the oil extraction such for making the *Laddoo* (a vernacular sweet dish) on special occasion of *Sankranti* (day of worship of lord Shiva, on 14th January every year) particularly in the Pachmarhi. In most of the surveyed area of Narmada valley (on both the sides of holy Narmada river) sesame is grown only as mixed crop with arhar, jowar and sometimes with soybean. Only very few fields of pure crop, were observed during the course of exploration. Previously sesame was grown by each and every farming family of this area for its oil and other proposes but now a days it has been mostly replaced by soybean.

The surveyed areas are mostly inhabited by *Gonds*, *Korkus* tribals and *Kirars*, *Gurjars*, *Raghuwanshis* and other migrants from Northern India who were growing

sesame as an oilseed crop from the ancient times for their regular and occasional domestic requirements. The crop is grown during July as a pure *kharif* crop or mixed with the other *kharif* crops. Sowing starts with the onset of monsoon or depending upon the availability of moisture and/or irrigation facilities. Sesame is also grown in *rabi*/summer season in this area. The summer types are distinct types and vernacularly known as *maghai tili* because it is grown in the month of *Magh* or the *Magha* according to the old Hindu calendar (sowing is done mostly from January 2000 to February 2001).

Research efforts are required to be strengthened for the re-establishment of this high quality oil crop (sesame), otherwise it will be completely replaced from the farmers fields. Now a days the farmers talk about sesame that "*Tili to billa gayi*" which means sesame has been completely eradicated from the area.

## References

- Joshi AB (1961) *Sesamum*, A monograph, Indian Central Oilseeds Committee, Hyderabad.
- Weiss WA (1971) Castor, Sesame, Safflower, Leonard Hill, London, 311-525.
- Bedigra D and JR Harlan (1986) Evidence for cultivation of sesame in the ancient world. *Econ. Bot.* **40**: 137-154.
- Nayar NM and KL Mehta (1968) Sesame: its uses, botany, cytogenetics and origin. *Econ. Bot.* **24**: 20-31.

## Viruses Intercepted in Exotic Germplasm during 1991-2000 in Quarantine

**RK Khetarpal, Shamsheer Singh, DB Parakh, AK Maurya and V Celia Chalam**

*Division of Plant Quarantine, National Bureau of Plant Genetic Resources, New Delhi-110012*

**Key Words:** Germplasm, Legume, Quarantine, Interceptions, Seed-transmitted viruses

National Bureau of Plant Genetic Resources is a nodal agency for quarantine processing of exotic germplasm and transgenic planting material introduced in the country for research purposes by both public and private sector organizations. During the decade 1991-2000, about 6692 exotic legume and 425 flowering plants/planting material were grown in post-entry quarantine nursery and greenhouses for screening against exotic viruses or strains thereof. The objective was to minimize the risk of introduction of destructive viruses and its strains into the country and release samples to the indentor from

disease-free plants. A check-list of economically important seed-transmitted viruses associated with legumes and those yet not reported from India have been prepared (Kumar *et al.* 1994) and updated. Thus, based on the literature available, detection methods are employed to test the material for quarantine clearance.

Methods employed for testing legume and planting material included (i) visual inspection (ii) grow-out test of seeds and seedlings or rooted planting material grown in pots (iii) infectivity tests of suspected viruses on known hosts (iv) serological tests such as Enzyme Linked

types as *Til*. Black seeded types are mostly used in Havan/Poojas and other rituals. In all, 25 samples represented diversity from Narsinghpur, 1 from the adjoining district of Sehore, 32 from Hosangabad and 62 from Raisen district in Narmada valley of Madhya Pradesh. Besides, some very good single plant selections were made for plant types and other devisable traits. Some of the samples were collected from old stocks of the farmers, which are likely to be of primitive type.

In the surveyed area sesame cultivation is done for various uses other than the oil extraction such for making the *Laddoo* (a vernacular sweet dish) on special occasion of *Sankranti* (day of worship of lord Shiva, on 14th January every year) particularly in the Pachmarhi. In most of the surveyed area of Narmada valley (on both the sides of holy Narmada river) sesame is grown only as mixed crop with arhar, jowar and sometimes with soybean. Only very few fields of pure crop, were observed during the course of exploration. Previously sesame was grown by each and every farming family of this area for its oil and other proposes but now a days it has been mostly replaced by soybean.

The surveyed areas are mostly inhabited by *Gonds*, *Korkus* tribals and *Kirars*, *Gurjars*, *Raghuwanshis* and other migrants from Northern India who were growing

sesame as an oilseed crop from the ancient times for their regular and occasional domestic requirements. The crop is grown during July as a pure *kharif* crop or mixed with the other *kharif* crops. Sowing starts with the onset of monsoon or depending upon the availability of moisture and/or irrigation facilities. Sesame is also grown in *rabi*/summer season in this area. The summer types are distinct types and vernacularly known as *maghai tili* because it is grown in the month of *Magh* or the *Magha* according to the old Hindu calendar (sowing is done mostly from January 2000 to February 2001).

Research efforts are required to be strengthened for the re-establishment of this high quality oil crop (sesame), otherwise it will be completely replaced from the farmers fields. Now a days the farmers talk about sesame that "*Tili to billa gayi*" which means sesame has been completely eradicated from the area.

## References

- Joshi AB (1961) *Sesamum*, A monograph, Indian Central Oilseeds Committee, Hyderabad.
- Weiss WA (1971) Castor, Sesame, Safflower, Leonard Hill, London, 311-525.
- Bedigra D and JR Harlan (1986) Evidence for cultivation of sesame in the ancient world. *Econ. Bot.* **40**: 137-154.
- Nayar NM and KL Mehta (1968) Sesame: its uses, botany, cytogenetics and origin. *Econ. Bot.* **24**: 20-31.

## Viruses Intercepted in Exotic Germplasm during 1991-2000 in Quarantine

**RK Khetarpal, Shamsheer Singh, DB Parakh, AK Maurya and V Celia Chalam**

*Division of Plant Quarantine, National Bureau of Plant Genetic Resources, New Delhi-110012*

**Key Words:** Germplasm, Legume, Quarantine, Interceptions, Seed-transmitted viruses

National Bureau of Plant Genetic Resources is a nodal agency for quarantine processing of exotic germplasm and transgenic planting material introduced in the country for research purposes by both public and private sector organizations. During the decade 1991-2000, about 6692 exotic legume and 425 flowering plants/planting material were grown in post-entry quarantine nursery and greenhouses for screening against exotic viruses or strains thereof. The objective was to minimize the risk of introduction of destructive viruses and its strains into the country and release samples to the indentor from

disease-free plants. A check-list of economically important seed-transmitted viruses associated with legumes and those yet not reported from India have been prepared (Kumar *et al.* 1994) and updated. Thus, based on the literature available, detection methods are employed to test the material for quarantine clearance.

Methods employed for testing legume and planting material included (i) visual inspection (ii) grow-out test of seeds and seedlings or rooted planting material grown in pots (iii) infectivity tests of suspected viruses on known hosts (iv) serological tests such as Enzyme Linked

Immunosorbent Assay (ELISA) and Dot Immunobinding Assay (DIBA) (Hadidi *et al.* 1998; Khetarpal *et al.* 1994; Parakh *et al.* 1994 and (v) electron microscopy.

The details of legume and other material received and grown is presented in Table 1. The harvest from disease-free plants after growing was released to the indentors.

The introduced germplasm grown under quarantine included seeds of adzuki bean, cowpea, faba bean, French bean, mungbean, pea, *Phaseolus* spp., savi bean, soybean, urdbean and wild *Vigna* spp. and seedlings of flowering plants viz.-*Chrysanthemum* and *Lilium* (Table 1).

The economically important seed transmitted viruses that were intercepted and not yet reported from India are cowpea mottle carmovirus in cowpea imported from the Philippines and broad bean stain comovirus in broad bean from Bulgaria. Among other interceptions are the viruses that possess a number of virulent strains such

as soybean mosaic potyvirus (SMV) in soybean from Brazil, Hungary, Nigeria, Taiwan and USA, pea seed-borne mosaic potyvirus (PSbMV) in pea from Australia, CIS (Russia), Columbia, Germany and The Netherlands, and in broad bean from Bulgaria, cowpea aphid-borne mosaic potyvirus (CABMV) in cowpea from USA, bean yellow mosaic potyvirus (BYMV) in broadbean from Bulgaria and in *Phaseolus* spp. from Colombia and bean common mosaic potyvirus (BCMV) in beans from Columbia, CIS (Russia), Hungary, USA and Taiwan (Table 2).

The unidentified viruses in other legume crops are presented in Table 2. The plants showing typical viral symptoms were subjected to infectivity test, ELISA and electron microscopy to confirm the presence of viruses. The ELISA readings were quantified at 405 nm absorbance on a Dynatech or Biotech microplate reader. Samples having the absorbance value twice or more than twice

**Table 1. Legume crops processed during 1991-2000 in quarantine for seed-transmitted viruses**

| Crop                               | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|------------------------------------|------|------|------|------|------|------|------|------|------|------|
| Asparagus bean                     | -    | -    | -    | -    | -    | -    | -    | -    | -    | 01   |
| <i>Crotolaria</i> spp.             | 27   | -    | -    | -    | -    | -    | -    | -    | -    | -    |
| <i>Dolichos</i> spp.               | 08   | -    | 02   | -    | -    | -    | -    | -    | -    | -    |
| <i>Glycine</i> spp.                | 113  | 131  | 102  | 09   | 99   | 520  | 220  | 222  | 177  | 1251 |
| <i>Lablab purpureus</i>            | -    | 04   | -    | -    | -    | -    | -    | -    | -    | -    |
| <i>Lathyrus</i> spp.               | 43   | 133  | -    | 45   | 01   | 48   | 34   | -    | -    | -    |
| <i>Medicago</i> spp.               | -    | -    | -    | -    | -    | -    | 07   | -    | -    | -    |
| <i>Phaseolus</i> spp.              | 242  | 28   | 47   | -    | 82   | 222  | 78   | 12   | -    | 09   |
| <i>P. lunatus</i>                  | -    | 02   | -    | -    | -    | -    | -    | -    | -    | -    |
| <i>Pisum sativum</i>               | 269  | 117  | 26   | 37   | 45   | 90   | 24   | -    | 12   | 15   |
| <i>Psophocarpus tetragonolobus</i> | 16   | 04   | -    | -    | -    | 04   | -    | -    | -    | -    |
| <i>Trifolium</i> spp.              | -    | -    | -    | -    | -    | -    | 18   | -    | -    | -    |
| Wild <i>Vigna</i> spp.             | -    | 39   | -    | 23   | -    | 38   | -    | -    | -    | -    |
| <i>V. aconitifolia</i>             | 08   | 15   | -    | -    | -    | 04   | 04   | -    | -    | -    |
| <i>V. angularis</i>                | 02   | 42   | 42   | -    | -    | -    | 03   | -    | -    | -    |
| <i>V. catjang</i>                  | -    | 02   | -    | -    | -    | -    | -    | -    | -    | -    |
| <i>V. mungo</i>                    | -    | 01   | 01   | -    | -    | 04   | 06   | -    | -    | -    |
| <i>V. radiata</i>                  | 142  | 20   | 10   | 03   | 02   | 240  | 15   | 34   | -    | 06   |
| <i>V. umbellata</i>                | -    | 01   | -    | -    | -    | 04   | 08   | -    | -    | -    |
| <i>V. unguiculata</i>              | 62   | 31   | 69   | 42   | 17   | 241  | 34   | -    | -    | 124  |
| <i>Vicia</i> spp.                  | 163  | 180  | 62   | 60   | 60   | 76   | 08   | -    | 36   | -    |
| <i>Vicia faba</i>                  | -    | -    | -    | -    | -    | 04   | -    | -    | 43   | 65   |
| <b>Other material</b>              |      |      |      |      |      |      |      |      |      |      |
| <i>Chrysanthemum</i> spp.          | -    | -    | -    | -    | -    | -    | -    | -    | 271  | -    |
| <i>Lilium</i> spp.                 | -    | -    | -    | -    | -    | -    | -    | -    | 154  | -    |

Table 2. Viruses intercepted during post-entry quarantine isolation growing (1991-2000)

| Crop                         | Interception                        | Source                                                 |
|------------------------------|-------------------------------------|--------------------------------------------------------|
| Adzuki bean                  | Unidentified filamentous virus      | Germany                                                |
| Cowpea                       | Cowpea-aphid borne mosaic potyvirus | USA                                                    |
|                              | Cowpea mottle carmovirus*           | Philippines                                            |
|                              | Unidentified filamentous virus      | USA                                                    |
| Faba bean                    | Pea seed borne mosaic potyvirus     | Bulgaria                                               |
|                              | Bean yellow mosaic potyvirus        | Bulgaria                                               |
|                              | Broad bean stain comovirus*         | Bulgaria                                               |
| French bean                  | Bean common mosaic potyvirus        | Columbia, CIS, Hungary, USA                            |
| <i>Lilium</i> spp.           | Carla-virus particles               | Israel                                                 |
| Mung bean                    | Unidentified isometric virus        | Germany, Indonesia, AVRDC (Taiwan)                     |
|                              | Bean common mosaic potyvirus        | AVRDC (Taiwan)                                         |
| Pea                          | Pea seed borne mosaic potyvirus     | Australia, Bulgaria, Columbia, Germany, Holland, Syria |
| <i>Phaseolus acutifolius</i> | Unidentified filamentous virus      | USA                                                    |
| Savi bean                    | Unidentified filamentous virus      | France                                                 |
| Soybean                      | Soybean mosaic potyvirus            | Brazil, Hungary, Nigeria, Taiwan, Thailand, USA        |

\* Viruses not reported from India

the average values of the healthy control were considered as positive (infected) in ELISA.

During the quarantine processing, seeds showing mottling symptoms on seed coat in case of soybean and split seed coat symptoms in case of pea were removed as they were suspected to carry SMV and PSbMV, respectively. In the grow-out test, apparently infected seedlings were uprooted and destroyed or transplanted in isolation, thereby removing the potential source of virus infection.

The inadvertent introduction of viral diseases intercepted in imported seeds and planting material could thus be eliminated by deploying a combination of above mentioned virological techniques.

The post-entry quarantine growing facilitated in identifying the infected plants in a given accession, thus contributing in release of disease-free harvest of the

same accession to the indentors. It may be noted that only the infected plants of an accession were rejected and never all the plants of an accession were found to be infected.

## References

- Hadidi A, RK Khetarpal and H Koganezawa (eds.) (1998) *Plant Virus Disease Control*. American Phytopathological Society (APS Press), St. Paul, Minnesota, USA, 684 p.
- Khetarpal RK, DB Parakh, Shamsheer Singh, Ram Nath, RK Jain and A Varma (1994) Bean Common Mosaic Virus detected by DAC-ELISA in exotic *Phaseolus vulgaris* L. *Indian J. Virol.* **10**: 13-16.
- Kumar CA, RK Khetarpal, DB Parakh, Shamsheer Singh and Ram Nath (1994) *Check-List on Seed Transmitted Viruses: Leguminous Hosts*. Tech. Bull. NBPGR, New Delhi.
- Parakh DB, RK Khetarpal, Shamsheer Singh and Ram Nath (1994) Post-entry quarantine detection of soybean mosaic virus by ELISA in soybean germplasm. *Indian J. Virol.* **10**: 17-21.

all temperatures at NAP. However, low-pressure fumigation resulted in significant decrease in germination. Fumigations at 23°C exhibited slight enhancement and those at 33°C caused little deterioration in germination in specific cases but in general, orange oil fumigation was found superior to others. These results are supported by previous reports that seed quality and viability were not affected by the citrus peel treatments (Don-Pedro, 1985). Crushed orange peel treatment has also been reported to improve the quality of seed during storage as compared to untreated lot. Deleterious effects on seed viability and vigour in the event of repeated fumigations or fumigation at higher concentration, temperatures or seed moisture contents and longer exposure periods have also been reported (Scudamore and Goodship, 1992; Gupta and Kashyap, 1995; Ren *et al.* 1996).

The studies revealed that citrus peel oils if used judiciously, would not affect seed viability which may be rather enhanced on account of prevention of damage caused by insects. Hence, citrus peel oil fumigation treatments at NAP can be safely recommended for quarantine disinfestation of cowpea seeds harbouring hidden infestation caused by *C. maculatus*. Further studies are required for use of these oils in low-pressure fumigation.

## References

- Don-Pedro KN (1985) Toxicity of some citrus peels to *Dermestes maculatus* and *Callosobruchus maculatus* F. *J. Stored Prod. Res.* **21**: 31-34.
- Don-Pedro KN (1996) Fumigant toxicity of citrus peel oils against adult and immature stages of storage insect pests. *Pesticide-Sci.* **47**: 213-223.
- Gupta M and RK Kashyap (1995) Phosphine fumigation against pulse beetle: germination and vigour of green gram seed. *Seed Sci. Technol.* **23**: 429-438.
- Kapur Manju Lata, BR Verma and DK Singh (2000) Investigations on the use of indigenous citrus peel oils against hidden infestation cause by pulse beetle in quarantine. In: Extended Summaries Vol. 2. Voluntary Papers, Natural Resources, *International Conference on Managing Natural Resources for Sustainable Agricultural Production in 21<sup>st</sup> Century*, February 14-18, 2000, New Delhi, India.
- Ren Yong Lin, IG O'Brien and J. Desmarchelier (1996) Effect of hydrogen cyanide and carbonyl sulphide on the germination and plumule vigour of wheat. *Pesticide Sci.* **47**: 1-5.
- Scudamore KA and Goodship G (1992) The effect of fumigation with methyl bromide on the germination of different varieties of wheat, barley and oats. *Seed Sci. Technol.* **20**: 375-390.
- Taylor RWD (1991) Resistance to grain fumigants and future prospects for their use. *Pesticide Outlook*, **22**: 22-24.
- Tripathi AK, Veena Prajapati, Rashmi Gupta and Sushil Kumar (1999) Herbal material for the insect pest management in stored grains under tropical conditions *J. Medicinal Aromatic Plant Sci.* **21**: 408-430.

## Collection and Conservation of Lac Insects and their Host-Plants: Importance and Strategies

**K Krishan Sharma, P Kumar and KK Kumar**

*Indian Lac Research Institute, Namkum, Ranchi-834010, Jharkhand*

**Key Words:** Lac insect, *Kerria* species, Host plants

Lac is regarded as an important natural heritage of our country as its utility has been known since time immemorial. The financial value of lac insects and their host-plants is of major importance in the economics of tribal lac growers. Cultivation of lac not only provides livelihood to millions of them but also has helped in conserving the vast stretches of forests. Forests are store-house of lac insect diversity. Over exploitation of these directly affects the survival of lac insects. Habitat destruction has been the major cause of shrinkage in

area of lac cultivation. With destruction of forests disappear the lac insect also. Human impact on environment particularly on forests has put many species of lac insects and lac host-plants in the 'waiting list' of extinction. Hence, preservation of habitat is the most important criterion for conservation of lac insects.

India is privileged in being the largest producer of lac in the world. Lac insects are the crowning glory of India's rich insect fauna. Of the nine genera and 87 species of lac insects reported from the world (Sharma

and Ramani, 1999), two genera and 19 species are found in our country representing 21.8% of the known lac insects species diversity (Table 1).

Lac insect ecosystem is a complex multi-trophic web of flora and fauna. Eight species of lac predators, 19 species of primary parasites and 35 species of secondary parasites (Das, 1990) besides, several fungal pathogens (Shaoji, 1993) represent a rich biodiversity of this ecosystem. Some of the insect fauna associated with the lac insects are species specific and hence, loss of even one species of lac insect will pose a danger of losing many other related insect species.

Lac insects are our highly valued but least appreciated resources. With the increase in human population inaccessible areas are being encroached upon which has

affected adversely lac insects and their host-plants. Some of the important and real threats which, merit immediate attention are:

- For commercial production of lac mainly *Kerria lacca* (Kerr) has been exploited. Potential of other species remains to be tested and exploited. In the absence of any human intervention the un-exploited lac species remain neglected and may be lost. Wild lac insects are principally distributed in the forest and sub-forest region thus, the future of lac insects is intricately linked to the fate of forests. Fast depleting forest cover of the country is a serious threat to the biodiversity of lac insects as well as their host plants.

Following are the threats to lac insects and their host plants:

**Table 1. Different species of lac insects reported from India (modified after Sharma *et al.* 1999) and their vulnerability status.**

| S. No.                                                                                                                                                                    | Lac insects species                     | Host plants                | State/Locality from which reported                                                  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|----------------------------|-------------------------------------------------------------------------------------|
| <b>A. <i>Kerria</i> spp. reported from major lac growing areas</b>                                                                                                        |                                         |                            |                                                                                     |
| 1                                                                                                                                                                         | <i>K. albizzae</i>                      | <i>Landolphia</i> sp.      | Bihar*, Uttar Pradesh and West Bengal                                               |
| 2                                                                                                                                                                         | <i>K. brancheata</i>                    | <i>Schleichera oleosa</i>  | Bihar                                                                               |
| 3                                                                                                                                                                         | <i>K. chinensis chinensis</i>           | <i>Cajanus cajan</i>       | North-East India                                                                    |
| 4                                                                                                                                                                         | <i>K. kydia</i>                         | <i>Kydia calycina</i>      | Assam (Silcher)                                                                     |
| 5                                                                                                                                                                         | <i>K. fici fici</i>                     | <i>Ficus religiosa</i>     | Bihar (Monghyr), Delhi, Jammu and Kashmir, Rajasthan, Uttar Pradesh and West Bengal |
| 6                                                                                                                                                                         | <i>K. lacca lacca</i>                   | <i>Ficus religiosa</i>     | All India                                                                           |
| 7                                                                                                                                                                         | <i>K. mysorensis</i>                    | <i>Shorea talura</i>       | Karnataka (Mysore)                                                                  |
| 8                                                                                                                                                                         | <i>K. nagoliensis</i>                   | <i>Schleichera oleosa</i>  | Madhya Pradesh**                                                                    |
| 9                                                                                                                                                                         | <i>K. sharda</i>                        | <i>Schleichera oleosa</i>  | Orissa (Mayurbhanj)                                                                 |
| 10                                                                                                                                                                        | <i>K.c. rangoonesis</i>                 | <i>Quisqualis</i> sp.      | Assam                                                                               |
| <b>B. <i>Kerria</i> spp. reported either from minor lac growing or non-lac growing regions and are considered endangered</b>                                              |                                         |                            |                                                                                     |
| 1                                                                                                                                                                         | <i>K. chamberlini</i>                   | <i>Ficus infectoria</i>    | Rajasthan (Jodhpur)                                                                 |
| 2                                                                                                                                                                         | <i>K. communis</i>                      | <i>Ficus mysorensis</i>    | Andhra Pradesh, Goa, Karnataka, Kerala Maharashtra and Tamil Nadu                   |
| 3                                                                                                                                                                         | <i>K. ebracheata</i>                    | <i>Ficus elastica</i>      | Bihar (Manbhum District), Karnataka                                                 |
| 4                                                                                                                                                                         | <i>K. fici jhansiensis</i>              | <i>Ziziphus mauritiana</i> | Uttar Pradesh (Jhansi)                                                              |
| 5                                                                                                                                                                         | <i>K. indicola</i>                      | <i>Ziziphus mauritiana</i> | Bihar, Uttar Pradesh (Jamunia)                                                      |
| 6                                                                                                                                                                         | <i>K. ambigua</i>                       | <i>Jheolia</i> ?           | Uttar Pradesh (Guna near Jhansi)                                                    |
| 7                                                                                                                                                                         | <i>K. nepalensis</i>                    | <i>Litchi chinensis</i>    | Bihar (Champaran)                                                                   |
| 8                                                                                                                                                                         | <i>K. pusana</i>                        | <i>Ziziphus mauritiana</i> | Bihar, Pusa                                                                         |
| <b>C. <i>Paratachardina</i> spp. which do not produce true lac and are treated as pests, bearing the burnt of control measures, thus making these the most vulnerable</b> |                                         |                            |                                                                                     |
| 1                                                                                                                                                                         | <i>P. lobata</i>                        | <i>Pongamia pinnata</i>    | Andhra Pradesh, Karnataka and Tamil Nadu                                            |
| 2                                                                                                                                                                         | <i>P. lobata</i> var. <i>schmidtii</i>  |                            |                                                                                     |
| 3                                                                                                                                                                         | <i>P. lobata</i> var. <i>walezuchae</i> |                            |                                                                                     |
| 4                                                                                                                                                                         | <i>P. mithilae</i>                      | <i>Photinia notoniana</i>  | Meghalaya (Shillong)                                                                |
| 5                                                                                                                                                                         | <i>P. silvestrii</i>                    | <i>Ixora parviflora</i>    | Karnataka (Mysore)                                                                  |
| 6                                                                                                                                                                         | <i>P. ternata</i>                       | <i>Acacia chundra</i>      | Kerala (Travancore)                                                                 |
| 7                                                                                                                                                                         | <i>P. theae</i>                         | <i>Thea chinensis</i>      | Sikkim and West Bengal                                                              |

\* Bihar includes Jharkhand also

\*\* Madhya Pradesh includes Chhattisgarh also

? Botanical name not traceable

- Many of the lac host plants like lichi (*Litchi chinensis*), ber (*Ziziphus mauritiana*), mango (*Mangifera indica*) and sandal (*Santalum album*) are economically important. Therefore, lac insect populations infesting such plant species are deliberately destroyed paving the way to erosion of the biodiversity of lac insects.
- Fluctuating prices of lac and over dependence on foreign buyers leading to shrinking economic returns from lac cultivation has eroded the lac cultivation area. Orissa, Gujarat, Assam, Punjab and Uttar Pradesh earlier contributed significantly in lac production but now their share is almost negligible as cultivation of lac has been abandoned. Many species of lac insects reported from these places have thus, become endangered.
- Unlike conservation of plant species, conservation of lac insects is more demanding and requires continuous monitoring as they can only be maintained under living state on host-plants. The mechanism and manpower available for this purpose is inadequate.
- Some of the species/varieties of lac insects e.g. *kusmi* strain of *K. lacca* which produces superior quality of lac are exclusive to our country and need to be protected in this era of free trade and open market.
- Species of *Paratachardina* do not produce true lac and hence, are not cultivated. These insects are direct target of pest control measures and this makes them the most vulnerable.
- Out of more than 400 reported lac-hosts not more than two dozens are utilized for commercial production of lac. Danger looms large on other host-plants whose economic importance remains to be realized.
- Collection and survey of lac insects and their host-plants unlike in other crops is very demanding and poses certain peculiar difficulties. In non-lac growing regions people do not have any knowledge about lac insects and are unable to provide any information regarding its habits and habitats.

*Strategies for conservation:* Fate of lac insects and their host-plants is linked with the fate of forests. Urgent and immediate steps are required to have these resources conserved. Strategies which are expected to yield results, are listed as follows:

- There is strong need to undertake extensive surveys of our country and abroad to know the present status of the lac insects and their plant-hosts biodiversity.

The reported species of lac insect do not give any idea, hitherto, of unreported species and more importantly the infraspecific genetic diversity of those species of economic value. There is a great need for properly identifying, documenting and conserving (*in situ* and *ex situ*) the diversity of lac insects.

- Action needs to be initiated to build a strong infrastructure to develop field germplasm bank to conserve at one suitable place, all the recorded lac insects and host-plants. Protected lac insect and host habitats on the pattern of sanctuaries and wild life parks in different agro-climatic zones are needed to conserve the precious wealth of our country.
- To offset the shrinking forests there is an urgent need to integrate lac culture with agriculture. This will not only augment the earnings/unit area but also help in conserving the lac insect and host plants. A system has to be evolved where lac insects can remain as one component of the agri-horticultural ecosystem without adversely affecting the economic returns from these crops.
- Afforestation programmes should include planting of lac host tree species according to the preference of the lac insects.
- Scientific research on lac insects' fauna should be encouraged in different research institutions and universities regarding lac-culture as an important component of different cropping systems. An All India Coordinated Research Project on lac insects could be the first step in this direction.
- Lac insects of *Paratachardina* species have been reported to be very potential biocontrol agents for managing weeds (Campbell *et al.* 1994) and need to be nurtured as such.
- Under suitable local initiative there is considerable scope utilizing lac hosts in India which are either poorly exploited or not exploited at all. Such species might prove to be suitable if experimented with. Awareness regarding usefulness and conservation of lac insects and host-plants should be emphasized to the people residing close to the lac habitats.

In the ultimate analysis it is only the love for nature that will set us on the path of conservation. Lac belongs to us and conservation of lac insects and their host-plants is our responsibility. Let us protect these for the posterity.

## References

- Campbell MH, RH Holtcamp, LH McCormick, PJ Wykes, JF Donaldson, PJ Gullan and PS Gillespie (1994) Biological control of the native shrubs, *Cassinia* spp. using the native scale insects *Austrotachardia* sp. and *Paratarchardia* sp. (Hemiptera : Kerriidae) in New South Wales. *Plant Protection Quarterly* 9: 64-68.
- Das BB (1990) Present status of entomological research on lac in India and future strategies. Part 1. Present status of knowledge. *Indian Shellac*. 9-16.
- Shaoji Gu (1993) An investigation on the pathogens of both lac insects and their host plants. *Forest Research* 6: 711-713.
- Sharma K Krishan, A Bhattacharya and SN Sushil (1999) Indian lac insect, *Kerria lacca* as an important source of honeydew. *Bee World*. 80: 115-118.
- Sharma K Krishan and R Ramani (1999) An update on synoptic catalogue of lac insects (Homoptera Tachardiidae). *J. Bombay Nat. Hist. Soc.* 96: 438-443.

## Bioresource Potential of North-Western Himalayas

**A Pratap, S Singh, HK Choudhary and GS Sethi**

*Cytogenetics and Tissue Culture Laboratory, Department of Plant Breeding and Genetics, Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur-176062, Himachal Pradesh*

**Key Words: Bioresources, India, North-West Himalayas, PGRs**

Hills and mountains occupy one fifth of earth's landscape and are home to one tenth of the world's population. An additional two billion people live downstream from the mountains and directly depend on them for their water, hydroelectricity, grasslands, timber, medicines and mineral resources. Patterns and processes influencing natural as well as human systems in the mountains influence not only the hill people of India, China, Nepal, Pakistan, Laos, Vietnam, Malaysia and many other countries but also those living in the adjacent lowland areas. Development prospects of the 90% of the world's population living in the 75% of the earth's plains are ultimately bound to what happens or doesn't happen in the hills which occupy only 25% of the earth's surface and where only 10% of the world's population lives.

However, in the recent years, the mountain specificities like fragility, marginality, diversity and vulnerability have been seriously tempered with by the developments like relentless population pressures, market integration from local to national and international levels, migration to the cities, revolution in the technology and social mobility, which have weakened and disrupted the traditional structures. Extreme internal variability and complexity of hills, with a multiplicity of highly localized micro-ecosystems providing the habitats for many unique crop varieties and animals species have been disturbed or are being disturbed. Environmental developmental issues concerned with a fragile and vulnerable hill landscape

like the Himalayas have, thus, to be on the forefront of sustainable development.

For sustainable agricultural development, plant genetic diversity is a key ingredient. The use of plant diversity—a gene, genotype, genepool and ecosystem levels increases the capacity of crops and agro-ecosystems to adjust the unpredictable weather conditions and unexpected pests and diseases. Diversity also provides capacity to adapt the changing crop needs and also to contribute to essential ecological processes. However, the tropical and sub-tropical regions which harbour the major portion of biological diversity are being over-exploited and abused. Both natural disasters and human activities are progressively eroding the earth's capacity to support life and at the same time the population explosion combined with increasing level of energy consumption are resulting in the destruction of the buffer that has always existed to protect against harmful environmental changes. Therefore, the international community has an increased responsibility to ensure that conservation, development and utilization of the biological/genetic diversity is sustainable, economic and equitable especially in the developing nations.

According to FAO, management and conservation of natural resource base and orientation of technological and institutional changes which conserve land, water, plant and animal genetic resources define the sustainable development of hills that is environmentally non-degrading,

## Effect of Citrus Peel Oil Fumigation on Germination of Cowpea Seed

**Manju Lata Kapur, DK Singh\* and BR Verma**

*Division of Plant Quarantine, National Bureau of Plant Genetic Resources, New Delhi-110012*

**Key Words:** Citrus Peel Oils, Cowpea, Fumigation, Germination, Seeds

Fumigants are not only unique but rather irreplaceable pesticides which act as gas and can provide effective and economical control of insects without disturbing the infested material in anyway. Use of many fumigants is being limited due to their harmful effects on human health and environment. Currently only two fumigants, methyl bromide and aluminum phosphide or phosphine are in regular use, but these too, have a bleak future due to several reasons. Methyl bromide has been designated as an ozone depleting substance and its production and consumption levels would be frozen to 1991 and 1995-98 levels in developed and developing nations by the year 2001 and 2015, respectively. Hence, eventual phase-out of methyl bromide seems to be inevitable. Phosphine is simpler and less hazardous to apply than methyl bromide but it requires relatively long exposure period up to five days or, even longer to overcome problems of insect resistance being reported from all over the world (Taylor *et al.* 1991; Tripathi *et al.* 1999). Thus, there is an urgent need to develop safe alternatives that have the potential to replace toxic fumigants, yet are simple and convenient to use.

Natural plant products especially the essential oils, appear to be quite promising in this regard. Many of them are volatile at ordinary temperatures and sufficiently toxic to fall within the definition of fumigants but these need to be evaluated for their efficacy against a particular pest and any adverse effects on the materials for which these are intended to be used. Citrus peel essential oils, besides being eco-friendly, are liquid at room temperature and unlike gaseous fumigants, are easier and safer to store as well as handle. Don-Pedro (1996) demonstrated vapour toxicity of these oils against *Callosobruchus maculatus* F. and *Dermestes maculatus*. In view of the prevailing biodiversity in *Citrus* spp. in different geographical regions in terms of chemical composition, fumigant toxicity of indigenous citrus peel oils against hidden infestation caused by *C. maculatus* in cowpea

seed has also been investigated to work out the feasibility of using these oils for quarantine fumigation of seeds (Kapur *et al.* 2000). As there was no report available on the effect of fumigation with citrus peel oils on viability and vigour of seeds, present investigations were taken up to study the use of citrus peel oil fumigation as a safe quarantine treatment *i.e.* at a dose providing complete mortality of pulse beetle within the seed, for disinfection of seeds without affecting their germination.

Healthy seeds of cowpea cv. Pusa Komal, were exposed to the vapours of industrially extracted lime peel oils, orange peel oil and d-limonene, in 24 h fumigation tests at different temperatures *viz.*- 23°C  $\pm$  1°C, 28°C  $\pm$  1°C and 33°C  $\pm$  1°C at normal air pressure (NAP) and 3 h fumigation tests at 28°C  $\pm$  1°C at low pressures at LC<sub>99</sub> for pupae of *C. maculatus* F., the most tolerant stage of the insect found within the seed. LC<sub>99</sub> for pupae of *C. maculatus* F. within the seed, was standardized for different conditions of temperatures and pressure for a particular quantity of seed (unpublished) as it has been reported that sorption of citrus peel oil fumes occurs in the presence of cowpea grains or strips of dried fish, the commodities being fumigated, and this tends to reduce the amount of vapour available for fumigant action outside the materials (Don-Pedro, 1996). Seeds were aerated for 24 h in case of NAP and were given three air washings in case of low-pressure fumigation. Thereafter, 100 seeds were picked at random and were subjected to germination test by the rolled paper towel method as per ISTA rules. Three replications were run for each treatment and an untreated control. Seeds were kept for germination at 25°C  $\pm$  1°C. First germination count was recorded on 5<sup>th</sup> day and root and shoot length were measured on the 7<sup>th</sup> day. The data was subjected to statistical analysis using ANOVA and critical difference at 5% level was observed.

Results indicated no significant difference in germination of fumigated seeds with that of control at

\*Department of Zoology, University of Delhi, Delhi-110007

all temperatures at NAP. However, low-pressure fumigation resulted in significant decrease in germination. Fumigations at 23°C exhibited slight enhancement and those at 33°C caused little deterioration in germination in specific cases but in general, orange oil fumigation was found superior to others. These results are supported by previous reports that seed quality and viability were not affected by the citrus peel treatments (Don-Pedro, 1985). Crushed orange peel treatment has also been reported to improve the quality of seed during storage as compared to untreated lot. Deleterious effects on seed viability and vigour in the event of repeated fumigations or fumigation at higher concentration, temperatures or seed moisture contents and longer exposure periods have also been reported (Scudamore and Goodship, 1992; Gupta and Kashyap, 1995; Ren *et al.* 1996).

The studies revealed that citrus peel oils if used judiciously, would not affect seed viability which may be rather enhanced on account of prevention of damage caused by insects. Hence, citrus peel oil fumigation treatments at NAP can be safely recommended for quarantine disinfestation of cowpea seeds harbouring hidden infestation caused by *C. maculatus*. Further studies are required for use of these oils in low-pressure fumigation.

## References

- Don-Pedro KN (1985) Toxicity of some citrus peels to *Dermestes maculatus* and *Callosobruchus maculatus* F. *J. Stored Prod. Res.* **21**: 31-34.
- Don-Pedro KN (1996) Fumigant toxicity of citrus peel oils against adult and immature stages of storage insect pests. *Pesticide-Sci.* **47**: 213-223.
- Gupta M and RK Kashyap (1995) Phosphine fumigation against pulse beetle: germination and vigour of green gram seed. *Seed Sci. Technol.* **23**: 429-438.
- Kapur Manju Lata, BR Verma and DK Singh (2000) Investigations on the use of indigenous citrus peel oils against hidden infestation cause by pulse beetle in quarantine. In: Extended Summaries Vol. 2. Voluntary Papers, Natural Resources, *International Conference on Managing Natural Resources for Sustainable Agricultural Production in 21<sup>st</sup> Century*, February 14-18, 2000, New Delhi, India.
- Ren Yong Lin, IG O'Brien and J. Desmarchelier (1996) Effect of hydrogen cyanide and carbonyl sulphide on the germination and plumule vigour of wheat. *Pesticide Sci.* **47**: 1-5.
- Scudamore KA and Goodship G (1992) The effect of fumigation with methyl bromide on the germination of different varieties of wheat, barley and oats. *Seed Sci. Technol.* **20**: 375-390.
- Taylor RWD (1991) Resistance to grain fumigants and future prospects for their use. *Pesticide Outlook*, **22**: 22-24.
- Tripathi AK, Veena Prajapati, Rashmi Gupta and Sushil Kumar (1999) Herbal material for the insect pest management in stored grains under tropical conditions *J. Medicinal Aromatic Plant Sci.* **21**: 408-430.

## Collection and Conservation of Lac Insects and their Host-Plants: Importance and Strategies

**K Krishan Sharma, P Kumar and KK Kumar**

*Indian Lac Research Institute, Namkum, Ranchi-834010, Jharkhand*

**Key Words:** Lac insect, *Kerria* species, Host plants

Lac is regarded as an important natural heritage of our country as its utility has been known since time immemorial. The financial value of lac insects and their host-plants is of major importance in the economics of tribal lac growers. Cultivation of lac not only provides livelihood to millions of them but also has helped in conserving the vast stretches of forests. Forests are store-house of lac insect diversity. Over exploitation of these directly affects the survival of lac insects. Habitat destruction has been the major cause of shrinkage in

area of lac cultivation. With destruction of forests disappear the lac insect also. Human impact on environment particularly on forests has put many species of lac insects and lac host-plants in the 'waiting list' of extinction. Hence, preservation of habitat is the most important criterion for conservation of lac insects.

India is privileged in being the largest producer of lac in the world. Lac insects are the crowning glory of India's rich insect fauna. Of the nine genera and 87 species of lac insects reported from the world (Sharma

## References

- Campbell MH, RH Holtcamp, LH McCormick, PJ Wykes, JF Donaldson, PJ Gullan and PS Gillespie (1994) Biological control of the native shrubs, *Cassinia* spp. using the native scale insects *Austrotachardia* sp. and *Paratachardina* sp. (Hemiptera : Kerriidae) in New South Wales. *Plant Protection Quarterly* 9: 64-68.
- Das BB (1990) Present status of entomological research on lac in India and future strategies. Part 1. Present status of knowledge. *Indian Shellac*. 9-16.
- Shaoji Gu (1993) An investigation on the pathogens of both lac insects and their host plants. *Forest Research* 6: 711-713.
- Sharma K Krishan, A Bhattacharya and SN Sushil (1999) Indian lac insect, *Kerria lacca* as an important source of honeydew. *Bee World*. 80: 115-118.
- Sharma K Krishan and R Ramani (1999) An update on synoptic catalogue of lac insects (Homoptera Tachardiidae). *J. Bombay Nat. Hist. Soc.* 96: 438-443.

## Bioresource Potential of North-Western Himalayas

**A Pratap, S Singh, HK Choudhary and GS Sethi**

*Cytogenetics and Tissue Culture Laboratory, Department of Plant Breeding and Genetics, Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur-176062, Himachal Pradesh*

**Key Words: Bioresources, India, North-West Himalayas, PGRs**

Hills and mountains occupy one fifth of earth's landscape and are home to one tenth of the world's population. An additional two billion people live downstream from the mountains and directly depend on them for their water, hydroelectricity, grasslands, timber, medicines and mineral resources. Patterns and processes influencing natural as well as human systems in the mountains influence not only the hill people of India, China, Nepal, Pakistan, Laos, Vietnam, Malaysia and many other countries but also those living in the adjacent lowland areas. Development prospects of the 90% of the world's population living in the 75% of the earth's plains are ultimately bound to what happens or doesn't happen in the hills which occupy only 25% of the earth's surface and where only 10% of the world's population lives.

However, in the recent years, the mountain specificities like fragility, marginality, diversity and vulnerability have been seriously tempered with by the developments like relentless population pressures, market integration from local to national and international levels, migration to the cities, revolution in the technology and social mobility, which have weakened and disrupted the traditional structures. Extreme internal variability and complexity of hills, with a multiplicity of highly localized micro-ecosystems providing the habitats for many unique crop varieties and animals species have been disturbed or are being disturbed. Environmental developmental issues concerned with a fragile and vulnerable hill landscape

like the Himalayas have, thus, to be on the forefront of sustainable development.

For sustainable agricultural development, plant genetic diversity is a key ingredient. The use of plant diversity—a gene, genotype, genepool and ecosystem levels increases the capacity of crops and agro-ecosystems to adjust the unpredictable weather conditions and unexpected pests and diseases. Diversity also provides capacity to adapt the changing crop needs and also to contribute to essential ecological processes. However, the tropical and sub-tropical regions which harbour the major portion of biological diversity are being over-exploited and abused. Both natural disasters and human activities are progressively eroding the earth's capacity to support life and at the same time the population explosion combined with increasing level of energy consumption are resulting in the destruction of the buffer that has always existed to protect against harmful environmental changes. Therefore, the international community has an increased responsibility to ensure that conservation, development and utilization of the biological/genetic diversity is sustainable, economic and equitable especially in the developing nations.

According to FAO, management and conservation of natural resource base and orientation of technological and institutional changes which conserve land, water, plant and animal genetic resources define the sustainable development of hills that is environmentally non-degrading,

technically appropriate, economically viable and socially acceptable.

Asia has the highest, largest and most populated mountain systems in the world. Typical of these agricultural systems is the diversity of crops grown here. This crop diversity is also one of the farmers' strategies for reducing risk in the face of harsh and highly variable climate. The Himalayan mountain regions are considered to be centres of diversity for rice, buckwheat, fenugreek, tea, mango, cucumber, gram, pea and moth. Naked barley, wheat, finger millet, amaranthus, lathyrus and peas not only constitute the dietary sources of the hill people but are also compatible with natural resource-base sustainability. However, at present the strategy is required to tap and exploit the underexploited crops of hills like quinowa, tarwi, oca, kaniwa, ullucu and mashua which besides providing energy rich food to hill people, will reduce the pressure on traditional crops.

Cold desert areas of high mountains, which constitute a considerable proportion of hills, have emerged as the natural greenhouses with tremendous scope for off-season agriculture. Cultivation of off-season seed potato, sweet peas and many other vegetables have become extremely promising for the hill farmers which find a ready market in metropolitan cities, thus improving the economy of hills. Moreover several other cash and exotic crops like seabuckthorn, buckwheat, saffron, guchchhi, kala-jira, mushroom, kulth and hops have not only given more promising alternatives to traditional crops like wheat and rice but have also opened new avenues for agriculture-based business. Step-wise exploitation of these crops will certainly go a long way in hill agriculture and collection and maintenance of these irreplaceable genetic resources is, therefore, a must for sustained hill agriculture. High value fruit crops such as kiwis and cherries are the market-oriented crops which can be made more lucrative by following integrated land use system in the North-West Himalayas.

The North-Western hills of the country are the hidden treasures of germplasm resources. These are the coffers of rich genetic biodiversity with respect to the wild species and landraces of important foodgrain, pulse, horticultural and forage crops. The important wild species include *Elymus*, *Avena*, *Aegilops*, *Agropyron*, *Eremopyrum* and *Hordeum* (of the family Triticaceae), wild chickpea (*Cicer*), wild pome, stone and nut fruits (*Pyrus*, *Prunus*, *Malus* and *Juglans*), *Allium* spp. and *Medicago* spp. Other species such as *Sorbus*, *Rubus*, *Ribes*, *Lepidum*,

*Carum*, *Linum* and *Cucumis* also display considerable genetic diversity in this region. One of the biggest repositories of landraces of winter wheat, buckwheat and rye are found here. The conservation of use of this biodiversity is essential for continued maintenance and improvement of agricultural production and thus, to sustainable development and poverty alleviation of hills and of the nation as a whole.

Effective conservation of plant genetic resources requires a complementary approach which makes use of *ex situ* and *in situ* conservation methods using biotechnological tools. For many crop-species and their wild relatives, cryopreservation *i.e.* long-term conservation can be undertaken by storing at very low temperatures and humidities and also in genebanks. Further mass multiplication of endangered and unique flora of hills by micropropagation and industrialization of agriculture will certainly become the most potent approaches for the conservation of endangered genetic diversity of North-Western Himalayas. We have also got success in the micropropagation of numerous vegetative species of hills like that of ginger, turmeric, cherries, apple, peach, plum, gladiolus, carnation and so on. Crop diversification through introduction, domestication, off-season floriculture and olericulture, medicinal and aromatic plants and industrialization through food processing units, organic farming, agri-silviculture, agro-forestry and tea-industries will lead to a metamorphosis in the hill economy without compromising with nature.

Today, we are much concerned about environmental security. Intensive cultivation of land without conservation of natural biodiversity and soil structure would lead to springing up of desert. Moreover, in their daily struggle to survive the rural poor are forced to adopt the strategies that affect flora, fauna, woody biomass, water and pasturelands. Therefore, poverty alleviation and reduction in income disparities are necessary to tackle poverty related environmental problems. Moreover, since most of the poor live on the edges of subsistence, effective strategies for removal of poverty and control of population requires purposeful governmental intervention to help the poor to earn a decent and eco-friendly livelihood which does not compromise with the rich genetic biodiversity of hills. Maintenance of ecological balances, renewable resource base, cultural stocks and assimilative capacity of the environment are the pre-requisites for the conservation and maintenance of rich bioresources of hills and we must not forget that any irreversible

change in the environment will be a suicidal step for mankind.

The possibility of using selected inputs as well as the introduction of new crop and livestock species like those of sheep, goats, yak, alpaca and illama as well as of cattle will help greatly in harvesting the integrated benefits. Rearing yak and sheep together in high altitude natural pasturelands is an excellent example of integrated land and animal use system.

The future strategies of hill agriculture should pay systematic attention to their environmental impact. The life systems which put unsustainable burdens on the bio resources which are essential life support systems of earth have to be discouraged.

Thus, given the complexities in achieving maintenance and utilization of bioresources especially in the North-Western Himalayas, the following are the important steps:

1. Develop technologies, which can help to increase the productivity and profitability of small farm operations.
2. Development and implement techniques like integrated nutrient supply and integrated disease and pest management, so as to achieve ecological sustainability as well as technical sufficiency.
3. Give priorities to secure the livelihood of families that either have no assets or only small holdings.
4. Change the systems of landuse and sustainable utilization of bioresources.

## Madhya Pradesh – A Unique and Rich Habitat of Plant Genetic Resource

**VK Gour, AS Tiwari and SK Mitra**

Department of Plant Breeding and Genetics, Jawahar Lal Nehru Krishi Vishwa Vidyalaya, Jabalpur-482004, Madhya Pradesh

**Key Words:** Explorations, Madhya Pradesh, Plant genetic resources

Indian sub-continent nurtures more than 350 domesticated species of economic importance with almost similar number of wild forms/relatives. These species along with thousands of others are native to the land of 10 distinctive phyto-geographical zones with further splitting into 39 sub-zones. Conservationists set very high priority to the areas under hill and mountains, coastal, rainfed and arid agro-ecosystems than to the central Indian region, which is also rich for different species of economic importance.

Plant Genetic Resource of Madhya Pradesh has contributed to the national genebank through different joint exploration programmes viz.-IARI-PL480 (1966-1970), NBPGR (1976 to date), NBPGR-IPGRI (1989-1993), NBPGR-ICRISAT (1988-1994), Indo-USAID (1992) as reported by Shrivastava and Gautam (1999). However, these have been extensive and limited to easily accessible areas. The crops covered included wheat (*Triticum aestivum*, *T. durum* and *T. dicoccum*) grain legumes (*Vigna mungo*, *V. radiata*, *Lens culinaris*, *Cicer arietinum*, *Cajanus cajan*, *Macrotyloma uniflorum*, *Lathyrus* sp., and *Cyamopsis tetragonoloba*, oilseeds (*Brassica juncea*, *B. campestris* var. yellow and brown

sarson, *Sesamum indicum*, *Carthamus tinctorious*, *Arachis hypogaeae*, *Guizotia abyssinica* and *Ricinus communis*), minor millets (*Elusine coracana*, *Setaria italica*, *Panicum miliaceum*, *Paspalum scrobiculatum*, *Panicum sumatrense* and *Echinochloa frumentacea*), fibre crops (*Gossypium* sp.) cucumber and melons (*Cucumis* sp.), medicinal and under-utilized plants.

The present explorations have been conducted during April to December 2000 under Jai Vigyan National Science and Technology Mission on Conservation of Agro-biodiversity funded by NATP to safeguard the threatened crop genetic resources of Madhya Pradesh.

Four explorations were conducted covering 213 villages falling in 28 blocks belonging to 10 districts of Madhya Pradesh and Chattisgarh (Table 1). The samples of crop species prevalent were collected from fields, threshing floor and stores of cultivators as well as from mandis.

In four explorations, a total of 874 accessions were collected (Table 2). The results are discussed as crop group-wise.

change in the environment will be a suicidal step for mankind.

The possibility of using selected inputs as well as the introduction of new crop and livestock species like those of sheep, goats, yak, alpaca and illama as well as of cattle will help greatly in harvesting the integrated benefits. Rearing yak and sheep together in high altitude natural pasturelands is an excellent example of integrated land and animal use system.

The future strategies of hill agriculture should pay systematic attention to their environmental impact. The life systems which put unsustainable burdens on the bio resources which are essential life support systems of earth have to be discouraged.

Thus, given the complexities in achieving maintenance and utilization of bioresources especially in the North-Western Himalayas, the following are the important steps:

1. Develop technologies, which can help to increase the productivity and profitability of small farm operations.
2. Development and implement techniques like integrated nutrient supply and integrated disease and pest management, so as to achieve ecological sustainability as well as technical sufficiency.
3. Give priorities to secure the livelihood of families that either have no assets or only small holdings.
4. Change the systems of landuse and sustainable utilization of bioresources.

## Madhya Pradesh – A Unique and Rich Habitat of Plant Genetic Resource

**VK Gour, AS Tiwari and SK Mitra**

Department of Plant Breeding and Genetics, Jawahar Lal Nehru Krishi Vishwa Vidyalaya, Jabalpur-482004, Madhya Pradesh

**Key Words:** Explorations, Madhya Pradesh, Plant genetic resources

Indian sub-continent nurtures more than 350 domesticated species of economic importance with almost similar number of wild forms/relatives. These species along with thousands of others are native to the land of 10 distinctive phyto-geographical zones with further splitting into 39 sub-zones. Conservationists set very high priority to the areas under hill and mountains, coastal, rainfed and arid agro-ecosystems than to the central Indian region, which is also rich for different species of economic importance.

Plant Genetic Resource of Madhya Pradesh has contributed to the national genebank through different joint exploration programmes viz.-IARI-PL480 (1966-1970), NBPGR (1976 to date), NBPGR-IPGRI (1989-1993), NBPGR-ICRISAT (1988-1994), Indo-USAID (1992) as reported by Shrivastava and Gautam (1999). However, these have been extensive and limited to easily accessible areas. The crops covered included wheat (*Triticum aestivum*, *T. durum* and *T. dicoccum*) grain legumes (*Vigna mungo*, *V. radiata*, *Lens culinaris*, *Cicer arietinum*, *Cajanus cajan*, *Macrotyloma uniflorum*, *Lathyrus* sp., and *Cyamopsis tetragonoloba*, oilseeds (*Brassica juncea*, *B. campestris* var. yellow and brown

sarson, *Sesamum indicum*, *Carthamus tinctorious*, *Arachis hypogaeae*, *Guizotia abyssinica* and *Ricinus communis*), minor millets (*Elusine coracana*, *Setaria italica*, *Panicum miliaceum*, *Paspalum scrobiculatum*, *Panicum sumatrense* and *Echinochloa frumentacea*), fibre crops (*Gossypium* sp.) cucumber and melons (*Cucumis* sp.), medicinal and under-utilized plants.

The present explorations have been conducted during April to December 2000 under Jai Vigyan National Science and Technology Mission on Conservation of Agro-biodiversity funded by NATP to safeguard the threatened crop genetic resources of Madhya Pradesh.

Four explorations were conducted covering 213 villages falling in 28 blocks belonging to 10 districts of Madhya Pradesh and Chattisgarh (Table 1). The samples of crop species prevalent were collected from fields, threshing floor and stores of cultivators as well as from mandis.

In four explorations, a total of 874 accessions were collected (Table 2). The results are discussed as crop group-wise.

**Table 1. Areas explored for germplasm collection during April-December 2000**

| Districts                                              | Major Blocks/<br>Tehsils                                                                                                                 | Villages | No. of<br>accessions<br>collected |
|--------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|----------|-----------------------------------|
| Jabalpur<br>Narshingpur                                | Gotegaon, Barman,<br>Tendukheda, Joba                                                                                                    | 44       | 201                               |
| Jabalpur<br>Sagar<br>Damoh                             | Tendukhera, Patan,<br>Rehil, Dhana                                                                                                       | 12       | 123                               |
| Mandla<br>Dindori                                      | Niwas, Mandla,<br>Dindori, Samnapur<br>Amarpur, Chada,<br>Bajag                                                                          | 61       | 213                               |
| Mandla<br>Balaghat<br>Seoni<br>Kawardha<br>Rajnandgaon | Niwas Narayanganj,<br>Nainpur, Birsia<br>Kewlari, Lalbarra<br>Katangi, Waraseoni<br>Kirnapur, Borla,<br>Baihar, Khairgarh<br>Chhuikhadan | 96       | 337                               |

**Cereals:** Three hundred fifty six accessions belonging to six species exhibited wide diversity. In rice alone 271 accessions were collected. The maximum variability in rice has been recorded starting from its name to the majority of qualitative and quantitative traits. Maize exhibited variability for grain colour. Similarly, in other cereal crops, traditional cultivators were collected

indicating that still variability is existing due to diversified farming.

**Millets:** All accessions (128) of this group showed variations except *Paspalum scrobiculatum*, which is cleistogamous in nature. *Sorghum*, *Echinochloa*, *Panicum* sp., *Pennisetum* and *Setaria* showed variations for size of inflorescence and colour, whereas *Sorghum* and *Elusine* showed variation in shape of inflorescence.

**Grain legumes:** A total 236 accessions were collected. All accessions collected were the farmers' varieties. The species *Pisum*, *Lens* and *Lathyrus* showed negligible variations. *Cajanus* sp. showed maximum variation for different traits viz.- days to flowering/maturity and seed size, shape and colour. One accession of pigeon pea had unusually long pod bearing length. Out of 69 chickpea accessions, 41 were *deshi*, 21 *gulabi* and 7 *kabuli* types. Two accession of *deshi* have shown relatively high frequency of mutations depicting no direct selection in these accessions, thus, proving the primitiveness of the landrace being grown as variety by the framers. One accession even exhibited variation in the shape of leaflet, its tip (acute) and margin (smooth) and colour of anther lobe, which is yellow against orange in colour. In *Vigna mungo*, four accessions showed very high susceptibility to Yellow Mosaic Virus (YMV), while one of the accessions was resistant. *Vigna umbellata* and *Dolichos lablab* showed variation for seed size and seed colour.

**Table 2. Crop species collected from Madhya Pradesh**

| Crops                       | Species                                                                                                                                                                                                                                                                                                                                           | No. of accessions |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| Cereals                     | <i>Oryza sativa</i> (21), <i>Zea mays</i> (39), <i>Triticum</i> sp. (31), <i>Hordeum vulgare</i> (4), <i>Avena sativa</i> (01).                                                                                                                                                                                                                   | 346               |
| Millets                     | <i>Panicum</i> sp. (40), <i>Paspalum scrobiculatum</i> (31), <i>Setaria italica</i> 918), <i>Sorghum vulgare</i> (17), <i>Echinochloa frumentaceae</i> (11), <i>Eleusine coracana</i> (8), <i>Pennisetum typhoides</i> (03)                                                                                                                       | 128               |
| Grain<br>Legumes            | <i>Cicer arietinum</i> (69), <i>Cajanus cajan</i> (41), <i>Pisum sativum</i> (38), <i>Lens culinaris</i> (36), <i>Vigna mungo</i> (20), <i>Lathyrus sativus</i> (17), <i>Vigna radiata</i> (09), <i>Vigna umbellata</i> (02), and <i>Dolichos lablab</i> (04)                                                                                     | 236               |
| Oilseed                     | <i>Sesamum indicum</i> (29), <i>Brassica juncea</i> (27), <i>Linum usitatissimum</i> (27), <i>Guizotia abyssinica</i> (12), <i>Ricinus communis</i> (07) and <i>Jatropha</i> sp. (01)                                                                                                                                                             | 103               |
| Vegetable                   | <i>Coriandrum sativum</i> (08), <i>Solanum melongena</i> (04), <i>Cucumis</i> sp. (04), <i>Capscicum annum</i> (03), <i>Lycopersicon esculentum</i> (02), <i>Abelmoschus esculentus</i> (02), <i>Amaranthus viridis</i> (02), <i>Luffa</i> sp. (04), <i>Cucurbita maxima</i> (01), <i>Lagenaria siceraria</i> (01), <i>Vigna unguiculata</i> (01) | 32                |
| Fibre                       | <i>Crotalaria juncea</i> (05), <i>Hibiscus sabdariffa</i> (04), <i>Hibiscus cannabinus</i> (02), <i>Corchorus capsularis</i> (01)                                                                                                                                                                                                                 | 12                |
| Medicinal<br>plants         | <i>Dioscorea</i> sp. (04), <i>Jatropha curcas</i> (02), <i>Embelica ribes</i> (01), <i>Abutilon indicum</i> (01), <i>Clitoria ternatia</i> (01), <i>Gloriosa superba</i> (01), <i>Musa ferra</i> (01)                                                                                                                                             | 11                |
| Wild and weedy<br>relatives | <i>Sesamum mulyanam</i> (01), <i>Sesamum alata</i> (01), <i>Atylosia scaraboides</i> (01), <i>Vigna sublobata</i> (01), <i>Atylosia platycarpa</i> (01)                                                                                                                                                                                           | 05                |
| Fruit plants                | <i>Emblica officinalis</i> (01)                                                                                                                                                                                                                                                                                                                   | 01                |
| <b>Total</b>                |                                                                                                                                                                                                                                                                                                                                                   | <b>874</b>        |

**Oilseeds:** *Sesamum* showed variation in phyllotaxy, number of locules, maturity and seed colour. *Brassica* showed variation in seed size and maturity. *Linum* and *Guizotia* sp. showed no morphological variation amongst the accessions. *Ricinus* sp. showed variation for seed size and seed colour.

**Vegetables:** The 32 accessions over 15 species of vegetable crops showed diversity. The tomatoes grown on fencings of kitchen garden by the farmers although small in size but offers tremendous variation with regard to number of fruits/inflorescence, plant vigour, yielding ability and availability of berries for longer duration. The brinjal grown in village Barman district Narsinghpur is famous for its size and less seeds. It is preferred for making *bharta*.

**Fibre:** The genera *Hibiscus* and *Crotolaria* exhibited variation in flower colour and fruit size. The evaluations along with existing germplasm will show the true assessment of variability.

**Wild and weedy relatives:** The wild relatives of cultivated *Cajanus* sp., *Vigna* sp. and *Sesamum* have been collected and deposited in national genebank.

**Fruit plants:** Only one accession of *Embllica* sp. has been collected. The seed material is being sent to National Active Germplasm Site (NAGS) for evaluation.

#### Reference

- Shrivastava U and PL Gautam (1999) Plant germplasm collecting in India: present status, gaps in collection and future strategies, *Indian J. Pl. Genet. Resour.* 12: 123-147.

## Potential Medicinal Plants of Eastern Ghats (Orissa)

**N Dikshit, D Pani and Asit Singh**

*National Bureau of Plant Genetic Resources, Base Centre, Cuttack-753006 (Orissa)*

The eastern ghat hill ranges lies between 11° 30' and 22° N latitudes and 76° 50' and 86° 30' E longitude along the East coast of India. Floristically the region is enriched with about 2000 species of flowering plants comprising 13 % of the Indian elements (Nayar, *et al.* 1984). The chain of hill ranges of Eastern ghat in Orissa is rich repository of medicinal plants. Because of habitat degradation and over-exploitation of medicinal plants these resources are becoming scarce which needs systematic and scientific exploitation in a sustainable manner. Besides these the indigenous knowledge possessed by the local vaidyas, medicine men who are, rich source of information also needs to be documented in the changing IPR regime. With the above points in view, a study was made for survey and enumeration of important medicinal plants of Eastern ghat in Orissa. The present study is a preliminary step for screening potential medicinal plants present in the nature for traditional system of medicine.

The present paper is the result of the study done during 1999-2001. During this period, several exploration trips were conducted covering most part of the areas. The information's were collected from the local vaidyas, elder people and the medicine men of the concerned

area which were further compared with the information from various sources (Chopra, Nayar and Chopra, 1956, Chopra and Verma, 1969; Asolkar, *et al.* 1992). Besides this, we also studied the importance of medicinal plants used by the local people in their daily life. In total, information on 51 potential medicinal plant species collected during the exploration is documented and the species are enumerated with their botanical name, family, plant parts, disease, phenology and distribution. The plants were identified with the help of the flora of Orissa (Saxena and Brahmam, 1994-96). The collected germplasm are preserved in the field gene bank at NBPGR Base Centre, Cuttack.

In the present study, 51 useful medicinal plants of the Eastern ghat in Orissa are documented. It has been observed that these medicinal plants are economically important to the tribal people for various ailments. On investigation, it was found that formulations of medicinal plants either alone or in combination are used for various ailments. Disease-wise information of some plants is mentioned below and the list of the plants with their uses are given (Table 1).

Abortifacient—*Abrus precatorius*, *Aristolochia indica*, *Clitoria ternatea*, *Celastrus paniculatus*, *Withania*

**Oilseeds:** *Sesamum* showed variation in phyllotaxy, number of locules, maturity and seed colour. *Brassica* showed variation in seed size and maturity. *Linum* and *Guizotia* sp. showed no morphological variation amongst the accessions. *Ricinus* sp. showed variation for seed size and seed colour.

**Vegetables:** The 32 accessions over 15 species of vegetable crops showed diversity. The tomatoes grown on fencings of kitchen garden by the farmers although small in size but offers tremendous variation with regard to number of fruits/inflorescence, plant vigour, yielding ability and availability of berries for longer duration. The brinjal grown in village Barman district Narsinghpur is famous for its size and less seeds. It is preferred for making *bharta*.

**Fibre:** The genera *Hibiscus* and *Crotolaria* exhibited variation in flower colour and fruit size. The evaluations along with existing germplasm will show the true assessment of variability.

**Wild and weedy relatives:** The wild relatives of cultivated *Cajanus* sp., *Vigna* sp. and *Sesamum* have been collected and deposited in national genebank.

**Fruit plants:** Only one accession of *Emblica* sp. has been collected. The seed material is being sent to National Active Germplasm Site (NAGS) for evaluation.

#### Reference

- Shrivastava U and PL Gautam (1999) Plant germplasm collecting in India: present status, gaps in collection and future strategies, *Indian J. Pl. Genet. Resour.* 12: 123-147.

## Potential Medicinal Plants of Eastern Ghats (Orissa)

**N Dikshit, D Pani and Asit Singh**

*National Bureau of Plant Genetic Resources, Base Centre, Cuttack-753006 (Orissa)*

The eastern ghat hill ranges lies between 11° 30' and 22° N latitudes and 76° 50' and 86° 30' E longitude along the East coast of India. Floristically the region is enriched with about 2000 species of flowering plants comprising 13 % of the Indian elements (Nayar, *et al.* 1984). The chain of hill ranges of Eastern ghat in Orissa is rich repository of medicinal plants. Because of habitat degradation and over-exploitation of medicinal plants these resources are becoming scarce which needs systematic and scientific exploitation in a sustainable manner. Besides these the indigenous knowledge possessed by the local vaidyas, medicine men who are, rich source of information also needs to be documented in the changing IPR regime. With the above points in view, a study was made for survey and enumeration of important medicinal plants of Eastern ghat in Orissa. The present study is a preliminary step for screening potential medicinal plants present in the nature for traditional system of medicine.

The present paper is the result of the study done during 1999-2001. During this period, several exploration trips were conducted covering most part of the areas. The information's were collected from the local vaidyas, elder people and the medicine men of the concerned

area which were further compared with the information from various sources (Chopra, Nayar and Chopra, 1956, Chopra and Verma, 1969; Asolkar, *et al.* 1992). Besides this, we also studied the importance of medicinal plants used by the local people in their daily life. In total, information on 51 potential medicinal plant species collected during the exploration is documented and the species are enumerated with their botanical name, family, plant parts, disease, phenology and distribution. The plants were identified with the help of the flora of Orissa (Saxena and Brahmam, 1994-96). The collected germplasm are preserved in the field gene bank at NBPGR Base Centre, Cuttack.

In the present study, 51 useful medicinal plants of the Eastern ghat in Orissa are documented. It has been observed that these medicinal plants are economically important to the tribal people for various ailments. On investigation, it was found that formulations of medicinal plants either alone or in combination are used for various ailments. Disease-wise information of some plants is mentioned below and the list of the plants with their uses are given (Table 1).

Abortifacient—*Abrus precatorius*, *Aristolochia indica*, *Clitoria ternatea*, *Celastrus paniculatus*, *Withania*

Table 1. List of plant species with their uses

| Botanical name                                     | Phenology                                | Plant parts             | Medicinal uses                                                   | Distribution                                           |
|----------------------------------------------------|------------------------------------------|-------------------------|------------------------------------------------------------------|--------------------------------------------------------|
| <i>Abrus precatorius</i><br>(Fabaceae)             | Fl- Aug.- Sept.<br>Fr-Nov.-March         | Seeds, Roots            | Easy abortion of foetus,<br>snake bite                           | Similipal, Boudh<br>Gandhamardan,<br>Bolangir, Sonepur |
| <i>Achyranthes aspera</i><br>(Amaranthaceae)       | Fl. and Fr.-<br>Oct.- Feb.               | All parts               | Stomach pain, fever,<br>contraceptive, headache                  | Kandhamal, Boudh<br>Bolangir, Sonepur                  |
| <i>Andrographis paniculata</i><br>(Acanthaceae)    | Fl. and Fr. –<br>Sept. – May             | All parts               | Blood purification, excessive<br>bile check-up                   | Dhenkanal                                              |
| <i>Argyrea speciosa</i><br>(Convolvulaceae)        | Fl.-July – Sept.<br>Fr- Nov.-April       | Roots, Leaves           | Nervous system, wounds,<br>skin diseases                         | Aska, Ganjam                                           |
| <i>Aristolochia indica</i> *<br>(Aristolochiaceae) | Fl. – July- Oct.<br>Fr- Nov.- Feb.       | Roots, Seeds            | Abortifacient, cough                                             | Mayurbhanj, Koraput,<br>Sambalapur,                    |
| <i>Asparagus racemosus</i><br>(Liliaceae)          | Fl.- Sept.- Oct.<br>Fr- Nov.- Dec.       | Tuber, Roots            | Aphrodisiac, total strength,<br>skin disease, dysentery          | Similipal, Phulbani<br>Gandhamardhan,<br>Dhenkanal,    |
| <i>Caesalpinia crista</i><br>(Caesalpiniaceae)     | Fl.-Feb.-April<br>Fr.-April- May         | Leaves, Seeds           | Asthma, snake bite, swelling                                     | Gandhamardhan                                          |
| <i>Calotropis gigantea</i><br>(Asclepiadaceae)     | Fl.-Dec.- July<br>Fr- Feb.- June         | Bark, Roots             | Cold, cough, asthma, snake<br>bite, rheumatism                   | Similipal                                              |
| <i>Celastrus paniculatus</i><br>(Celastraceae)     | Fl.-April-June,<br>Fr- Oct.-Jan.         | Bark, Leaves,<br>Seeds  | Abortifacient, cold, gout oil-<br>mosquito repellent, rheumatism | Similipal                                              |
| <i>Centella asiatica</i><br>(Apiaceae)             | Fl. and Fr. –<br>Throughout the<br>year  | Leaves                  | Memory power, eye trouble,<br>fever                              | Similipal                                              |
| <i>Chloroxylon swietenia</i><br>(Rutaceae)         | Fl. –<br>March - April,<br>Fr.-May- June | Leaves, Seeds           | Healing wounds, Rheumatism                                       | Mahendragiri, Ganjam,<br>Angul                         |
| <i>Cissampelos pareira</i><br>(Menispermaceae)     | Fl. June - Nov.<br>Fr- Nov.- Jan.        | Roots, Leaves           | Inflammation, wounds, eye<br>troubles, boils                     | Dhenkanal and<br>Similipal                             |
| <i>Cissus quarangularis</i><br>(Vitaceae)          | Fl. and Fr.-<br>April- Jan.              | Stem, Roots             | Fracture bones, eye diseases                                     | Similipal, Anugul<br>Dhenkanal                         |
| <i>Clitoria ternatea</i><br>(Fabaceae)             | Fl.- July- Oct.<br>Fr- Nov.-Dec.         | Roots                   | Abortion, snake bite                                             | Dhenkanal and<br>Gandhamardhan                         |
| <i>Coleus amboinicus</i><br>(Lamiaceae)            | Fl. and Fr.-<br>Oct.- Dec.               | Leaves                  | Scorpion sting, urinary disease                                  | Dhenkanal, Ganjam<br>Phulbani                          |
| <i>Costus speciosus</i><br>(Costaceae)             | Fl. and Fr.-<br>July –Dec.               | Rhizomes                | Dysentery, digestive trouble                                     | Eastern ghat                                           |
| <i>Curculigo orchoides</i> **<br>(Amaryllidaceae)  | Fl.-April- Sept.                         | Rhizomes                | Cuts, skin disease, headache,<br>good health                     | Dhenkanal                                              |
| <i>Datura metel</i><br>(Solanaceae)                | Fl. and Fr.-<br>Throughout<br>the year   | Leaves, Roots,<br>Seeds | Cough, asthma, making liquor,<br>toothache                       | Gandhamardhan, i<br>Similipal, Dhenkanal               |
| <i>Datura stramonium</i><br>(Solanaceae)           | Fr- Nov.                                 | Flower, Fruits          | Earache, dandruff falling hair                                   | Sambalpur                                              |
| <i>Desmodium gangeticum</i><br>(Fabaceae)          | Fl. and Fr. –<br>May - Jan.              | Roots                   | Fever, cough, vomiting,<br>asthma                                | Dhenkanal, Bolangir,<br>Boudh                          |
| <i>Diplocyclos palmatus</i><br>(Cucurbitaceae)     | Fl. and Fr. –<br>Oct.- Jan.              | All parts               | Conception, swelling, increase<br>sperm quality                  | Similipal, Koraput,<br>Dhenkanal,<br>Gandhamardhan     |

| Botanical name                                     | Phenology                                                       | Plant parts            | Medicinal uses                                                                     | Distribution                                                                              |
|----------------------------------------------------|-----------------------------------------------------------------|------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| <i>Eclipta alba</i><br>(Asteraceae)                | Fl. and Fr. –<br>Aug.- April                                    | Leaves, Roots          | Cattarrh in infants, ulcers and<br>wounds in cattle                                | Eastern ghat                                                                              |
| <i>Gloriosa superba**</i><br>(Liliaceae)           | Fl.-Sept.- Nov.<br>Fr.- Nov.- Dec.                              | Roots                  | Leprosy, piles, snake bite,<br>scorpion sting                                      | Ghantasila, Koraput,<br>Ganjam, Mahendragiri                                              |
| <i>Gymnema sylvestre**</i><br>(Asclepiadaceae)     | Fl.-Aug.- Oct.<br>Fr.-Jan.-March                                | Leaves, Roots          | Effective in diabetes, stomach<br>pain                                             | Similipal, Ganjam,<br>Bolangir, Boudh<br>Gandhamardhan                                    |
| <i>Holarrhena antidysenterica</i><br>(Apocynaceae) | Fl.-May- July<br>Fr.-Oct.- Feb.                                 | Bark,<br>Seeds         | Curing amoebic, antidyenteric,<br>dropsy, headache, fever                          | Similipal                                                                                 |
| <i>Hygrophila spinosa</i><br>(Acanthaceae)         | Fl. and Fr. –<br>Oct.-Feb.                                      | Seeds, Leaves          | Jaundice, anasarca<br>urinogenitaltract, dropsy                                    | Dhenkanal                                                                                 |
| <i>Kalanchoe lacinata</i><br>(Crassulaceae)        | Fr.- April                                                      | Leaves                 | Insect bite, dysentery                                                             | Similipal, Sambalpur                                                                      |
| <i>Mucuna pruriens</i><br>(Fabaceae)               | Fl- Sept.- Nov.<br>Fr.- Jan.- April                             | Seeds, Roots           | Dropsy, purgative, elephantiasis                                                   | Similipal                                                                                 |
| <i>Ocimum basilicum</i><br>(Lamiaceae)             | Fl. and Fr-<br>Sept.- June                                      | All parts              | Dysentery, diarrhoea, bowel<br>complaints of children, cough                       | Sambalpur, Similipal,<br>Batipathar,<br>Grishchandpur                                     |
| <i>Ocimum sanctum</i><br>(Lamiaceae)               | Fl. and Fr.-<br>Dec.- Jan.                                      | All parts              | Genito urinary system,<br>antibacterial, mosquito repellent,<br>insecticidal       | Similipal                                                                                 |
| <i>Oroxylum indicum</i><br>(Bignoniaceae)          | Fl. July- Aug.<br>Fr-Dec.-March                                 | Bark, Stem,<br>Seeds   | Hydrocele problem, astringent,<br>oil used for earache                             | Similipal, Boudh<br>Dhenkanal, Ganjam,<br>Koraput, Bolangir,<br>Sonepur,<br>Gandhamardhan |
| <i>Paederia scandens</i><br>(Rubiaceae)            | Fl. –Aug.- Oct.                                                 | Leaves                 | Diarrhoea, bowel trouble                                                           | Similipal                                                                                 |
| <i>Phyllanthus emblica</i><br>(Euphorbiaceae)      | Fl.- Feb.- May<br>Fr. Oct. - April<br>Deciduous-<br>May - April | All parts              | Laxative, diarrhoea, jaundice,<br>cough, asthma                                    | Gandhamardhan                                                                             |
| <i>Plumbago rosea</i><br>(Plumbaginaceae)          | Fl.and Fr.-<br>Nov.-March                                       | Roots                  | Scabies, oil useful in rheumatism<br>and paralysis                                 | Ajayagada,<br>Mahendragiri, Ganjam                                                        |
| <i>Plumbago zeylanica</i><br>(Plumbaginaceae)      | Fl. and Fr.-<br>Sept.- April                                    | Roots                  | Appetizer, epilepsy, ulcers,<br>rheumatism, chest pain                             | Dhenkanal                                                                                 |
| <i>Pterocarpus santalinus</i><br>(Fabaceae)        | Fl.- Apr.- July<br>Fr.-Aug.- Oct.                               | Wood                   | Strengthening the sight,<br>inflammation, headache,<br>inbiliousness, skin disease | Similipal                                                                                 |
| <i>Rauwolfia serpentina*</i><br>(Apocynaceae)      | Fl. and Fr.-<br>May - Nov.                                      | Roots, Leaves          | Reduces blood pressure, antidote<br>to insect and snake bite                       | Gandhamardhan                                                                             |
| <i>Scindapsus officinalis</i><br>(Araceae)         | Fr.- June- July,<br>Fr.- Jan.                                   | Fruits, Seeds          | Rheumatism, asthma bronchitis,<br>menstrual disorders                              | Similipal, Malayagiri,<br>Dhenkanal                                                       |
| <i>Smilax macrophylla</i><br>(Liliaceae)           | Fl.- Apr.- July<br>Fr.- Oct.- Jan.                              | Roots                  | Blood less dysentery, venereal<br>disease, rheumatism                              | Similipal                                                                                 |
| <i>Solanum xanthocarpum</i><br>(Solanaceae)        | Fl. and Fr.-<br>All the year round                              | All parts              | Cough, asthma, sore throat,<br>toothache, vomiting                                 | Similipal                                                                                 |
| <i>Strychnos nux-vomica</i><br>(Loganiaceae)       | Fl.- Mar.- Apr.<br>Fr.- Dec.- Jan.                              | Roots, Bark,<br>Leaves | Febrifuge, useful in<br>homeopathic system                                         | Similipal, Dhenkanal,<br>Nayagarh, Rayagada                                               |

| Botanical name                                    | Phenology                           | Plant parts             | Medicinal uses                                          | Distribution                                                               |
|---------------------------------------------------|-------------------------------------|-------------------------|---------------------------------------------------------|----------------------------------------------------------------------------|
| <i>Strychnos potatorum</i><br>(Loganiaceae)       | Fl.-May<br>Fr.- Oct.- Dec.          | Seeds                   | Eye disease, diabetes, dysentery, gonorrhoea            | Similipal, Ganjam<br>Kalahandi, Sambalpur,<br>Gandhamardhan                |
| <i>Terminalia bellirica</i><br>(Combretaceae)     | Fl.- Mar.-May<br>Fr.- Oct.- Dec.    | Fruits                  | Piles, dropsy, headache sore throat                     | Similipal,<br>Gandhamardhan,<br>Dhenkanal                                  |
| <i>Terminalia chebula</i><br>(Combretaceae)       | Fl.-Mar.-April<br>Fr.-Nov.- Dec.    | Fruits                  | Cold, cough, skin disease                               | Dhenkanal, Similipal,<br>Gandhamardhan                                     |
| <i>Tinospora cordifolia</i><br>(Menispermaceae)   | Fl.- Aug.-Dec.<br>Fr.- Mar.-May     | Stem, Roots             | Chronic diarrhoea, dysentery, malaria                   | Dhenkanal                                                                  |
| <i>Trichosanthes bracteata</i><br>(Cucurbitaceae) | Fl.-Aug.-Sept.<br>Fr. -Nov.- Dec.   | Fruits, Roots           | Rheumatism, oil used to cure hemicramia,                | Dhenkanal                                                                  |
| <i>Urginea indica</i> **<br>(Liliaceae)           | Fl. -Mar.- May<br>Fr.- May - July   | Bulb                    | Bronchial catarrh, chronic dysentery                    | Dhenkanal, Bolangir,<br>Mayurbhanj, Bargad,<br>Gandhamardhan,<br>Kalahandi |
| <i>Valeriana officinalis</i><br>(Valerianaceae)   | Fl. and Fr.-<br>Aug.- Nov.          | Roots                   | Stimulant, antiseptic, hysteria, epilepsy               | Mahendragiri                                                               |
| <i>Vernonia anthelmintica</i><br>(Asteraceae)     | Fl.- Sept.- Dec.<br>Fr.- Nov.- Jan. | Seeds                   | Asthma, skin disease, scorpion sting                    | Similipal                                                                  |
| <i>Wedelia chinensis</i><br>(Asteraceae)          | Fl and Fr.-<br>Sept.- April         | All parts               | Hair growth and dyeing, cough, menorrhagia              | Aska, Ganjam,<br>Mahendragiri                                              |
| <i>Withania somnifera</i><br>(Solanaceae)         | Fl. and Fr.-<br>Oct.-May            | Roots, Leaves,<br>Seeds | Abortifacient, debility from old age, painfull swelling | Dhenkanal                                                                  |

Note: Fl: flowering, Fr-Fruiting \* Endangered, \*\* Vulnerable

*somnifera*, Antidote to snake venom – *Rauvolfia serpentina*, Diabetes – *Gymnema sylvestre*, *Strychnos potatorum*, Dandruff, falling hair or madness – *Datura stramonium*, Epilepsy – *Valeriana officinalis*, *Plumbago zeylancia*, Jaundice – *Phyllanthus emblica*, *Hygrophila spinosa*, Fever – *Achyranthes aspera*, *Strychnos nux-vomica*, Menstrual disorder- *Scindapsus officinalis*, Paralysis – *Plumbago rosea*, Snake bite – *Clitoria ternatea*, *Caesalpinia crista*, *Gloriosa superba*, *Calotropis gigantia*, Urinary discharge – *Coleus amboinicus*.

Due to extensive use of the species and deforestation, the natural populations of medicinal plant resources are becoming scarce and vanishing. Out of the total collections two species viz.- *Rauvolfia serpentina* and *Aristolochia indica* are endangered and four species viz.- *Curculigo orchiodes*, *Gloriosa superba*, *Gymnema sylvestre* and *Urginea indica* are vulnerable. Thus, there is an urgent

need for systematic and scientific exploitation in a sustainable manner, for conservation and long-term use of rare species of the region.

#### References

- Chopra RN, SL Nayar and IC Chopra (1956) Glossary of Indian medicinal plants. CSIR, New Delhi. 330 p.
- Chopra RN., IC Chopra and BS Verma (1969) Supplement to glossary of Indian medicinal plants, CSIR, New Delhi. 119p.
- Nayar MP, M Ahmed and DCS Raju (1984) Endemic and rare plants of eastern ghats. *Indian. J. Forest.* 7(1): 35-42.
- Asolkar LV, KK Kakkar and OJ Chakre (1992) Second supplement to glossary of Indian medicinal plants with active principles, part 1(A-K) 1965-1981, CSIR, New Delhi. 414p.
- Saxena HO and M Brahman (1994-96) The flora of Orissa. Regional Research Laboratory, Bhubaneswar and Orissa Forest Development Corporation Ltd. Bhubaneswar, Vol. 1-4: 2918 p.

## Pathogenic Fungi Intercepted in Introduced Germplasm during the Year 2000

PC Agarwal, Baleshwar Singh, Indra Rani, KD Joshi, AK Maurya and RK Khetarpal

Division of Plant Quarantine, National Bureau of Plant Genetic Resources, New Delhi-110012

**Key Words:** Quarantine, Germplasm, Pathogenic fungi

The Division of Plant Quarantine at NBPGR, on an average examines more than 65,000 introduced samples of various crops each year. During these examinations a large number of pathogenic fungi of quarantine significance have been intercepted on a variety of crops (Agarwal *et al.* 1998, Agarwal *et al.* 2000). This paper deals with pathogenic fungi intercepted during the year 2000 in various germplasm samples introduced.

In the year 2000, a total of 1,22,183 samples of different crops were processed for quarantine clearance. Introduced germplasm included true seeds, rooted plants, cuttings, rhizomes, suckers, bulbs, nuts and tissue culture plantlets, *etc.* All the seed samples were first examined under a stereo-binocular microscope for the presence of fungal fructifications and for symptoms such as discoloration, malformation and deformation. Unhealthy

looking seeds were placed on moist blotters in plastic Petri-plates (the number of seeds/plate varied depending upon the size of the seed and the sample) and incubated for 7 days at  $20\pm 2^{\circ}\text{C}$  under alternating cycles of 12 h light and darkness. Observations for the associated pathogenic fungi were recorded on the eighth-day under a stereo-binocular microscope. Slides were also made and observed under compound microscope whenever needed. Chemically treated samples of various crops were grown in Post Entry Quarantine Nursery (PEQN).

A number of pathogenic fungi of great economic significance were intercepted on different crops and their wild relatives (Table 1). During visual examination by the unaided eye, sclerotia of *Claviceps purpurea*, was found mixed with the seed samples of wheat from

**Table 1. Pathogenic fungi intercepted in introduced germplasm during the year 2000**

| Fungi intercepted                  | Crop                           | Source             |
|------------------------------------|--------------------------------|--------------------|
| <i>Alternaria brassicae</i>        | <i>Brassica</i> spp.           | Australia, Canada  |
| <i>A. brassicicola</i>             | <i>Brassica</i> spp.           | Australia, Canada, |
| <i>Botrytis cinerea</i>            | <i>Vitis vinifera</i>          | Russia             |
|                                    | <i>Ribes</i> sp.               | USA                |
| <i>Claviceps fusiformis</i>        | <i>Pennisetum typhoides</i>    | Nigeria            |
| <i>C. purpurea</i>                 | <i>Triticum aestivum</i>       | Switzerland        |
| <i>Colletotrichum dematium</i>     | <i>Glycine max</i>             | USA                |
| <i>Drechslera longirostrata</i>    | <i>Pennisetum typhoides</i>    | Nigeria            |
| <i>D. sorghicola</i>               | <i>Pennisetum typhoides</i>    | Nigeria            |
|                                    | <i>Zea mays</i>                | Mexico, Thailand   |
|                                    | <i>Lycopersicon esculentum</i> | Thailand           |
| <i>D. sorokiniana</i>              | <i>Triticum aestivum</i>       | Australia, Syria   |
| <i>D. rostrata</i>                 | <i>Pennisetum typhoides</i>    | Nigeria, USA       |
|                                    | <i>Zea mays</i>                | Thailand           |
|                                    | <i>Triticum aestivum</i>       | Mexico             |
| <i>D. oryzae</i>                   | <i>Oryza sativa</i>            | Uganda             |
| <i>Fusarium solani</i>             | <i>Prunus persica</i>          | Italy              |
|                                    | <i>Capsicum annum</i>          | Taiwan             |
|                                    | <i>Sesamum indicum</i>         | Bulgaria           |
| <i>Macrophomina phaseolina</i>     | <i>Glycine</i> spp.            | USA                |
| <i>Peronospora manshurica</i>      | <i>Glycine max</i>             | USA                |
| <i>Phomopsis sojae</i>             | <i>Carthamus tinctorious</i>   | USA                |
| <i>Puccinia carthami</i>           | <i>Helianthus annuus</i>       | Australia, France  |
| <i>P. helianthi</i>                | <i>Brassica juncea</i>         | Australia, Canada  |
| <i>Phoma lingam</i>                | <i>Pennisetum typhoides</i>    | USA, Nigeria       |
| <i>Tolyposporium penicillariae</i> |                                |                    |

Switzerland. This ergot pathogen of wheat has been reported only once on a single ear head of barley and *Stipa sibirica* from India and is not reported on wheat. Observation of seeds under stereo-binocular microscope revealed crusts of oospores of *Peronospora manshurica*, the downy mildew fungus on soybean seed received from USA and teliospores and uredospores of *Puccinia carthami* on safflower seeds also received from USA. *Peronospora manshurica* is reported worldwide (CMI 1979), has so far not been recorded from India. Oospores of this downy mildew could remain viable for 8 years (Pathak *et al.* 1978) and 33 physiological races have been reported from USA alone (Dunleavy, 1997; Lim *et al.* 1984). In all 38 samples of soybean found infected with this downy mildew were rejected and destroyed. Teliospores of *Puccinia carthami* carried on the seeds of safflower were reported to have caused serious epiphytotic of the safflower in the USA in 1949 and 1950 (Thomas, 1952). *Puccinia carthami*, *P. carduncelli*, *P. verruca*, and *Melampsora ricini* have been reported on *Carthamus* spp. (CMI, 1968). In India, however, only *P. carthami* has been recorded on *Carthamus tinctorius* Linn. and *C. oxyacantha* M. Bieb. (Prasada and Chotia, 1950). There is always a likelihood of introducing other three rusts along with the import of safflower seeds.

Observation of seeds incubated on moist blotters revealed a large number of economically significant pathogens. *Botrytis cinerea*, the grey mould fungus that was detected in a number of crops, has a wide host range and caused heavy crop losses of chickpea in states of Bihar, Haryana, Punjab and U.P. (Lambat *et al.* 1985). While, *B. cinerea* is considered as a common saprophyte in European countries.

*Alternaria brassicae* detected on seeds of *Brassica* spp. has become a major problem due to its spread from rape-seed at harvest to seeds of other *Brassica* spp. Chahal and Kang (1979) reported internal seed borne infection of *A. brassicae* at levels of 59% in India.

*Colletotrichum dematium*, *Drechslera sorokiniana*, *Fusarium solani* and *Macrophomina phaseolina*, are known to possess a wide host range. These pathogens have been intercepted on a large number of hosts from different countries.

**Observation of crops raised in PEQN:** Loose smut of wheat (*Ustilago segetum* var. *tritici*) was intercepted in 2 entries (*i.e.* IBWSN-Entry No. 58 and 3<sup>rd</sup> EGPSN-Entry No. 123) from CIMMYT, Mexico and loose smut of barley (*U. nuda*) in one entry (IBYT-LRA-MW-Entry No. 19) from ICARDA, Syria. Infected plants were uprooted and destroyed.

Interception of pathogens not known to occur in India, or those that possess physiologic races or have a wide host range emphasize the need to conduct a thorough and critical test of seed health during quarantine processing.

## References

- Agarwal PC, Usha Dev, Baleshwar Singh, Ram Nath, A Majumdar, Indra Rani, Dinesh Chand and KD Joshi (2000) Pathogenic Fungi Intercepted in Germplasm Introduced During 1995-99. *Indian J. Plant Genet. Resour.* 14: In Press.
- Agarwal PC, Baleshwar Singh and PL Gautam (1998) Plant quarantine as an aid to safer exchange, conservation and utilization of plant genetic resources. *Indian J. Plant Genet. Resour.* 11: 165-171.
- Chahal AS and MS Kang (1979) Some aspects of seed-borne infection of *Alternaria brassicae* in rape and mustard cultures in Punjab. *Indian J. Mycol. Plant Pathol.* 9: 51-55.
- CMI (1968) *Descriptions of Pathogenic Fungi and Bacteria*. No. 174. Commonwealth Mycological Institute, Kew, Surrey, England.
- CMI (1979) *Distribution Maps of Plant Diseases*. Map No. 268, edn 3. Commonwealth Mycological Institute, Kew, Surrey, England.
- Dunleavy JM (1977) Nine new races of *Peronospora manshurica* found on soybean in the Mid West. *Plant Disease Reporter* 61: 661-663
- Lambat AK, Ram Nath, PC Agarwal, RK Khetarpal, Usha Dev, P Kaur, A Majumdar, JL Varshney, PM Mukewar and Indra Rani (1985) Pathogenic fungi intercepted in imported seed and planting material during 1982. *Indian Phytopathol.* 38: 109-111.
- Lim SM, RL Bernard, CD Nickell and LE Gray (1984) New physiological races of *Peronospora manshurica* virulent to the gene Rpm in soybeans. *Plant Disease*. 68: 71-72.
- Pathak VK, SB Mathur and P Neergaard (1978) Detection of *Peronospora manshurica* (Naum.) Syd. In: *Seeds of soybean, Glycine max. European and Mediterranean Plant Protection Organization Bulletin*. 8: 21-28.
- Prasada R and MP Chotia (1950) Studies on safflower rust in India. *Phytopathology*. 40: 363-367.
- Thomas CA (1952) Transmission of safflower rust on treated seeds. *Phytopathology*. 42: 108-109.

## Origin, Evolution and Diffusion of Maize (*Zea mays* L.)

**JKS Sachan and BB Singh**

*Division of Genetics, Indian Agricultural Research Institute, New Delhi-110012*

**Key Words:** Maize, *Zea mays*, Origin, Evolution, Teosinte, Hybridization

### Pattern of evolution in maize and its wild relatives:

To study the (1) phylogeny of maize (2) origin of maize and (3) antiquity of maize in India, multidisciplinary approach *e.g.* chromosome differentiation, isoenzyme polymorphism, knob-heterochromatin distribution, crossability relationships, exine sculpture, ethnobotany *etc.* have been adopted. A large number of collections of North-Eastern Himalayan (NEH) maize along with established Mesoamerican races and the wild relatives of maize such as teosinte (*Zea diploperennis*, *Z. luxurians*, *Z. parviglumis*, *Z. mexicana*), *Coix* spp., *Chionachne* spp. and *Trilobachne cookei* have been subjected to above studies.

*Cytological characterization of North-Eastern Himalayan (NEH) maize:* Because of the distance from the centre of origin, the antiquity and diversity of NEH maize is of considerable evolutionary significance. The NEH maize diversity has been characterized by the distribution pattern of constitutive heterochromatin, discernible by knobs, C- and Q-bands. Specific geographic pattern of C-heterochromatin has been observed. Frequency and combination of various knobs is the characteristic of different complexes.

Altogether 26 knob forming positions have been observed in NEH maize. Four new knob forming positions *i.e.* 1Lb, 2Lb, 2Lt and 9Lb have been identified in NEH maize. The knob constellation 2La, 4L, 6S, 6Lb, 8La and 9St is the characteristic feature of NEH maize. The occurrence of knob at 1La, 3L, 5L, 6Lc, 7St, 7L and 8Lb positions is less frequent. The NEH maize has been further characterized and grouped into two complexes (a) high knob number, strains with frequent positions at 2La, 4L, 6S, 8L and 9St, and (b) low knob number strains having frequent knobs at 3L, 6LB and 7L.

The Sikkim Primitive (SP) maize has been treated separately because of its unique characteristics. The knob constellation of SP maize (T-2 and Murlia) and the Nal-Tel, a Mexican primitive race share the following common knob positions. 2La, 4L, 5L, 6Lb, 6Lc, 7L, 8La, 8Lb, 9S and 9L. The lineage of SP maize has been assigned

to Nal-Tel Chapalote complex of Mexico. This suggests that Sikkim Primitive maize is the prototype of pre-historic wild corn.

*Karyotypic studies in maize and its wild relatives:* The study of the karyotype has been realized as an aid to evolutionary significance. When 28 collections of *Coix* from different geographical regions were used for their karyotypic studies, it was found that different populations of Indian origin largely fell into 2 major groups, *i.e.* (i) those with chromosome complement of  $2n = 10$  (*Coix aquatica*) and (ii) *C. lacryma-jobi* with  $2n = 20$ . The genomic length of *C. aquatica* was smallest (33.25  $\mu\text{m}$ ) with mean chromosome length 6.64  $\mu\text{m}$ . The genomic length of *C. lacryma-jobi* and *Zea mays* were 80.64  $\mu\text{m}$  and 87.43  $\mu\text{m}$ , respectively. The relative length, arm ratio and centromeric index widely varied in these three taxa. The karyotype of maize is symmetrical and entirely different from *Coix*.

*Trilobachne cookei* showed bimodel karyotype ( $2n=20$ ) having six telocentric, two metacentric and two submetacentric pairs of chromosomes. The arm ratio greatly varied from 1.09 to 7.5. *Chionachne koenigii* also showed  $2n = 20$  karyotype with nine pairs of submetacentric and one pair of metacentric chromosomes. Maize and teosinte showed similar karyotype. The karyotypes of *Coix*, *Chionachne* and *Trilobachne* did not show any relationship with *Zea*.

A new cytotype of *Coix*-28 with chromosome number  $2n=18$  without any meiotic abnormality has been identified. This suggests that basic chromosome number in *Coix* spp. is 5.

*Distribution of constitutive heterochromatin in maize and its wild relatives:* The distribution of C- and Q-bands in maize and teosinte were terminal and sub-terminal which were comparable to each other. Chromosome banding patterns of maize and teosinte showed reciprocal introgression of C-heterochromatin. Striking differences in the distribution of C-heterochromatin have been observed between American and Asiatic genera of Maydeae. Among the *Coix* spp. only cultivated *Coix*

showed 22 small terminal bands while wild *Coix* did not reveal any band, however, chromosomes were differentiated by enhanced and reduced fluorescence. *Trilobachne* manifested minute centromeric C-heterochromatin in all the chromosomes. *Chionachne* did not reveal any C- or Q-band.

**Pachytene analysis of *Coix* and maize:** For the first time detailed study of pachytene chromosomes of *C. aquatic* along with maize and teosinte have been made. The relative length of chromosomes in 26 collections of *Coix* ranged from 13.55-28.28. The total genomic length in maize, teosinte and *Coix* was 565  $\mu\text{m}$ , 547  $\mu\text{m}$  and 838  $\mu\text{m}$ . The genome of *Coix* is quite dissimilar to teosinte (*Zea diploperennis*, *Z. luxurians*, *Z. parviglumis*) and maize.

The wild *Coix* chromosomes are devoid of knobs. However, cultivated coix possess small terminal knobs.

*Coix*-21 and *Coix*-63 have shown structural heterozygosity. The hexavalents have been consistently observed. The pollen fertility was 75% and the normal seed set has been observed.

**Genetic distance studies based on isoenzyme polymorphism:** Elaborate studies on electrophoretic movement of different isoenzymes e.g. esterase, glutamate dehydrogenase, peroxidase, superoxide dismutase, catalase, malate dehydrogenase, acid phosphatase have been undertaken. Among the tribe Maydeae genetic distance was the least (0.30) between maize and teosinte. While *Chionachne* and *Coix* (GD=0.83) were apart from maize and teosinte. *Coix* and *Chionachne* were distantly related with (GD=0.65) each other. Based on GD the heirarchical order of Maydeae is as follows:

Maize: Teosinte > *Coix* > *Trilobachne* > *Chionachne*

Analysis of isozyme polymorphism in Maydeae indicated the prevalence of wider diversity not only at inter-generic level but also at inter- and intra-specific levels. Based on phylogenetic relationships genetic distances between teosinte and maize, three groups have been formed. Teosinte(s) (with large amount of C-heterochromatin) e.g. *Zea diploperennis*, *Z. luxurians* and *Z. mexicana* are distinct from a group and lie at one end. The maize races with low C-heterochromatin e.g. Confite Morocho and Palomero Taluqueno lie at another extreme end. While the races like Pira and Sikkim Primitive with intermediate C-heterochromatin lie in the middle indicating that these races are product of teosinte introgression into maize.

**Scanning electron microscopic studies of pollen grains in Maydeae:** Detailed study of pollen exine surface in various collections of maize, *Coix*, *Chionachne*, *Trilobachne*, teosinte and sorghum have been made through SEM. In these genera pollen grain size was found to vary between 31.25  $\mu\text{m}$  (*Chionachne*) to 124.70  $\mu\text{m}$  (SP maize). The mean pollen grain size in maize was 106.14  $\mu\text{m}$  followed by teosinte (85.11  $\mu\text{m}$ ), *Coix* (55.99  $\mu\text{m}$ ) and *Chionachne* (34.70  $\mu\text{m}$ ).

Enormous variation in distribution pattern of spinules on the pollen surface has been observed in different genera of Maydeae. Pollen surface of the three species of teosinte and maize was similar. The spinules were dense and uniformly distributed. In *Coix* spinules were thinly distributed and followed curved path. In *Chionachne* spinules were sparse and in sorghum they tend to form groups of 8-12. These studies suggest that maize and teosinte are closely related and other genera of Asiatic Maydeae are not related.

**Ethnobotanical studies and the antiquity of maize in India:** Beaded ornamentation of the objects in the hands of deities in the temples of Somnathpur, Halebid and Belur of Karnataka state has aroused considerable interest regarding presence of maize in peninsular India in medieval period. However, through our meticulous studies based on religious, linguistic, sculptural, archaeological, agricultural and botanical records, it is concluded that the beaded objects in the hands of sculptural friezes do not represent maize. The pre-Columbian antiquity of Sikkim Primitive maize of the NEH region has no relevance with the maize like objects in Karnataka temples. There is no evidence of diffusion of NEH maize to peninsular India.

#### Studies on Distant Hybridization

**Crossability relationship in maize and its wild relatives:** To overcome the pre- and post-fertilization barriers in crosses between maize and its wild relatives pollen tube growth in vivo has been studied through fluorescence microscopy. It was observed that the pollens of *Chionachne*, *Coix*, *Trilobachne* and *Tripsacum* do germinate on the silks of maize but pollen tubes do not travel up to the ovule. By cutting the silks and pollinating the maize ears at the base on the silk, the seed development up to 15 days has been observed. Crosses between maize x *Chionachne* have shown seed development up to 100% and in maize x *Coix* spp. up to 25%. Therefore, wide crosses are within reach through embryo rescue.

Fluorescence study of pollen tube growth of SP maize on *Coix* has shown that maize pollen tube fertilizes the *Coix* embryo.

**Chiasma frequency and chromosome association in wide crosses:** Observation of chiasma frequency and chromosome configuration in maize x teosinte (*Zea diploperennis*, *Z. luxurians* *Z. parviglumis*) have shown reciprocal differences in chiasma frequency. In general there was decrease in chiasma frequency in all reciprocal crosses as compared to direct crosses e.g. CM 105 x *Z. diploperennis* chiasma frequency per cell was 19.55 as compared to its reciprocal cross (18.24). The chiasma frequency was reduced significantly per cell in reciprocal crosses (deviation range 1.3 to 2.68)/cell.

Reduction in chiasma frequency (per cell) was observed in all the maize x teosinte crosses. The deviation observed to be maximum in maize x *Zea diploperennis* (-5.28) and minimum in maize x *Zea parviglumis* (-1.49) over the mean parental values. This suggests that *Z. diploperennis* is more primitive than *Z. parviglumis*. Based on the degree of chiasma frequency following relationships have been deduced: *Z. diploperennis* > *Z. luxurians* > *Z. parviglumis* > *Z. mays*.

**Amphiploid theory of maize origin:** The secondary association of bivalents in various maize-teosinte (*Zea diploperennis*, *Z. luxurians* *Z. parviglumis*) have suggested the amphiploid ( $2n=4x = 2.0$ ) nature of maize origin. The secondary association of 5:5, 6:4 and 3:2:2:2 of bivalents at metaphase-I has been consistently observed.

When stock-6 derived haploid plants were meiotically analyzed, chromosome grouping was very much pronounced at diakinesis and metaphase I. About 75% of the cells showed grouping of 5.5. Five groups of two bivalents were noticed in 15% of the cells. These observations suggest that basic chromosome number in maize is 5.

**Biphyletic origin of maize:** In wide hybridization studies a series of maize-teosinte crosses were made and advanced progenies were generated. Primitive and advanced races of maize were crossed to diploid perennial teosinte (*Zea diploperennis*,  $2n = 20$ ), *Z. luxurians*, *Z. parviglumis* and *Z. mexicana*. Strikingly, segregating population of primitive maize and the most primitive teosinte (*Z. diploperennis*) consistently exhibited the phenomenon of catastrophic sexual transmutation (CST). This CST theory envisages that maize ear is the transformed, feminized central spike of tassel terminating the primary

branches of teosinte. The teosinte alone never transforms into maize. Only the primitive maize x *Z. diploperennis* combination transforms into maize. This suggest the biphyletic origin of maize. One ancestor being *Z. diploperennis* and other being primitive wild corn.

**Reduction in knob number in maize x teosinte hybrids:** Interesting phenomenon of disappearance of knob in maize x teosinte crosses have been noticed. This has adaptive significance of an organism under genomic stress environment.

| Material                 | Terminal knobs       | Inter-calary knobs   |
|--------------------------|----------------------|----------------------|
| CM111                    | 1                    | 7                    |
| Pira                     | 1                    | 9                    |
| <i>Zea diploperennis</i> | 6                    | 6                    |
| <i>Z. luxurians</i>      | 10                   | 5                    |
| CMIII x <i>Z. dip.</i>   | 1<br>(Reduction 83%) | 4<br>(Reduction 43%) |
| CMIII x <i>Z. lux.</i>   | 2<br>(Reduction 80%) | 5<br>(Reduction 29%) |
| Pira x <i>Z. lux.</i>    | 3<br>(Reduction 70%) | 8<br>(Reduction 11%) |

The reduction of terminal knob was more than the inter-calary knobs.

**Clonal and Micropropagation in Maize:** Homeotic transformation of male florets into plantlets *in vivo* in maize x teosinte hybrids have been studied. Lemma and palea are transformed into first and second leaf of the plantlet. These plantlets grow *in situ* and develop into complete miniature plants of 20-80 cm in height and produce aerial roots, tassel and seeds. In certain cross combinations direct emergence of plantlets have been observed from almost all the glumes e.g. CMIII x *Zea diploperennis* (98%) and in Palomero toluqueno x *Zea parviglumis* cross 88% of the glumes transformed into plantlets.

When these plantlets are removed from the mother plant and directly transplanted into the field, these plantlets grow like normal maize teosinte  $F_1$  plants. These plants ( $R_1$ ) again show the same phenomenon of *in vivo* regeneration. These observations suggest that explants of maize x teosinte hybrids and their derivatives will be totipotent with high regeneration ability. *In vitro* response of glume explant of these crosses is amazingly very high. The glume cultured at tassel initiation stage developed into whole plant without rooting or shooting media. Glume culture of CMIII x *Zea diploperennis*

in callusing medium (MS + 0.2 mg/l 2-4-D) produced somatic embryos in almost all the cases and regeneration of maize plant in hormone free medium. These studies open up new frontiers for genetic engineering, fixation of heterosis and chromosome manipulation in maize.

*Wide crosses for fodder, baby corn and other useful traits:* Maize x teosinte crosses particularly Sikkim Primitive maize x *Zea diploperennis* and Pira x *Z. diploperennis* have shown great promise for developing fodder maize hybrids (750 q/ha). In coordinated trials, teo-maize has ranked first in Central and North-Eastern zones. Similarly Teo-6 has first rank in North-West and

Central zones. These hybrids are tillering, luxuriant high yielding and free from diseases and have shown antibiosis to shoot borer. Novel trait which doubles the pollen shedding periods has been transferred from *Z. diploperennis* to maize.

Cross derivatives of Sikkim Primitives from Tripura (T-2) and Sikkim (S-2) have proved to be an excellent material for development of baby corn varieties. The baby corn population developed is prolific, early and vigorous. Brace root stocks suitable for waterlogging conditions has been developed through distant hybridization.

## DNA Fingerprinting and Genetic Relationship Study of Tea Plants Using Amplified Fragment Length Polymorphism (AFLP) Technique

**Rajan K Mishra and Swati Sen-Mandi**

Department of Botany, Bose Institute, 93/1 Acharya Prafulla Chandra Road, Calcutta-700009, West Bengal

**Key Words:** Tea (*Camellia sinensis*), DNA fingerprinting, AFLP, Genetic relationships

Cultivated tea consists of three species within the genus *Camellia* viz., *Camellia sinensis* China type *C. assamica* Assam type, *C. assamica lasiocalyx* - Cambod type (Wight, 1962); of these *Camellia sinensis* was the earliest known and used in tea cultivation. Intermediate plant types are available due to extensive cross-breeding between the species.

Till date, selection of tea plants from the wide generation available, for tea making industry is based on phenotypic characters which is time consuming. Heterogeneity in genome composition compounded with environmentally influenced variations in the field makes it difficult for precise characterization of tea plant/bushes on the basis of morphological characters.

In recent years characterization based on DNA sequence information have been used as the ultimate means of plant individualization. An array of methods, based on polymerase chain reaction using a DNA primer and a thermostable DNA polymerase are now available for DNA fingerprinting based documentation of plants (Song *et al.* 2000; William *et al.* 1990; Joshi *et al.* 1999 and Parani *et al.* 1997).

A relatively recent approach in the PCR mediated

amplification of specific DNA fragments for genome analysis is the AFLP study (Vos *et al.* 1995; Maughan *et al.* 1996; Barrett and Kidwell, 1998). This technique permits inspection of polymorphism at a large number of loci within a very short period; reproducibility of the technique is ensured by the use of restriction sites-specific adaptors and adaptor-specific primers with a variable number of selective nucleotides.

We present DNA fingerprinting pattern of some tea clones using AFLP technique. The genetic relationship between the clones is also presented through a cluster analysis study.

Leaves of tea plants from Ging Tea Estate, Darjeeling were used. Genomic DNA from young tea leaves were extracted using modified CTAB method of Gawel and Jarret (1991). AFLP analysis was carried out by using GIBCO-BRL AFLP analysis system-1 kit. Data scored from AFLPs generated with 8 primer pairs were used to compile a binary matrix for cluster analysis using the NTSYS-pc version 1.8 package.

Using 8 primer pair combinations in 29 tea clones, 677 PCR products were observed of which 469 were polymorphic (Table 1), the calculated average number

in callusing medium (MS + 0.2 mg/l 2-4-D) produced somatic embryos in almost all the cases and regeneration of maize plant in hormone free medium. These studies open up new frontiers for genetic engineering, fixation of heterosis and chromosome manipulation in maize.

*Wide crosses for fodder, baby corn and other useful traits:* Maize x teosinte crosses particularly Sikkim Primitive maize x *Zea diploperennis* and Pira x *Z. diploperennis* have shown great promise for developing fodder maize hybrids (750 q/ha). In coordinated trials, teo-maize has ranked first in Central and North-Eastern zones. Similarly Teo-6 has first rank in North-West and

Central zones. These hybrids are tillering, luxuriant high yielding and free from diseases and have shown antibiosis to shoot borer. Novel trait which doubles the pollen shedding periods has been transferred from *Z. diploperennis* to maize.

Cross derivatives of Sikkim Primitives from Tripura (T-2) and Sikkim (S-2) have proved to be an excellent material for development of baby corn varieties. The baby corn population developed is prolific, early and vigorous. Brace root stocks suitable for waterlogging conditions has been developed through distant hybridization.

## DNA Fingerprinting and Genetic Relationship Study of Tea Plants Using Amplified Fragment Length Polymorphism (AFLP) Technique

**Rajan K Mishra and Swati Sen-Mandi**

Department of Botany, Bose Institute, 93/1 Acharya Prafulla Chandra Road, Calcutta-700009, West Bengal

**Key Words:** Tea (*Camellia sinensis*), DNA fingerprinting, AFLP, Genetic relationships

Cultivated tea consists of three species within the genus *Camellia* viz., *Camellia sinensis* China type *C. assamica* Assam type, *C. assamica lasiocalyx* - Cambod type (Wight, 1962); of these *Camellia sinensis* was the earliest known and used in tea cultivation. Intermediate plant types are available due to extensive cross-breeding between the species.

Till date, selection of tea plants from the wide generation available, for tea making industry is based on phenotypic characters which is time consuming. Heterogeneity in genome composition compounded with environmentally influenced variations in the field makes it difficult for precise characterization of tea plant/bushes on the basis of morphological characters.

In recent years characterization based on DNA sequence information have been used as the ultimate means of plant individualization. An array of methods, based on polymerase chain reaction using a DNA primer and a thermostable DNA polymerase are now available for DNA fingerprinting based documentation of plants (Song *et al.* 2000; William *et al.* 1990; Joshi *et al.* 1999 and Parani *et al.* 1997).

A relatively recent approach in the PCR mediated

amplification of specific DNA fragments for genome analysis is the AFLP study (Vos *et al.* 1995; Maughan *et al.* 1996; Barrett and Kidwell, 1998). This technique permits inspection of polymorphism at a large number of loci within a very short period; reproducibility of the technique is ensured by the use of restriction sites-specific adaptors and adaptor-specific primers with a variable number of selective nucleotides.

We present DNA fingerprinting pattern of some tea clones using AFLP technique. The genetic relationship between the clones is also presented through a cluster analysis study.

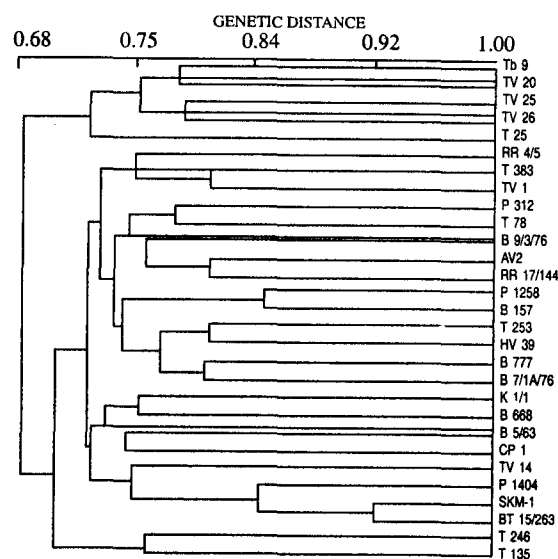
Leaves of tea plants from Ging Tea Estate, Darjeeling were used. Genomic DNA from young tea leaves were extracted using modified CTAB method of Gawel and Jarret (1991). AFLP analysis was carried out by using GIBCO-BRL AFLP analysis system-1 kit. Data scored from AFLPs generated with 8 primer pairs were used to compile a binary matrix for cluster analysis using the NTSYS-pc version 1.8 package.

Using 8 primer pair combinations in 29 tea clones, 677 PCR products were observed of which 469 were polymorphic (Table 1), the calculated average number

**Table 1. AFLP generated among 29 tea clones from Darjeeling region**

| Primer Pair                      | Total no. Bands | No. of Polymorphic Bands |
|----------------------------------|-----------------|--------------------------|
| E <sub>at</sub> M <sub>ctt</sub> | 121             | 82                       |
| E <sub>ta</sub> M <sub>cat</sub> | 37              | 19                       |
| E <sub>tg</sub> M <sub>cta</sub> | 99              | 76                       |
| E <sub>tc</sub> M <sub>cta</sub> | 111             | 79                       |
| E <sub>ag</sub> M <sub>cta</sub> | 96              | 66                       |
| E <sub>ac</sub> M <sub>cta</sub> | 48              | 36                       |
| E <sub>aa</sub> M <sub>caa</sub> | 78              | 45                       |
| E <sub>tg</sub> M <sub>ctg</sub> | 87              | 66                       |
| Total                            | 677             | 469                      |

of polymorphic fragments per primer pair is 58.6. Using the polymorphism data generated from AFLP of 29 tea clones, a similarity matrix was constructed which was used for preparing a dendrogram using UPGMA method. The dendrogram obtained, clearly divided the tea clones into three groups - each group containing plants that are conventionally assigned to China, Assam and Cambod types on the basis of their morphological characters (Fig. 1). It was interesting to note that the clones T246 and T135 conventionally assigned to the Assam group, appeared, from our DNA fingerprinting studies, to be separated from the three conventionally recognized clusters. This suggests that these two clones have arisen through extensive cross breeding between species within the genus *Camellia*. Among all the genotypes studied the similarity level was found to be above 68% Paul *et al.* (1997) reported a similarity level above 70% among tea clones of Indian and Kenyan origin. From studies on lilac, Marsolais *et al.* (1993) have shown that similarity coefficient about 50% is indicative of origin through inter-specific hybridization. Our finding that similarity level among tea genotypes, regardless of morphological grouping, ranged from 69.7% to 92% suggest that the clones represent intra-as well as inter-specific hybridization.

**Fig.1 Dendrogram illustrating genetic relatedness among 29 Tea plants**

### References

- Barrett BA and KK Kidwell (1998) *Crop Sci.* **38**: 1261-1271.  
 Gawel NJ and RL Jarret (1991) *Plant Mol. Biol. Rep.* **9**: 262-266.  
 Joshi SP, PK Ranjekar and VS Gupta (1999) *Current Sci.* **77**: 230-240.  
 Marsolais JV, JS Pringle and BN White (1993) *Taxon* **42**: 531-537.  
 Maughan PJ, MA Sanghai Maroof, GR Buss and GM Huestis (1996) *Theor. Appl. Genet.* **93**: 392-401.  
 Parani M, A Anand and A Parida (1997) *Curr Sci.* **1**: 81-83.  
 Paul S, FN Wachira, W Powel and R Waugh (1997) *Theor. Appl. Genet.* **94**: 255-263.  
 Song BK, MM Clyde, R Wickneswari and MN Normah (2000) *Ann. Bot.* **86**: 299-307.  
 Vos P, R Hogers, M Bluker, M Reijans, T Van de lee, M Horms, A Frijters, J Pot, J Peleman, M Kuiper and M Zabeau (1995) *Nucleic Acid. Res.* **23**: 4407-4414.  
 Wight W (1962) *Curr Sci.* **31**: 298-299.  
 Williams JGK, AR Kubelik, KJ Livak, JA Rafalski and SV Tingery (1990) *Nucleic Acids Res.* **18**: 6531-6535.

## Genetic Diversity Analysis and Fingerprinting of Diploid Cotton Cultivars Using Automated Amplified Fragment Length Polymorphism (AFLP)

**MK Rana and KV Bhat**

National Research Centre on DNA Fingerprinting, National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012

**Key Words:** Amplified Fragment Length Polymorphism (AFLP), Genetic diversity, *Gossypium* spp., Molecular markers

Cotton is an important cash crop of India. Nearly one third of India's earnings are from textile sector of which cotton alone contributes about 70% of raw material. All the four cultivated species of cotton are grown in the country of which 30% area is under diploid cottons.

The presence of genetic diversity in any species is important for its improvement. A large number of polymorphic markers are required for establishing genetic relationships among the cultivars and to assess the genetic diversity. Morphological markers are generally used for this purpose, but today we have various molecular marker systems available. Amplified fragment length polymorphism (AFLP) is a very powerful marker system that includes several-folds increase in the number of informative markers per analysis, highly reproducible banding pattern and no *a priori* sequence information of the DNA. It has been used to estimate genetic relationships in many studies including lentil (*Lens culinaris* Medikus) (Sharma *et al.* 1996), soybean (*Glycine max* L.) (Maughan *et al.* 1996), hops (*Humulus lupulus* L.) (Hartl and Seefelder, 1998), coconut (*Cocos nucifera* L.) (Perera *et al.* 1998), wheat (*Triticum aestivum* L.) (Barrett and Kidwell, 1998), neem (*Azadirachta indica*) (Singh *et al.* 1999), cotton (*Gossypium* spp.) (Pillay and Myers, 1999) *etc.* In the present study AFLP analysis was performed in diploid cotton cultivars to find the suitability of the technique for genetic diversity analysis and fingerprinting.

A total of 16 diploid cotton cultivars belonging to two species (Table 1) were used in the present study. These cultivars were developed and released under the Indian Agricultural Research Systems for cultivation in the specified regions of the country. Out of these 16 cultivars, seven belonged to *G. herbaceum* and eight to *G. arboreum*. One genotype was inter-specific hybrid between these two species.

DNA was extracted from 5 g of a bulked sample of leaves from 10 plants of each cultivar. The CTAB

**Table 1. List of cotton cultivars used in the study**

| Cultivar | Species             | Cultivar | Species                                              |
|----------|---------------------|----------|------------------------------------------------------|
| Sujay    | <i>G. herbaceum</i> | Sanjay   | <i>G. arboreum</i>                                   |
| Gcot 21  | <i>G. herbaceum</i> | Gcot 19  | <i>G. arboreum</i>                                   |
| Gcot 11  | <i>G. herbaceum</i> | Gcot 15  | <i>G. arboreum</i>                                   |
| Gcot 13  | <i>G. herbaceum</i> | G-27     | <i>G. arboreum</i>                                   |
| V797     | <i>G. herbaceum</i> | DDCC-1   | <i>G. arboreum</i>                                   |
| Jayadhar | <i>G. herbaceum</i> | RG8      | <i>G. arboreum</i>                                   |
| 4011     | <i>G. herbaceum</i> | HD327    | <i>G. arboreum</i>                                   |
| 824      | <i>G. arboreum</i>  | G.CotDH9 | <i>G. herbaceum</i> x<br><i>G. arboreum</i> (hybrid) |

DNA extraction procedure of Sagahai-Marroof *et al.* (1984) was used with some modifications for DNA extraction. The concentration of DNA in the RNA-free samples was determined with a Hoefer DNA Fluorometer Model DQ 200 (Hoefer Pharmacia Biotech Inc., San Francisco, CA) using Hoechst 33258 as the dye and calf thymus DNA as the standard (Brunk *et al.* 1979).

AFLP analysis was performed according to the protocol of Vos *et al.* (1995) that is supplied with AFLP Plant Mapping protocol from Perkin Elmer Applied Biosystems (USA) with slight modifications to suit to the material under investigation. DNA restriction, ligation, and pre-selective and selective amplifications of the samples were done as per the protocol. All amplifications were carried out in Perkin Elmer thermocycler (GeneAmp PCR System 9600). Six primer combinations of EcoRI+3 (E-plus three nucleotides) and MseI+3 (M-plus 3 nucleotides) were selected from initially 64 screened primer combinations (Table 2).

Samples containing 3 µl of selective PCR products, 0.5 µl of Gene Scan ROX 500 internal lane standard and Formamide were heated at 96°C for 5 min and quick chilled by placing on ice. DNA samples were capillary electrophoresed at constant power on an automated DNA sequencer (Perkin Elmer/Applied Biosystems model ABI Prism 310) equipped with GeneScan software (Perkin Elmer Applied Biosystems).

**Table 2. AFLP primer combinations, cultivars distinguished and level of polymorphism detected**

| Primer Combination | Cultivars | Species-specific Distinguished | % Polymorphism Markers |
|--------------------|-----------|--------------------------------|------------------------|
| E-AAG/ M-CAA       | 5         | 8                              | 76.9                   |
| E-ACA/ M-CAA       | 3         | 10                             | 50.0                   |
| E-ACT/ M-CTT       | 10        | 7                              | 58.2                   |
| E-AAG/ M-CAG       | 7         | 8                              | 83.5                   |
| E-ACA/ M-CAG       | 6         | 12                             | 85.0                   |
| E-ACT/ M-CAG       | 8         | 7                              | 64.6                   |

After the ABI Prism 310 collected data, GeneScan analysis software was used to analyze and display the results. Results so obtained were transformed into binary data using software Genotyper version 2.5. Further computing for UPGMA analysis to generate a dendrogram and for calculating similarity coefficients (Jaccard, 1908) were carried out using NTSYS-software (Rohlf, 1988).

AFLP markers were assayed for their usefulness in analyzing molecular diversity and fingerprinting 16 cultivars of cotton belonging to two cultivated species i.e. *G. herbaceum* and *G. arboreum*. A total of 751 markers were obtained with six primer combinations across all the cultivars (Table 2). Out of these 751 markers, 523 were polymorphic indicating 70% polymorphism. On an average 87 markers per primer-combination were recorded.

Primer combination E-ACT/M-CTT discriminated the maximum number of cultivars (10) by producing cultivar specific markers, which was followed by primer combination E-ACT/M-CAG that discriminated as many as 8 cultivars. All the cultivars but one (Gcot 19) could

be distinguished from one another using this set of six primer combinations. Only two primer combinations E-ACT/M-CTT and E-AAG/M-CAG distinguished as many as 14 cultivars. An average of 8.6 markers per primer combination were found that were specific to either *G. herbaceum* or *G. arboreum* species (Table 2). Earlier cultivar identification in cotton has been reported using RAPD (Multani and Lyon, 1995; Iqbal *et al.* 1997) markers but no single RAPD primer could discriminate all the cultivars in their studies. So far we have studied only six primer combinations and further studies are underway to find a single primer combination that could discriminate all the cultivars.

AFLP markers obtained across all the cultivars were subjected to UPGMA analysis to determine genetic relationships among the cultivars (Table 3). A range of 0.50 to 0.88 for similarity coefficient values was observed across the two species. Gcot11 and Gcot13 had the maximum similarity value (0.85) among the *G. herbaceum* cultivars, while Jayadhar and Gcot11 had the least similarity coefficient value (0.68). Between *G. arboreum* cultivars Gcot15 with 824 and Gcot19 had the maximum similarity (0.88) while G-27 and Sanjay were the least similar (0.70). The close similarity between Gcot19 and Gcot15 and that between Gcot11 and Gcot13 may be explained by some commonness in their ancestry. Gcot15 and Gcot19 were procured from the same place. Average genetic similarity index across all 16-variety comparisons was found to be 66.0. It was 78.0 and 73.0 among the cultivars of *G. herbaceum* and *G. arboreum*, respectively. However,

**Table 3. Similarity coefficient values among diploid cotton cultivars using AFLP analysis**

|          | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   | 16   |
|----------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Sujay    | 1.00 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Gcot21   | 0.81 | 1.00 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Gcot11   | 0.81 | 0.80 | 1.00 |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Gcot13   | 0.80 | 0.80 | 0.85 | 1.00 |      |      |      |      |      |      |      |      |      |      |      |      |
| V797     | 0.81 | 0.78 | 0.81 | 0.83 | 1.00 |      |      |      |      |      |      |      |      |      |      |      |
| Jayadhar | 0.71 | 0.69 | 0.68 | 0.71 | 0.72 | 1.00 |      |      |      |      |      |      |      |      |      |      |
| 4011     | 0.79 | 0.80 | 0.83 | 0.84 | 0.81 | 0.74 | 1.00 |      |      |      |      |      |      |      |      |      |
| GcotDH9  | 0.78 | 0.78 | 0.79 | 0.80 | 0.80 | 0.74 | 0.83 | 1.00 |      |      |      |      |      |      |      |      |
| 824      | 0.66 | 0.52 | 0.56 | 0.56 | 0.54 | 0.50 | 0.56 | 0.55 | 1.00 |      |      |      |      |      |      |      |
| Sanjay   | 0.63 | 0.55 | 0.54 | 0.54 | 0.54 | 0.54 | 0.56 | 0.57 | 0.66 | 1.00 |      |      |      |      |      |      |
| Gcot19   | 0.64 | 0.53 | 0.57 | 0.55 | 0.55 | 0.54 | 0.57 | 0.57 | 0.78 | 0.76 | 1.00 |      |      |      |      |      |
| Gcot15   | 0.63 | 0.61 | 0.65 | 0.64 | 0.66 | 0.60 | 0.65 | 0.67 | 0.88 | 0.85 | 0.88 | 1.00 |      |      |      |      |
| G27      | 0.63 | 0.54 | 0.56 | 0.56 | 0.55 | 0.55 | 0.57 | 0.56 | 0.71 | 0.70 | 0.78 | 0.81 | 1.00 |      |      |      |
| DDCC1    | 0.63 | 0.55 | 0.57 | 0.55 | 0.54 | 0.53 | 0.59 | 0.56 | 0.77 | 0.73 | 0.81 | 0.81 | 0.77 | 1.00 |      |      |
| RG8      | 0.66 | 0.55 | 0.58 | 0.58 | 0.57 | 0.54 | 0.57 | 0.58 | 0.77 | 0.74 | 0.82 | 0.85 | 0.79 | 0.81 | 1.00 |      |
| HD327    | 0.64 | 0.53 | 0.56 | 0.54 | 0.53 | 0.50 | 0.56 | 0.54 | 0.74 | 0.67 | 0.75 | 0.75 | 0.73 | 0.78 | 0.76 | 1.00 |

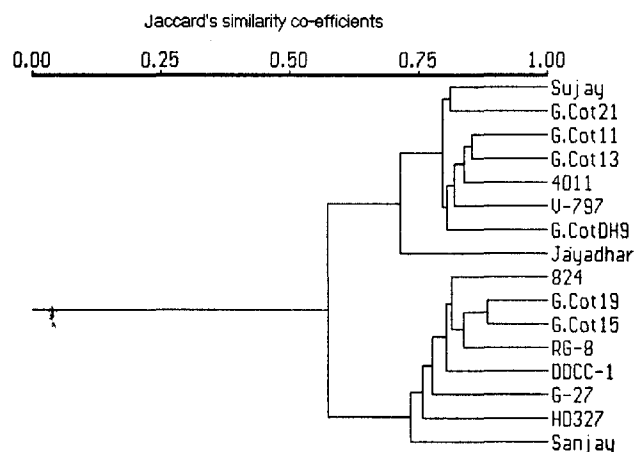


Fig. 1. Dendrogram generated through UPGMA analysis for 16 cultivars diploid cotton

genetic similarity index was 57.0 between the cultivars of the two species. Cluster analysis revealed separate clustering of cultivars of both the species (Fig. 1). GcotDH-9, an inter-specific hybrid, clustered with its female parent 4011. Jayadhar was the most distinct cultivar and did not cluster with any of the cultivars of its group of *G. herbaceum* cultivars. *G. arboreum* cultivars 824, Gcot19, Gcot15 and RG8 formed clear clustering into one group. Separate clustering of *G. hirsutum* and *G. barbadense* cultivars has been reported earlier using allozyme (Percy and Wendel, 1990), RAPD (Tatineni *et al.* 1996) and AFLP (Pillay and Myers, 1999) analyses.

In conclusion, this study shows that AFLP is able to discriminate closely related genotypes in cotton and provides sufficient numbers of polymorphic markers in a few experiments. With the automation of the AFLP technique and application of multiplex PCR a large number of samples can be analysed in a short time paving the way for effective characterization and conservation of cotton plant genetic resources.

## References

- Barrett BA and KK Kidwell (1998) AFLP-based genetic diversity assessment among wheat cultivars from the Pacific North-West. *Crop Sci.* **38**: 1261-1271.
- Brunk CF, KC Jones and TW James (1979) Assay for nanogram quantities of DNA in cellular homogenates. *Anal. Biochem.* **92**: 497-500.
- Hartl L and S Seefelder (1998) Diversity of selected hop cultivars detected by fluorescent AFLPs. *Theor. Appl. Genet.* **96**: 112-116.
- Iqbal MJ, N Aziz, NA Saeed, Y Zafar and KA Malik (1997) Genetic diversity evaluation of some elite cotton varieties by RAPD analysis. *Theor. Appl. Genet.* **94**: 139-144.
- Jaccard P (1908) Nouvelles recherches sur la distribution florale. *Bull. Soc. Vaud. Sci. Nat.* **44**: 223-270.
- Maughan PJ, MA Saghai-Marooof, GR Buss and GM Huestis (1996) Amplified fragment length polymorphism (AFLP) in soybean: species diversity, inheritance, and near isogenic lines analysis. *Theor. Appl. Genet.* **93**: 392-401.
- Multani DS and BR Lyon (1995) Genetic fingerprinting of Australian cotton cultivars with RAPD markers. *Genome* **38**: 1005-1008.
- Percy RG and JF Wendel (1990) Allozyme evidence for the origin and diversification of *Gossypium barbadense* L. *Theor. Appl. Genet.* **79**: 529-542.
- Perera L, JR Russell, J Provan, JW Mc Nicol and W Powell (1998) Evaluating genetic relationships between indigenous coconut (*Cocos nucifera* L.) accessions from Sri Lanka by means of AFLP profiling. *Theor. Appl. Genet.* **96**: 545-550.
- Pillay M and GO Myers (1999) Genetic diversity in cotton assessed by variation in ribosomal RNA genes and AFLP markers. *Crop Sci.* **39**: 1881-1886.
- Rohlf FJ (1993). NTSYS-pc Numerical taxonomy and multivariate analysis system, version 1.80. Exeter Software, Setauket, New York.
- Saghai-Marooof MA, KM Soliman, RA Jorgensen and RW Allard (1984) Ribosomal DNA spacer-length polymorphism in barley: Mendelian inheritance, chromosomal location, and population dynamics. *Proc. Natl. Acad. Sci. (USA)* **81**: 8014-8018.
- Sharma SK, MR Knox and THN Ellis (1996) AFLP analysis of the diversity and phylogeny of *Lens* and its comparison with RAPD analysis. *Theor. Appl. Genet.* **93**: 751-758.
- Singh A, MS Negi, J Rajagopal, S Bhatia, UK Tomar, PS Srivastava, and M Lakshmikumaran (1999) Assessment of genetic diversity in *Azadirachta indica* using AFLP markers. *Theor. Appl. Genet.* **99**: 272-279.
- Tatineni V, RG Cantrell and DD Davis (1996) Genetic diversity in elite cotton germplasm determined by morphological characteristics and RAPDs. *Crop Sci.* **36**: 186-192.
- Vos P, R Hogers, M Reijans, T Van de Lee, M Hornes, A Freijters, J Pot, J Pleman, M Kuiper and M. Zabeau (1995) AFLP: a new technique for DNA Fingerprinting. *Nucleic Acid Res.* **23**: 4407-4414.

## Introgression of Novel Sources of Rust Resistance from Wild *Triticum* and *Aegilops* Species into Bread and Durum Wheat Cultivars

HS Dhaliwal, P Chunneja, RK Goel, SK Nayar\*, R Kaur and Harjit Singh

Department of Genetics and Biotechnology, Punjab Agricultural University, Ludhiana-141004, Punjab

**Key Words:** Bread wheat, Rust resistance, Durum wheat, Virulent strains, STMS primers

The Genetic base for resistance to various diseases among bread wheat cultivars in India is extremely narrow. The germplasm of wild progenitor and non-progenitor *Triticum* and *Aegilops* species comprises a huge reservoir of unexploited variability for disease resistance to various wheat diseases. The germplasm of wild *Triticum* and *Aegilops* species maintained at PAU, Ludhiana (Table 1) has been exhaustively screened under laboratory and field conditions over years and locations and a number of useful sources for resistance to leaf rust (*Puccinia recondita*) and stripe rust (*P. striiformis*) have been identified (Harjit Singh and Dhaliwal, 2000). With an aim to transfer this useful character, one or more accessions of several wild species

were crossed with rust susceptible cultivars of bread and durum wheats. Backcross breeding programme with the recurrent parent was continued along with cytogenetical studies and screening for rust resistance followed by selfing till fertile and homozygous rust resistant derivatives were recovered. This introgression of new sources of resistance into cultivated wheat are reported here.

For screening at the seedling stage rust infection types were recorded according to 0-4 scale given by Stakman *et al.* (1962). The disease severity under field conditions was recorded as percentage of leaf area covered by rust following modified Cobb's scale (Peterson *et al.* 1948). For C-banding, protocol of Friebe *et al.*

**Table 1.** Material used for wheat germplasm enhancement

| Receipient parent                 | Donor parent                       | Derivative No. | Generation                     | Cytological Status                            |
|-----------------------------------|------------------------------------|----------------|--------------------------------|-----------------------------------------------|
| <i>T. aestivum</i> cv. WL71       | <i>Ae. ovata</i> Acc. 3547         | 175            | BC <sub>3</sub> F <sub>9</sub> | 5M-5D substitution                            |
|                                   |                                    | 187            | BC <sub>2</sub> F <sub>8</sub> | 5M-5D substitution                            |
|                                   |                                    | 201            | BC <sub>2</sub> F <sub>8</sub> | 2AL translocation                             |
|                                   |                                    | 206            | BC <sub>2</sub> F <sub>8</sub> | 2AL translocation                             |
|                                   |                                    | 237            | BC <sub>2</sub> F <sub>6</sub> | 2AL translocation                             |
| <i>T. aestivum</i> cv WL 711      | <i>Ae. triuncialis</i><br>Acc.3549 | 258            | BC <sub>2</sub> F <sub>8</sub> | 5U-5A substitution                            |
|                                   |                                    | 272            | BC <sub>2</sub> F <sub>8</sub> | 5U-5A substitution                            |
|                                   |                                    | 293            | BC <sub>2</sub> F <sub>8</sub> | No detectable alien chromatin                 |
|                                   |                                    | 297            | BC <sub>2</sub> F <sub>8</sub> | An additional pair of acrocentric chromosomes |
| <i>T. durum</i> cv. Bijaga Yellow | <i>T. dicoccoides</i><br>Acc. 4656 | 395            | BC <sub>2</sub> F <sub>7</sub> | Euploid (2n=28)                               |
| <i>T. durum</i> cv. Malvi Local   | <i>T. araraticum</i><br>Acc. 4692  | 403            | BC <sub>2</sub> F <sub>8</sub> | Euploid                                       |
| <i>T. durum</i> vc. Malvi Local   | <i>T. araraticum</i><br>Acc. 4697  | 413            | BC <sub>2</sub> F <sub>6</sub> | Euploid                                       |
| <i>T. durum</i> cv. Bijaga Yellow | <i>T. araraticum</i><br>Acc. 4699  | 417            | BC <sub>2</sub> F <sub>8</sub> | Euploid                                       |
| <i>T. durum</i> cv. MACS9         | <i>T. araraticum</i><br>Acc.4753   | 422            | BC <sub>2</sub> F <sub>7</sub> | Euploid                                       |
| <i>T. durum</i> cv. A206          | <i>T. urartu</i> Acc.5301          | 435            | BC <sub>1</sub> F <sub>6</sub> | Euploid                                       |
|                                   | <i>T. urartu</i> Acc.5340          | 443            | BC <sub>4</sub> F <sub>7</sub> | Euploid                                       |

\* Directorate of Wheat Research, Flowerdale, Shimla-171001, Himachal Pradesh

(1992) was followed. For molecular studies, wheat microsatellite markers were selected based on linkage map developed and STMS primers were used (Röder *et al.* 1998).

In the *Ae. ovata*, derivatives in WL 711 background, wheat chromosome 5-D has been substituted by 5M chromosome from *Ae. ovata* (derivative No. 175, 187) which has been confirmed through C-banding and microsatellite markers. Similarly in *Ae. triuncialis* derivatives 258 and 272, chromosome 5A of wheat has been substituted by 5U of *Ae. triuncialis*. In another derivative, 293, no alien chromatin could be detected with C-banding. The STMS marker gwm 368 indicated the transfer of a leaf rust resistance gene from *Ae. triuncialis* to either the A or the D genome of wheat (Aghaee-Sarbarzeh *et al.* 2001) These derivatives are maintaining resistance to leaf rust at seedling as well as field level. A third group of derivatives (297) carried

an additional pair of acrocentric chromosomes. All the *Triticum durum* derivatives are with  $2n=28$  chromosomes with occasional univalents.

The interspecific hybridisation derivatives of cultivated bread and durum wheats were screened at the seedling stage against five prevalent pathotypes of *P. recondita* and three pathotypes of *P. striiformis* at Ludhiana and at Flowerdale, Shimla. The rust reaction at the seedling stage and in the field is presented in Table 2.

**Leaf rust:** All the derivatives (in *T. aestivum* and *T. durum* background) except 297 were resistant to all the *P. recondita* pathotypes used at seedling stage. Only some of the alien genes for leaf rust resistance such as *Lr 19* and *Lr 24* from *Agropyron elongatum* and *Lr 28* from *Ae. speltoides* provides resistance against these prevalent and most virulent pathotypes of *P. recondita*. The resistance of most of the derivatives except 297 to all the pathotypes tested here indicate

**Table 2. Seedling and field evaluation of interspecific derivatives and their parents**

| Derivative No.         | Seedling Reaction* |                      |                        |                        |                 |            |            |            | Field Reaction** |             |
|------------------------|--------------------|----------------------|------------------------|------------------------|-----------------|------------|------------|------------|------------------|-------------|
|                        | Leaf Rust          |                      |                        |                        | Stripe Rust     |            |            |            | Leaf Rust        | Stripe Rust |
|                        | IR 5<br>(12-2)     | 109R<br>63<br>(77-1) | 109R<br>31-1<br>(77-2) | 121R<br>63-1<br>(77-5) | 21R5<br>(104-2) | 46S<br>103 | 46S<br>102 | 46S<br>119 |                  |             |
| 175                    | 0;                 | ;                    | ;1-3                   | ;1                     | ;12             | 2          | ;-         | ;-3        | R                | R           |
| 182                    | ;                  | ;                    | ;1                     | ;1                     | ;               | 0;         | ;          | ;          | R                | R           |
| 201                    | ;                  | ;                    | ;1                     | ;1                     | ;               | 0;         | ;          | 3-         | R                | 5MR         |
| 206                    | ;                  | ;1                   | ;                      | ;+                     | ;+              | ;          | ;          | 2-         | R                | R           |
| 237                    | ;1-                | -                    | -                      | ;1                     | ;1              | 2          | 0;         | 2          | r                | r-tmr       |
| 258                    | ;12                | ;12                  | ;1                     | ;                      | x               | ;          | 3          | 3+         | 10S              | 80S         |
| 272                    | x-                 | x                    | ;12                    | ;                      | ;12             | 3          | 3          | 3          | 10S              | 80S         |
| 293                    | 0;                 | 0;-33+               | 0;                     | 0;                     | 0;              | 3+         | 3+         | 3          | R                | 80S         |
| 297                    | 0;                 | 0;-33+               | 33+                    | 0;-3                   | ;-33+           | 3          | 3          | 3          | 10MS             | 20MS        |
| 395                    | ;+                 | ;                    | ;                      | x-                     | ;12             | 2          | 2          | 2          | R                | 5R          |
| 403                    | ;12                | ;                    | 0;                     | x                      | x               | 3          | 3          | 3+         | R                | R-TR        |
| 413                    | 0;                 | -                    | -                      | 0;                     | 0;              | 3+         | 3          | 3+         | R                | R           |
| 417                    | 12                 | -                    | -                      | -0;                    | 1+              | 2          | 2+         | 2          | R                | TMR         |
| 422                    | ;1                 | ;                    | 0;                     | x                      | ;12             | 2+         | 2+         | 2-         | R                | -           |
| 443                    | ;1                 | ;                    | ;+                     | x+                     | 2               | 2          | 2          | 2          | R                | R           |
| WL711                  | x                  | 3                    | 33+                    | 33+                    | 3               | 3          | 3          | 3          | 60S              | 80S         |
| <i>Ae. ovata</i>       | ;                  | -                    | ;1                     | ;                      | 2               | -          | 0;         | -          | R                | R           |
| Acc. 3547              |                    |                      |                        |                        |                 |            |            |            |                  |             |
| <i>Ae. triuncialis</i> | -                  | -                    | ;-                     | ;-                     | ;1              | -          | -          | -          | R                | 10MR        |

Contd.

Table 2. Cond.

| Derivative No. | Seedling Reaction* |                      |                        |                        |                 |            |            |            | Field Reaction** |             |
|----------------|--------------------|----------------------|------------------------|------------------------|-----------------|------------|------------|------------|------------------|-------------|
|                | Leaf Rust          |                      |                        |                        | Stripe Rust     |            |            |            | Leaf Rust        | Stripe Rust |
|                | IR 5<br>(12-2)     | 109R<br>63<br>(77-1) | 109R<br>31-1<br>(77-2) | 121R<br>63-1<br>(77-5) | 21R5<br>(104-2) | 46S<br>103 | 46S<br>102 | 46S<br>119 |                  |             |
| s Acc.3549     |                    |                      |                        |                        |                 |            |            |            |                  |             |
| Bijaga Yellow  | 3c                 | ;                    | 0;                     | 33+                    | 33+             | x-         | 3          | 2          | F                | 80S         |
| Malvi Local    | 3                  | -                    | -                      | -3-                    | 3+              | 3+         | 2+         | 3          | 60S              | 60S         |
| MACS 9         | 3                  | -                    | -                      | ;1                     | 3+              | 3+         | 3+         | 3+         | 60S              | 30S         |
| A206           | ;1                 | -                    | ;                      | 0;                     | 1               | 3C         | 3C         | 3+         | TR               | TR          |

\* Based on Stakman *et al.* (1962)\*\* Based on modified Cobb's scale (Peterson *et al.* 1948)

that new genes for leaf rust resistance have been introgressed from wild *Triticum* and *Aegilops* species.

**Stripe rust:** The *Triticum aestivum* derivatives 182, 206, 237 and *Triticum durum* derivatives 395, 417 and 443 were resistant to all the *P. striiformis* pathotypes both at seedling and adult stage under field conditions. Derivatives 175 and 201 were resistant to pathotype 46S103 and 46S102 and susceptible to pathotype 46S119. Derivative 258 was resistant to pathotype 46S102 only. Derivatives 403 and 413 were susceptible at the seedling stage to all the three pathotypes but were resistant at the adult plant stage. These derivatives may have adult plant resistance (APR) genes for stripe rust resistance. However, *triuncialis* derivatives 272, 293 and 294 were susceptible to the new currently prevalent stripe rust pathotypes both at seedling and adult stage. The resistance of some of the derivatives against all the three prevalent and highly virulent pathotypes of stripe rust indicates that at least four new genes for stripe rust resistance from *Ae. ovata*, *T. dicoccoides*, *T. araraticum* and *T. urartu* have been transferred.

These novel hitherto unexploited sources of resistance to leaf and stripe rust successfully introgressed into the cultivated bread and durum wheats are available for use

in the wheat breeding programme in the country. The work to further characterise the new genes and to tag them with molecular markers for marker aided selection (MAS) and pyramiding is in progress.

## References

- Aghaee-Sarbarzeh M, Harjit Singh and HS Dhaliwal (2001) Microsatellite marker linked to leaf rust resistance transferred from *Aegilops triuncialis* into hexaploid wheat. *Plant Breed.* **119** (in press).
- Friebe B, FJ Zeller, Y Mukai, BP Forster, P Bartos and RA McIntosh (1992) Characteristics of rust resistant wheat – *Agropyron intermedium* derivatives by C-banding, *in situ* hybridization and isozyme analysis. *Theor. Appl. Genet.* **83**: 775 -785.
- Harjit Singh and HS Dhaliwal (2000) Interspecific genetic diversity for resistance to wheat rusts in wild *Triticum* and *Aegilops* species. *Wheat Inf. Ser.* **90**: 21-30.
- Peterson RR, AR Campbell and AE Hanah (1948) A diagrammatic scale for estimation of rust intensity of leaves and stem of cereals. *C. J. Res. Series.* **C-26**: 496-500.
- Röder MS, V Korzun, K Wendehake, J Plaschke, M Tixier, P Leroy, and MW Ganal (1998) A microsatellite map of wheat. *Genetics* **149**: 2007-23.
- Stakman EC, DM Steward and WO Loegeing (1962) Identification of physiological races of *Puccinia recondita* var. *tritici*. *Miss. Agri. Expt. Sta. Sci. J. Series Paper* 4691.

## Survey, Identification and Selection of Superior Clones of Dashehari

**SK Saxena, Room Singh, RR Sharma and DS Khurdiya**

*Division of Fruits and Horticultural Technology, Indian Agricultural Research Institute, New Delhi-110012*

India's share in the world production of fruits is about 8% and produces about 65% of the world's mangoes, ranking first in mango production. There are numerous cultivars of mango being cultivated world over but limited number of them could attain commercial status. Commercial cultivation of Dashehari for very long period had brought either several changes in the cultivar due to the genetic shift or climatic factors. A superior type Dashehari-51, identified at CISH, Lucknow, bears good crop each year with no "off" bearing rhythm and with negligible malformation (Rajput *et al.* 1996). Thus, concerted efforts have been made to survey the different mango growing regions to identify and select the superior clones of Dashehari.

Dashehari orchards in Malihabad and Rehmankhera areas of Lucknow; Rasoolabad and Chaubeypur of Kanpur; Kunda and Kalakankar areas of Pratapgarh; Ramnagar, Kashi Vidyapeeth, Narwal, Barwan, Jagatpur, Mohansarai, Sikhar and Raja ka Talab areas of Varanasi; Jakhani, Kachhawa and Chunar areas in Mirzapur; Siyana and Makri areas in Bulandshahar; Moradabad, Meerut, Muzzafarnagar and Saharanpur districts of Uttar Pradesh; Sabour in Bihar and Malda and Murshidabad districts in West Bengal were surveyed between 1992 to 1999. The plants showing morphologically distinct character, moderate plant growth, regular bearing, good yield with improved fruit size, quality characters and resistance to malformation disease *etc.* were selected. Fruits were sampled from different places between 1<sup>st</sup> week of June and 4<sup>th</sup> week of July. Fruit samples were brought at IARI, New Delhi and were analysed for different physico-chemical characteristics as per standard procedures (AOAC, 1980).

On the basis of extensive surveys conducted in different places, seven distinct clones of Dashehari were identified. Mango orchards of Saharanpur and nearby areas were found free from malformation disease. Fruit maturity was expressed on the basis of specific gravity. Fruits having specific gravity less than one was identified

as floater while those with greater specific gravity as sinker (matured fruit). Fruits of Sabour-D-1 contained 50% sinker on 6<sup>th</sup> June and those from Kunda-D-1 had 40% sinker fruits on 15<sup>th</sup> June. All fruits from Malihabad (16<sup>th</sup> June), Makri (20<sup>th</sup> June) and Behat (27<sup>th</sup> June) were floater. This indicated that the harvesting at all of these places could have been delayed by 10-20 days for getting properly matured fruits. Fully matured fruits (all sinkers) were available at Behat (Saharanpur) by the end of 4<sup>th</sup> week of July.

### *Physico-chemical characters of the selected clones*

**Fruit maturity:** The mature fruits from Behat (Saharanpur) showed reduced pressure of 12.8 psi against 25.86 in floaters (Table 1). Interestingly, floater and sinker fruits from Sabour (28 lb psi each) and Kunda (18.07, 17.26 lb psi) showed almost equal pressure, indicating a very marginal fluctuation of specific gravity for a particular location. The fruits collected from Behat (Saharanpur) showed reduced pressure with the advancement of ripening. After ripening, however, the floating fruits of Makri-D-1 showed the maximum fruit pressure (7.15 lbs psi) at room temperature. On the contrary, those of Makri-D-2 recorded the maximum fruit pressure (3.25 lb psi) in cool storage (Table 2).

**Shelf/storage life:** The fruits of all clones studied upto 10% physiological loss in weight (PLW) from mature unripe stage revealed much prolonged shelf life in cool storage (12 to 22 days). There was hardly any difference in the shelf life of fruits of these clones at room temperature and cool storage at both stages of maturity, except those collected from Behat (Saharanpur) which showed much difference in storage life between the floater (22 days) and sinker (16 days) in cool storage due to different harvesting time (Table 2). Sabour D-1 also showed long shelf life (18 days in cool storage). Further, the fruits of Kunda-D-1 exhibited a better shelf life (6 and 7 days) at room temperature and 15 and 17 days in cool storage.

**Table 1. Physico-chemical characters of Dashehari clones**

| Observations                                     | Sabour-D-1           |                      | Kunda-D-1             |                       | Malihabad-D-1         | Makri-D-1             | Makri-D-2             | Behat-D-1             | Behat-D-2             |
|--------------------------------------------------|----------------------|----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
|                                                  | F                    | S                    | F                     | S                     | F                     | F                     | F                     | F                     | S                     |
| Date of harvest                                  | 6 <sup>th</sup> June | 6 <sup>th</sup> June | 15 <sup>th</sup> June | 15 <sup>th</sup> June | 16 <sup>th</sup> June | 20 <sup>th</sup> June | 20 <sup>th</sup> June | 27 <sup>th</sup> June | 24 <sup>th</sup> July |
| Pressure test (lbs) at harvest /sq inch          | 28.0                 | 28.0                 | 18.07                 | 17.26                 | 23.99                 | 25.75                 | 27.92                 | 25.86                 | 12.80                 |
| Extent of fruit maturity (%)                     | 50                   | 50                   | 60                    | 40                    | —                     | —                     | —                     | —                     | 100                   |
| Moisture (%)                                     | 77.16                | 77.69                | 72.85                 | 75.67                 | 79.70                 | 83.65                 | 80.75                 | 84.69                 | 75.68                 |
| T.S.S. (%)                                       | 10.45                | 9.0                  | 15.35                 | 14.95                 | 10.35                 | 9.40                  | 9.60                  | 10.10                 | 13.40                 |
| Acidity (%)                                      | 1.39                 | 1.39                 | 0.72                  | 0.42                  | 1.21                  | 1.93                  | 1.81                  | 1.04                  | 0.40                  |
| TSS:Acidity (Ratio)                              | 7.51                 | 6.47                 | 36.54                 | 20.76                 | 8.55                  | 4.87                  | 5.30                  | 9.71                  | 33.50                 |
| Reducing sugars (%)                              | 3.76                 | 3.68                 | 3.45                  | 3.41                  | 2.63                  | 2.81                  | 2.88                  | 3.15                  | 2.28                  |
| Total sugars (%)                                 | 12.75                | 13.58                | 10.57                 | 9.10                  | 4.26                  | 6.52                  | 8.27                  | 4.77                  | 7.82                  |
| Total carotenoids ( $\mu\text{g}/100\text{ g}$ ) | 806.12               | 1735.65              | 975.82                | 1056.82               | 293.13                | 393.41                | 358.70                | 470.56                | 1677.79               |

F = Floater      S = Sinker

**Table 2. Economic shelf life, spoilage, ripening and fruit quality of Dashehari clones**

| Fruit characters                                 | Storage | Sabour-D-1 |         | Kunda-D-1 |         | Malihabad-D-1 | Makri-D-1 | Makri-D-2 | Behat-D-1 | Behat-D-2 |
|--------------------------------------------------|---------|------------|---------|-----------|---------|---------------|-----------|-----------|-----------|-----------|
|                                                  |         | F          | S       | F         | S       | F             | F         | F         | F         | S         |
| Pressure test (lbs/psi) at ripening              | RT      | 2.90       | 3.20    | 1.85      | 2.08    | 1.17          | 7.15      | 4.87      | 1.75      | 2.15      |
|                                                  | CS      | 2.32       | 2.65    | 2.68      | 2.40    | 1.39          | 2.44      | 3.25      | 2.00      | 1.88      |
| Economic shelf-life (days at 10% PLW)            | RT      | 7          | 7       | 6         | 7       | 5             | 6         | 6         | 9         | 10        |
|                                                  | CS      | 18         | 17      | 15        | 17      | 16            | 12        | 13        | 22        | 16        |
| Spoilage (%)                                     | RT      | 44.67      | 50.00   | 17.64     | Nil     | Nil           | 24.0      | 9.09      | 9.09      | 47.05     |
|                                                  | CS      | 44.06      | 46.09   | Nil       | Nil     | Nil           | Nil       | Nil       | Nil       | 16.66     |
| Ripening (%)                                     | RT      | 100.0      | 100.0   | 34.48     | 38.88   | —             | —         | —         | —         | 64.70     |
|                                                  | CS      | 100.0      | 100.0   | 67.85     | 66.66   | 5.26          | 16.0      | 4.54      | 21.42     | 50.00     |
| Moisture (%)                                     | RT      | 81.67      | 82.66   | 77.10     | 73.80   | 71.10         | 80.20     | 82.10     | 83.00     | 75.86     |
|                                                  | CS      | 81.38      | 74.89   | 78.60     | 82.00   | 78.93         | 88.20     | 87.70     | 81.11     | 78.40     |
| T.S.S.(%)                                        | RT      | 20.00      | 21.60   | 24.70     | 25.40   | 17.15         | 19.10     | 17.60     | 15.10     | 23.60     |
|                                                  | CS      | 19.00      | 20.00   | 21.10     | 22.00   | 15.10         | 16.20     | 17.30     | 16.30     | 17.30     |
| Acidity (%)                                      | RT      | 0.06       | 0.19    | 0.16      | 0.08    | 0.32          | 0.16      | 0.24      | 0.16      | 0.08      |
|                                                  | CS      | 0.06       | 0.09    | 0.16      | 0.16    | 0.24          | 0.16      | 0.08      | 0.08      | 0.12      |
| Reducing sugar (%)                               | RT      | 5.28       | 5.08    | 2.78      | 6.42    | 2.26          | 3.31      | 2.65      | 2.24      | 2.67      |
|                                                  | CS      | 6.32       | 10.30   | 1.65      | 2.33    | 1.92          | 3.18      | 3.61      | 2.59      | 1.97      |
| Total sugar (%)                                  | RT      | 9.89       | 15.02   | 14.00     | 19.19   | 15.77         | 16.35     | 11.27     | 14.00     | 14.73     |
|                                                  | CS      | 11.39      | 13.73   | 12.74     | 16.93   | 12.47         | 14.81     | 15.26     | 13.63     | 13.77     |
| Total carotenoids ( $\mu\text{g}/100\text{ g}$ ) | RT      | 2294.92    | 3943.78 | 6344.77   | 3731.65 | 4512.69       | 6151.92   | 4773.04   | 7424.73   | 5623.50   |
|                                                  | CS      | 2294.32    | 2834.90 | 2815.61   | 2584.19 | 2429.91       | 1706.72   | 2106.89   | 3162.74   | 4908.0    |

F = Floater      S = Sinker      RT = Room Temperature CS=Cool storage (20 $\pm$ 5°C)

**Spoilage:** Kunda-D-1 (sinker) and Malihabad (floater) did not show any spoilage during ripening at room temperature as well as in cool storage. Further, Behat-D-1, Makri-D-1, Makri-D-2, and Kunda -D-1, (floater) were also observed to be free from spoilage during ripening in cool storage. In contrast, Sabour clone showed high degree of spoilage, which was due to early harvest of the fruits.

**Fruit ripening:** Fruits obtained from Sabour (early harvest) ripened well when these were harvested at a later stage. Fruits of Kunda-D-1 also showed good ripening at cool storage followed by room temperature in both floaters (67.85 and 34.48%) and in sinkers (66.66 and 38.88%), respectively. Fruits of Behat-D-2, however, showed good ripening only in sinkers (64.70 and 50%) under both conditions of storage. Fruits of other clones did not ripen satisfactorily even in cool storage.

**Fruit quality:** Freshly harvested fruits of different clones of Dashehari contained 72.85% to 84.69% moisture and there was no difference in moisture content between the sinkers and the floaters fruits of Sabour, however, Kunda-D-1 had slightly higher moisture in sinker fruits. Further, the sinker fruits late harvest (last week of July) from Behat-D-2 had lower moisture content than the floaters. Highest moisture content (84.69%) at harvest was observed in Behat D-1 followed by Makri D-1 and the lowest were in Kunda-D-1 (72.85%). Total soluble solids ranged from 9.0 to 15.35 (°Brix) in the freshly harvested fruits of different clones. At this stage, floater fruits had slightly higher TSS as compared to the sinkers, with the lapse in storage time, TSS content significantly increased at room temperature in all the clones from 15.1 to 25.4°Brix (Table 2). Further, the fruits stored at low temperature showed comparatively less TSS

except in case of Behat-D-1. The highest TSS at room temperature (25.4, 24.7) and at cool storage (22.0, 21.10 °Brix) was found in clones of Kunda, followed by clones of Sabour. The acidity varied between 0.40 to 1.93% in different clones depending on the time of harvest (Table 1). It is worthwhile to mention that the fruits of Kunda-D-1 harvested on 15<sup>th</sup> June had the minimum acidity (0.42%) which is quite comparable from freshly harvested fruits of Behat-D-2 which showed the minimum level of acidity (0.40) when harvested on 24<sup>th</sup> July. In general, the acidity in fruits of all clones reduced progressively at room temperature and cool storage (0.06 to 0.32%) with the advancement of ripening.

The total carotenoid pigments in the ripened fruits of different clones of Dashehari varied from 2294.32 (Sabour-D-1) to 7424.73 (Behat D-1).

The selection of better/improved clones of mango cv. Dashehari with regard to increased fruit yield, size and quality, availability of fruits for longer time, with higher shelf life for boosting export, extensive surveys were conducted in different parts of U.P., Bihar and West Bengal. These studies have resulted in the identification of some good clones of Dashehari. Out of those, clones of Kunda and Sabour appear to be promising owing to their earliest availability, better fruit quality and storability. The shelf life of all fruits could be prolonged (12 to 22 days) in cool storage. Similarly, the mango plants in the vicinity of Behat, Chhutmalpur and nearby areas were found to be virtually free from malformation.

#### References

- AOAC (1980) *Official Analytical Methods*. 15<sup>th</sup> Edition, Association of Analytical Chemists, Washington, D.C.
- Rajput MS, KL Chadha and SS Negi (1996) Dashehari-51, a regular bearing and high yielding clone of mango Cv. Dashehari. 5<sup>th</sup> Intl. Mango Symposium, Tel Aviv, 42 p.

## Evaluation of Ber Varieties

**JS Bal**

*Department of Horticulture, Punjab Agricultural University, Ludhiana-141004, Punjab*

**Key Words:** Evaluation, Ber, *Zizyphus*

A large number of ber varieties are available in India, out of which a few have been classified as early, mid and late varieties. Many workers (Chadha *et al.* 1972; Bal and Jawanda, 1981; Bal and Uppal, 1992; Aulakh, 1994) have determined the physico-chemical characters of ber varieties under different agro-climatic conditions. There are many grafted varieties in the country which are reputed for the specific traits. In the present studies, 42 ber varieties have been screened and evaluated for their yield and fruit quality attributes.

Investigations on evaluation of ber (*Zizyphus mauritiana* Lamk) varieties were carried out at Punjab Agriculture University, Ludhiana and RFRS, Bahadurgarh (Patiala) for several years on 42 ber varieties. These varieties are raised by budding *in situ* on katha ber seedlings. The observations on fruit yield, fruit size, fruit weight and pulp per cent were recorded. Total soluble solids were determined with the help of hand refractometer and values were corrected at 20°C. The acidity was estimated by titrating a known volume of the pulp against N/10 NaOH using phenolphthalein as indicator and expressed in terms of citric acid. Vitamin C was determined by using 2,6-dichlorophenol indophenol dye titration method.

The physico-chemical characters of different varieties are presented in Table 1. Different varieties yielded 50 to 200 kg fruits/tree. The average yield of fruits/tree was the highest (200 kg) in Umran. The other high yielding varieties were Kala Gola (170 kg), Sanaur-2 (160 kg) and Sanaur-5 and Desi Alwar (150 kg). The lowest fruit yield/tree was recorded in Rashmi (70 kg) and ZG-4 (50 kg). Aulakh (1994) reported little variation in fruit yield in different ber cultivars perhaps due to seasonal variation.

The fruit size and weight varies greatly among the different ber varieties. The average fruit size was noted largest in Umran followed by Sanaur-2, Glory, Thornless and Kaithli and the smallest in Safeda and Illaichi.

Dhingra *et al.* (1973); Bal and Jawanda (1981); Bal and Uppal (1992) and Aulakh (1994) also reported large sized fruits of Umran cultivar. The differences in fruit size and weight as compared to the reports of other workers may be due to different cultural practices adopted and age of the plants. The varieties like Katha Bombay, Rashmi, Umran and Nalagarh produced higher percentage of pulp, whereas Safeda, Chinese, Katha Phul and Mirchia were considered as less pulpy varieties. Soft and thin skin of Kaithli, Banarsi, Illaichi and Nazuk were preferred over thick skin of Golar, Gorva and Katha Bombay. It is the general opinion that pulp should be reasonably hard in texture so that fruits can stand transport action very well. Umran being a hard textured variety, it can transport to longer distance without much deterioration.

The total soluble solids' contents of different varieties varies between 11.3% in Katha Phul and 19.4% in Sanaur-2. Nalagarh, Laddu, Bahadurgarhi, Rashmi, Safeda, selected Safeda, Pathani and Desi Alwar also contain higher total soluble solids. However, Chadha *et al.* (1972) reported higher TSS in ber varieties as compared to the present studies. These differences may be due to the different cultural practices and crop-load on the trees. Acidity was found to be the highest (0.61%) in Chinese cultivar, closely followed by in Surti, Sanaur-3 and Katha Phul and the lowest in ZG-3, Laddu, Banarasi and Umran (Dhingra *et al.* 1973) have also reported variation in acid content in different ber varieties.

All the ber varieties contain good amount of vitamin C ranging between 63 to 148 mg/1000 g of pulp. Vitamin C estimated highest in Kala Gola, Pathani, Narikeli and Illaichi and the lowest in Rohtaki Gola, Safeda, Chinese and Dandan. However, Dhingra *et al.* (1973) reported relatively lower values of Vitamin C in different ber varieties when compared with the values of present study.

Table 1. Physico-chemical characteristics of ber

| Varieties        | Fruit yield<br>(kg/tree) | Fruit size  |              | Fruit<br>weight (g) | Pulp<br>(%) | TSS<br>(%) | Acidity<br>(%) | Vitamin C<br>(mg/100 g) |
|------------------|--------------------------|-------------|--------------|---------------------|-------------|------------|----------------|-------------------------|
|                  |                          | Length (cm) | Breadth (cm) |                     |             |            |                |                         |
| Bahadurgarhi     | 100                      | 3.7         | 2.7          | 14.0                | 90          | 18.0       | 0.47           | 115                     |
| Banarsi          | 100                      | 4.2         | 2.6          | 16.8                | 93          | 12.5       | 0.20           | 99                      |
| Banarsi Pawandi  | 110                      | 4.2         | 2.8          | 14.5                | 93          | 13.8       | 0.26           | 127                     |
| Chhuhara         | 75                       | 3.4         | 2.4          | 9.5                 | 92          | 14.8       | 0.28           | 117                     |
| Chinese          | 110                      | 3.4         | 2.8          | 12.8                | 87          | 13.6       | 0.61           | 86                      |
| Dandan           | 137                      | 3.9         | 2.6          | 11.4                | 93          | 14.8       | 0.25           | 89                      |
| Desi Alwar       | 150                      | 4.4         | 2.8          | 20.9                | 92          | 17.2       | 0.24           | 118                     |
| Glory            | 120                      | 4.8         | 2.7          | 16.7                | 92          | 15.5       | 0.32           | 105                     |
| Golar            | 110                      | 4.0         | 3.0          | 20.0                | 90          | 14.7       | 0.33           | 123                     |
| Gorva            | 90                       | 3.3         | 2.7          | 13.1                | 88          | 16.0       | 0.42           | 105                     |
| Illaichi         | 125                      | 2.2         | 1.9          | 5.6                 | 93          | 15.8       | 0.25           | 135                     |
| Kaithli          | 120                      | 4.5         | 2.8          | 17.5                | 93          | 14.2       | 0.24           | 17                      |
| Kala Gola        | 170                      | 3.5         | 3.0          | 19.8                | 92          | 15.8       | 0.29           | 148                     |
| Katha Bombay     | 120                      | 3.8         | 2.6          | 14.1                | 94          | 14.1       | 0.33           | 112                     |
| Katha Gurgaon    | 125                      | 3.1         | 2.5          | 11.0                | 93          | 13.9       | 0.29           | 117                     |
| Katha Phul       | 120                      | 2.8         | 2.3          | 8.5                 | 86          | 11.3       | 0.50           | 95                      |
| Laddu            | 80                       | 3.7         | 2.1          | 10.9                | 83          | 16.4       | 0.29           | 91                      |
| Mirchia          | 75                       | 4.4         | 2.3          | 10.1                | 83          | 16.4       | 0.29           | 91                      |
| Nalagarh         | 120                      | 3.6         | 3.0          | 17.4                | 94          | 18.9       | 0.23           | 123                     |
| Narikeli         | 125                      | 4.3         | 2.8          | 17.2                | 93          | 13.2       | 0.24           | 138                     |
| Nazuk            | 85                       | 3.7         | 2.1          | 7.8                 | 90          | 16.9       | 0.32           | 95                      |
| Noki             | 140                      | 4.5         | 2.3          | 11.5                | 93          | 14.4       | 0.36           | 107                     |
| Pathani          | 100                      | 3.1         | 2.5          | 9.4                 | 92          | 17.2       | 0.49           | 146                     |
| Rashmi           | 70                       | 3.4         | 2.4          | 11.0                | 94          | 17.8       | 0.24           | 127                     |
| Rohtaki Gola     | 90                       | 3.6         | 2.6          | 13.8                | 90          | 14.7       | 0.32           | 63                      |
| Safeda           | 110                      | 2.7         | 2.1          | 6.9                 | 87          | 17.8       | 0.43           | 85                      |
| Sanaur-1         | 125                      | 4.3         | 2.3          | 12.8                | 90          | 14.3       | 0.28           | 104                     |
| Sanaur-2         | 160                      | 4.5         | 3.1          | 23.2                | 92          | 19.4       | 0.44           | 118                     |
| Sanaur-3         | 140                      | 3.9         | 3.1          | 15.2                | 88          | 16.0       | 0.56           | 108                     |
| Sanaur-4         | 140                      | 4.2         | 2.9          | 18.0                | 92          | 15.6       | 0.38           | 92                      |
| Sanaur-5         | 150                      | 4.0         | 2.8          | 18.1                | 91          | 14.5       | 0.25           | 114                     |
| Sanaur-6         | 95                       | 4.6         | 2.4          | 18.5                | 91          | 16.8       | 0.38           | 112                     |
| Sandhura Narnaul | 100                      | 4.4         | 2.6          | 14.0                | 91          | 15.2       | 0.23           | 100                     |
| Selected Safeda  | 120                      | 3.2         | 2.9          | 13.8                | 90          | 17.5       | 0.32           | 95                      |
| Seo              | 110                      | 3.5         | 2.9          | 16.2                | 90          | 14.6       | 0.30           | 126                     |
| Surti            | 100                      | 3.7         | 3.2          | 18.1                | 91          | 14.5       | 0.58           | 105                     |
| Thornless        | 140                      | 4.6         | 2.8          | 23.4                | 93          | 13.3       | 0.26           | 105                     |
| Umran            | 200                      | 5.1         | 3.6          | 32.1                | 94          | 14.0       | 0.20           | 120                     |
| Wallaiti         | 125                      | 4.1         | 2.6          | 16.5                | 93          | 13.7       | 0.32           | 93                      |
| ZG-2             | 140                      | 3.8         | 2.9          | 15.4                | 92          | 14.4       | 0.25           | 103                     |
| ZG-3             | 130                      | 3.3         | 2.4          | 15.2                | 91          | 13.5       | 0.16           | 116                     |
| ZG-4             | 50                       | 3.8         | 3.0          | 16.5                | 91          | 13.8       | 0.49           | 115                     |

## References

- Aulakh PS (1994) Performance of ber cultivars grown under Patiala conditions. *Prog. Hort.* 26(3-4): 14-46.
- Bal JS and DK Uppal (1992) Ber varieties, Assoc. Publishing Co., New Delhi, pp. 90.
- Bal JS and JS Jawanda (1981) Studies on physico-chemical characteristics of ber cultivars grown at Ludhiana. *Hortic. J.* 1: 42-47.
- Dhingra RP, JP Singh and SD Chitkara. 1973. Varietal variation in physico-chemical characters of ber (*Zizyphus mauritiana* Lamk). *Haryana J. Hort. Sci.* 2: 61-65.

## Evaluation of Pomegranate Germplasm under Punjab Conditions

**WS Dhillon and KK Sharma**

*Department of Horticulture, Punjab Agricultural University, Ludhiana-141004, Punjab*

**Key Words:** Evaluation, Pomegranate germplasm

Pomegranate (*Punica granatum* L.) is considered to be one of the most important desert fruit in India as well as in the world. Its juice is very refreshing, nutritive and have medicinal properties. In India, this fruit is commercially grown in states of Maharashtra, Karnataka, Gujarat and Rajasthan. Pomegranate is not fastidious to soil and edaphic conditions, hence performs well even in marginal soils. The efforts have been made to grow pomegranate successfully under Punjab conditions. To achieve this, the germplasm of pomegranate were collected from different sources and evaluated for their adaptability.

Thirty varieties of pomegranate were collected and planted in the New Orchard of the Department of Horticulture, Punjab Agricultural University, Ludhiana. The cuttings were planted during January 1991 and received uniform cultural practices during the course of studies. The data on various parameters were recorded by taking the tree as a unit and replicated twice by following the randomized block design. The growth parameters such as stem girth and tree spread were measured in the month of January after the fifth year of plantation. Stem girth was recorded 15 cm above the ground level. The tree height and tree spread (mean of North-South + East-West) were recorded with meter rod. The number of fruits was counted at harvest stage. The fruit weight was recorded. The peel of the fruit was separated and the weight was recorded. Similarly, 400 grains were taken from each fruit and their collective weight was calculated. The juice weight from each fruit was recorded after extracting it from all the grains. The chemical composition (TSS and acidity) were recorded by using standard procedures of AOAC (1980).

The growth data given in Table 1 revealed that Kandhari was most adaptive under Punjab conditions followed by Moga-Local, Assam-Local and PAU Selection.

The maximum plant height (2.75 m), spread (2.11m) and stem girth (25.2 cm) was recorded in Kandhari followed by 2.50, 2.48 and 2.37 m height in Moga-Local, Assam-Local and PAU Selection, respectively. The minimum growth was observed in LP<sub>3</sub> and LP<sub>5</sub>. The highest number of fruits (88) were recorded in Moga-Local followed by 73 in Russian Seedling and 71 in Nabha CVs. The lowest (fruits/tree) were, however noted in Ichikdana. Rane *et al.* (1982) reported that the production of 50 to 60 fruits/tree were most economical. The heaviest fruit (487.5 g) was produced by PAU Selection followed by Ganesh (455.5 g) and PS-77 (437.0 g) and the lightest (162.5 g) in Malas. Khodade (1987) also reported more than 400 g/fruit weight in Ganesh. The minimum (67.5 g) peel weight of the fruit was noted in Malas and maximum (216.0 g) in PAU Selection. The peel weight is directly associated with fruit weight. The cultivars, which produced higher fruit weight, also produced higher peel weight. The weight of 400 grains of the fruit was highest (145.0 g) in Kandhari followed by Chawla-1 (142.5 g) and the lowest in Shirin Anar (75.0 g). In different varieties of pomegranate, Singh (1997) reported the weight of 400 grains ranging between 87 to 103 g.

The juice weight was maximum (102.5/fruit) in PAU Selection, closely followed by Kandhari (102.1 g) and minimum (45.0 g) in Russian Seedling. This was due to very bold seeds in Russian Seedling. The highest TSS of 15.0% was recorded in Assam-Local, followed by 14.3% in Ganesh and 14.2% in PS-77. The lowest TSS of 10.9% was noted in Chawla-1. The maleic acid content was as low as 0.39% in Ganesh and as high as 3.51% in Shirin Anar. However, TSS up to 17.94% and juice acidity of 0.25% was recorded by Raturi and Hiwale (1991) under dry conditions of cultivation.

Table 1. Performance of pomegranate varieties under Punjab conditions

| Cultivars               | Tree height (m) | Tree spread (m) | Stem girth (cm) | Fruit weight (g) | Peel weight (g) | 400 arils weight (g) | Fruit number/tree | Juice weight (g) | TSS (%) | Acidity (%) |
|-------------------------|-----------------|-----------------|-----------------|------------------|-----------------|----------------------|-------------------|------------------|---------|-------------|
| Ganesh                  | 1.86            | 1.72            | 17.7            | 455.5            | 168.5           | 117.5                | 65                | 102.1            | 13.3    | 0.386       |
| Kandhari                | 2.75            | 2.11            | 25.2            | 372.5            | 145.6           | 145.0                | 67                | 70.0             | 12.4    | 0.485       |
| Moga-Local              | 2.5             | 1.82            | 16.5            | 256.3            | 107.0           | 102.5                | 88                | 72.3             | 13.9    | 0.603       |
| Assam-Local             | 2.48            | 1.43            | 16.6            | 212.5            | 92.5            | 100.0                | 42                | 47.0             | 15.0    | 0.536       |
| Malas                   | 2.28            | 1.58            | 21.8            | 162.5            | 67.5            | 95.0                 | 60                | 65.0             | 12.4    | 3.484       |
| Basse-in-Seedless       | 1.37            | 1.02            | 15.5            | 340.0            | 130.0           | 115.0                | 48                | 90.0             | 13.0    | 0.435       |
| PS-77                   | 2.12            | 1.60            | 19.5            | 437.0            | 155.0           | 95.0                 | 52                | 65.0             | 14.2    | 0.567       |
| G-137                   | 1.97            | 1.42            | 17.3            | 260.0            | 110.0           | 90.0                 | 60                | 69.0             | 13.3    | 0.425       |
| P-26                    | 1.40            | 1.40            | 14.5            | 260.0            | 100.0           | 95.0                 | 47                | 70.0             | 12.0    | 0.502       |
| Khog                    | 1.67            | 1.15            | 13.5            | 218.3            | 172.5           | 115.0                | 35                | 87.5             | 12.0    | 0.485       |
| Jodhpur White           | 1.60            | 1.40            | 17.0            | 302.5            | 170.0           | 95.0                 | 43                | 70.0             | 12.4    | 0.549       |
| CO1                     | 1.40            | 0.90            | 13.0            | 330.0            | 120.0           | 100.0                | 38                | 70.0             | 10.0    | 0.536       |
| Russian Seedling        | 1.92            | 1.45            | 16.0            | 387.5            | 180.0           | 85.0                 | 73                | 45.0             | 12.8    | 0.549       |
| Panipat Sel.            | 2.22            | 1.45            | 18.0            | 337.5            | 197.5           | 110.0                | 65                | 75.0             | 11.8    | 0.616       |
| Shirin Anar             | 1.45            | 0.72            | 11.5            | 250.0            | 112.5           | 75.0                 | 35                | 50.0             | 11.0    | 3.510       |
| LP <sub>4</sub>         | 1.30            | 0.45            | 8.5             | 250.0            | 100.0           | 90.0                 | 61                | 70.0             | 14.0    | 0.510       |
| Ichikdana               | 1.40            | 1.00            | 12.0            | 245.0            | 135.0           | 100.0                | 32                | 70.0             | 13.8    | 1.775       |
| Chawla-1                | 2.00            | 1.30            | 16.0            | 283.5            | 107.5           | 142.5                | 47                | 72.5             | 10.8    | 0.636       |
| Kali Shirin             | 1.45            | 1.30            | 13.5            | 300.0            | 112.0           | 110.0                | 71                | 75.0             | 12.4    | 0.576       |
| Anar Shirin             | 1.38            | 1.12            | 10.5            | 283.5            | 100.0           | 115.0                | 35                | 82.0             | 13.0    | 0.536       |
| PS77K3                  | 2.00            | 1.20            | 16.5            | 401.3            | 181.3           | 122.5                | 62                | 84.0             | 12.3    | 0.402       |
| A K Anar                | 1.97            | 1.45            | 20.0            | 281.3            | 121.3           | 115.0                | 38                | 81.5             | 12.7    | 0.569       |
| Kandhari Ganga Nagar    | 2.10            | 1.05            | 14.0            | 270.0            | 87.5            | 105.0                | 60                | 75.0             | 13.0    | 3.484       |
| Nabha                   | 2.02            | 1.46            | 16.0            | 320.0            | 112.5           | 123.5                | 71                | 87.5             | 12.9    | 0.552       |
| PAU Sel.                | 2.37            | 1.63            | 16.6            | 487.5            | 216.0           | 139.5                | 74                | 102.5            | 12.9    | 0.703       |
| Anar Shirin Muhamad Ali | 1.70            | 1.40            | 14.0            | 225.0            | 125.0           | 90.0                 | 52                | 60.0             | 12.0    | 0.576       |
| LP <sub>3</sub>         | 1.05            | 0.60            | 10.0            | —                | —               | —                    | —                 | —                | —       | —           |
| LP <sub>5</sub>         | 1.25            | 0.50            | 8.0             | —                | —               | —                    | —                 | —                | —       | —           |
| Ganesh Jandeel          | 1.70            | 1.15            | 15.0            | —                | —               | —                    | —                 | —                | —       | —           |
| Jyoti                   | 1.40            | 0.60            | 10.0            | —                | —               | —                    | —                 | —                | —       | —           |
| CD at 5%                | 0.32            | 0.17            | 2.0             | 23.8             | 21.3            | 11.9                 | 7.2               | 23.4             | 0.59    | 0.23        |

## References

- AOAC (1980) Official and Tentative Methods of Analysis. 13<sup>th</sup> ed., Washington DC, USA.
- Khodade MS (1987) Studies on physico-chemical changes during growth and development of pomegranate fruits. M Sc Thesis MPKV, Rahuri (Maharashtra).
- Rane DA, AP Karale, KM Wavhal and KB Kamble (1982) Paper

presented at All India Pomegranate Research Workers Meeting at MPAU, Rahuri, 1-2, July.

- Raturi GB and SS Hiwale (1991) Regulation of cropping in pomegranate under rainfed conditions. *Indian J. Hort.* **48**: 13-15.
- Singh NP (1997) Effect of mechanical deblossoming on yield and quality of pomegranate (*Punica granatum* L). M.Sc. Thesis. PAU, Ludhiana.

## Inter-relationships of Yield and Yield Components in Sunhemp (*Crotalaria* spp.)

**SK Gupta, OP Yadav and BPS Lather**

Department of Plant Breeding, CCS Haryana Agricultural University, Hisar-125004, Haryana

**Key Words:** Sunhemp, Diversity, Inter-relationship

Improvement in production potential of sunhemp (*Crotalaria* spp.) would certainly go a long way in its use as a green manuring crop. Correlation studies in *Crotalaria* breeding material will help in developing a selection scheme which would help in enhancing the genetic potential of this crop. Such information in *Crotalaria* is not available. The present investigation was therefore designed to work out the component of yield and their direct and indirect effects on its determinants in *Crotalaria*.

The experimental material consisted of eight genotypes of *Crotalaria*. Three out of eight genotypes were received from NBPGR, New Delhi and rest of the five were collected from different places in Haryana. Thus, a total of eight genotypes were sown in a randomized block design with three replications at Plant Breeding Experimental Farm during *kharif*, 2000. Each genotype was sown in six rows of 3 m each placed 45 cm apart with plant to plant spacing of 15 cm in each replication. Data on five randomly selected plants from each genotype in each replication were recorded for days to flowering, plant height, leaves/plant, leaf length, pod length, pods/plant, seeds/pod and seed yield/plant. Correlations and path-coefficients were computed following the methodology of Dewey and Lu (1959).

The correlation coefficients between grain yield and other characters studied are presented in Table 1. In

general, the genotypic correlations were of greater magnitude than their corresponding phenotypic correlations indicating that the environmental factors affected both the variables taken at a time at random and lack of association at environmental level. High genotypic correlations also suggested that there was inherent relationship between the characters studied. Seed yield had maximum value of positive correlation with number of pods/plant followed by pod length. This observation that pods/plant is significantly positive correlated with grain yield has also been reported in other legumes, such as chickpea (Pundir *et al.* 1988), lentil (Singh and Singh, 1991; Pandey *et al.* 1992) and in mungbean (Ramana and Singh, 1987). Days to flowering had negative insignificant correlation with grain yield as reported by Ramana and Singh (1987) in mungbean. Days to flowering and plant height are highly positive correlated with each other and both these characters were having significant negative correlation with pods/plant and seeds/pod. This may be because of the increase in vegetative phase due to increase in days to flowering resulting into increase in height of plants which reduces reproductive phase period and so reduces pods/plant and seed/pod. Leaf length showed high positive correlation with number of leaves/plant but had high negative correlation with seeds/pod. Path coefficient analysis using grain yield as dependent variable

**Table 1.** Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients between yield and its components in *Crotalaria* spp.

| Character              | Days to flower | Plant height | No. of leaves/plant | Leaf length | Pod length | Pods/plant | Seeds/pod | Seed yield/plant |
|------------------------|----------------|--------------|---------------------|-------------|------------|------------|-----------|------------------|
| Days to flower         |                | 1.008**      | 0.129               | 0.585**     | -0.223     | -0.504*    | -0.712**  | -0.187           |
| Plant height           | 0.920**        |              | 0.082               | 0.374       | -0.114     | -0.534**   | -0.680**  | -0.214           |
| Number of leaves/plant | 0.102          | -0.040       |                     | 1.070**     | -0.096     | 0.261      | -0.213    | 0.366            |
| Leaf length            | 0.389          | 0.422*       | 0.437*              |             | -0.156     | -0.358     | -0.607**  | 0.074            |
| Pod length             | -0.190         | -0.051       | -0.089              | -0.168      |            | 0.193      | -0.299    | 0.613**          |
| Pods/plant             | -0.482*        | -0.476*      | 0.214               | -0.231      | 0.157      |            | 0.344     | 0.779**          |
| Seeds/pod              | -0.507*        | -0.531**     | -0.102              | -0.410      | -0.184     | 0.320      |           | -0.149           |
| Seed yield/plant       | -0.201         | -0.159       | 0.242               | -0.034      | 0.652**    | 0.640**    | -0.072    |                  |

\*, \*\* Significant at 1% and 5% level, respectively.

**Table 2. Path coefficients of grain yield/plant vs other characters in *Crotalaria* spp.**

| Character              | Days to flower | Plant height | No. of leaves/plant | Leaf length   | Pod length    | Pods/plant   | Seeds/pod     | Seed yield/plant |
|------------------------|----------------|--------------|---------------------|---------------|---------------|--------------|---------------|------------------|
| Days to flower         | <b>-1.429</b>  | 1.018        | 0.072               | -0.274        | 0.053         | -0.340       | 0.712         | -0.187           |
| Plant height           | -1.44          | <b>1.009</b> | 0.045               | -0.175        | 0.027         | -0.360       | 0.680         | -0.214           |
| Number of leaves/plant | -0.184         | 0.083        | <b>0.558</b>        | -0.503        | 0.023         | 0.176        | 0.213         | 0.366            |
| Leaf length            | -0.837         | 0.378        | 0.599               | <b>-0.468</b> | 0.037         | -0.242       | 0.607         | 0.074            |
| Pod length             | 0.318          | -0.115       | -0.053              | 0.073         | <b>-0.239</b> | 0.130        | 0.499         | 0.613**          |
| Pods/plant             | 0.520          | -0.539       | -0.342              | 0.168         | -0.046        | <b>0.675</b> | 0.347         | 0.779**          |
| Seeds/pod              | 1.019          | -0.687       | -0.119              | 0.284         | 0.119         | 0.232        | <b>-0.999</b> | -0.149           |

Residual effect = 0.2491

Diagonal values are direct effects

and other characters as independent variables is presented in Table 2. Plant height exhibited largest direct and positive effect on grain yield followed by number of pods/plant and leaves/plant. Plant height and leaves/plant had considerable positive direct effect through number of seeds/pod. The high correlation of grain yield with pod length and number of pods/plant was observed as a result of their indirect contribution through seeds/pod and days to flowering. Residual effect was of low magnitude, suggesting that most of the components contributing to yield have been included in the analysis.

In view of the results discussed above, it may be inferred that selection based on seeds/pod will increase pod length and number of pods/plant *vis-à-vis* the grain yield. The number of pods/plant which is an important yield contributing component is the only direct component through which yield potential of plants may be effectively increased. Singh (1997) also suggested number of pods/plant to be the most important yield

component in pulse crops. It is further concluded that selection based on number of pods/plant will be more useful than any other yield component in *Crotalaria*.

### References

- Dewey DR and KH Lu (1959) A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J.* **51**: 515-518.
- Pandey A, DP Singh and BB Singh (1992) Interrelationship of yield and yield components in lentil (*Lens culinaris* Medik) germplasm. *Indian J. Pulses Res.* **5**: 142-144.
- Pundir RPS, KN Reddy and MH Mengesha (1988) ICRISAT Chickpea Germplasm Catalogue: Evaluation and Analysis. Patancheru, India, ICRISAT 99 p.
- Ramana MV and DP Singh (1987) Genetic parameters and character association in green gram. *Indian J. Agric. Sci.* **57**: 661-663.
- Singh DP (1997) Tailoring the plant type of pulse crops. *Plant Breed. Abstr.* **67**: 1213-1220.
- Singh DP and BB Singh (1991) Evaluation of exotic germplasm in lentil. *Narendra Deva J. Agric. Res.* **6**: 304-306.

## Evaluation of Groundnut Core Collection to Identify Sources of Tolerance to Low Temperature at Germination

**HD Upadhyaya, SN Nigam and Sube Singh**

*Genetic Resources and Enhancement Program, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru-502324, Andhra Pradesh*

**Key Words:** Ground nut, Tolerance, Low temperature, Core collection

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop cultivated in about 96 countries of the world. In the year 2000, it was cultivated on 23.84 million hectares with 34.52 million tonnes output of groundnut in shell. *Arachis hypogaea* is divided into two subspecies, *fastigiata* and *hypogaea*. The subspecies *fastigiata* is subdivided into four botanical varieties, *fastigiata*, *peruviana*, *aequatoriana*, and *vulgaris* and subspecies *hypogaea* into two botanical varieties, *hypogaea* and *hirsuta*. The crop is grown under wide range of climatic conditions, from warm tropical to humid temperate, although all the production environments can be characterized by a warm, frost-free period of at least 90 days (Bunting *et al.* 1985). During this growing season, mean temperatures generally range from 24 to 33°C (Saxena *et al.* 1983), with temperature optima for growth and dry matter production generally considered to lie within a similar range (Ketrang *et al.* 1982; Ketrang, 1984). The base temperature ( $T_b$ ), the temperature at or below which the rate of progress towards a phenological event is zero, for groundnut is considered to be 10°C. Bell *et al.* (1991) estimated mean  $T_b$  for 16 cultivars for germination to be 13.3°C. In some countries in Asia and North America, the temperatures at planting time are low resulting in delayed and poor germination/plant stand in groundnut and consequently poor yield and economic loss to the farmers. The objective of the study was to determine genetic variation and identify sources for low temperature (12°C) tolerance at germination in the core collection of groundnut.

The core collection of groundnut, consisting 1704 accessions (Upadhyaya *et al.* 2001), was screened for low temperature tolerance at germination under laboratory conditions. The core collection consisted of 584 (34.3%) accessions belonging to variety *vulgaris*, 299 (17.5%) to *fastigiata*, 27 (1.6%) to *peruviana*, 6 (0.4%) *aequatoriana*, 784 (46.0%) *hypogaea*, and 4 (0.2%) *hirsuta*. Gangapuri (*fastigiata*), ICGS 44 (*vulgaris*), ICGS 76 (*hypogaea*), and M 13 (*hypogaea*) were used as control cultivars. Twenty-five seeds of each accession

grown in 1999-2000 post-rainy season were treated with Captan, n-[(trichloromethyl) thio]-4-cyclohexene-1,2-dicarboxymide, at 2 g/kg seed before test. The seeds of *hypogaea* and *hirsuta* botanical varieties were also treated with ethrel (2-chloroethylphosphonic acid) before testing to overcome the possible effects of seed dormancy. Each accession was replicated twice. Rolled paper towel test (Ellis *et al.* 1985) was used for germination in an incubator at 12°C day/night temperature. Sufficient quantity of distilled water was added to the tray so as to keep 3-4 cm of rolls in the water. The number of germinating seeds was recorded at 10 days after incubation for *fastigiata*, *vulgaris*, *aequatoriana*, and *peruviana* types. In the case of *hypogaea* and *hirsuta*, very few seeds germinated at 10 days and germination was, hence, recorded at 15 days after incubation. The percentage germination was calculated and data analysed using completely randomized design. The accessions which showed 80% or more germination were considered as having tolerance for low temperature at germination. Among the tolerant accessions, land races were selected as they have the original variation and used to estimate diversity. The land races were grown in 1999 rainy and 1999-2000 post-rainy seasons on ridges in one row plot of 4 m length, in an augmented design. The distance between ridges was 60 cm and between plants 10 cm. The data on 12 morphological descriptors traits, and 15 quantitative traits each in 1999 rainy and 1999-2000 post-rainy season and oil and protein contents in the 1999-2000 post-rainy season were used to assess the diversity among them. The data on morphological descriptors, growth habit, stem colour and hair, leaf colour and hair, flower, flower streak, and peg colour were recorded on plot basis. Pod beak, constriction, and reticulation was recorded on 10 mature pods and primary seed colour on 10 sound mature seeds. The data on quantitative traits, days to 50% flowering and plot yield were recorded on plot basis, and primary branches, plant height, leaflet length and width on five randomly selected competitive plants. The number of seeds/pod, pod length

**Table 1. Performance of selected low temperature tolerant land races in the 1999-2000 post-rainy season, ICRISAT Centre, Patancheru, India**

| Landrace   | Botanical variety* | Country of origin | Germination** (%)    | Pod yield (t ha <sup>-1</sup> ) | Shelling percentage | 100-seed weight (g) | Oil (%) | Protein (%) |
|------------|--------------------|-------------------|----------------------|---------------------------------|---------------------|---------------------|---------|-------------|
| ICG 12553  | AEQ                | Ecuador           | 90 (72) <sup>+</sup> | 1.19                            | 68                  | 52                  | 50      | 24          |
| ICG 8570   | FST                | Argentina         | 92 (74)              | 1.54                            | 79                  | 46                  | 45      | 28          |
| ICG 4788   | FST                | Benin             | 82 (66)              | 1.39                            | 79                  | 54                  | 48      | 24          |
| ICG 12743  | FST                | Bolivia           | 92 (74)              | 1.84                            | 67                  | 53                  | 50      | 25          |
| ICG 14130  | FST                | Brazil            | 94 (76)              | 1.78                            | 73                  | 38                  | 49      | 24          |
| ICG 115    | FST                | India             | 86 (69)              | 1.67                            | 68                  | 38                  | 46      | 26          |
| ICG 7884   | FST                | Israel            | 96 (79)              | 1.56                            | 71                  | 57                  | 51      | 22          |
| ICG 7929   | FST                | Paraguay          | 94 (76)              | 1.29                            | 77                  | 43                  | 49      | 23          |
| ICG 7352   | FST                | Peru              | 94 (76)              | 1.17                            | 71                  | 52                  | 43      | 28          |
| ICG 1966   | FST                | Venezuela         | 96 (79)              | 1.35                            | 75                  | 40                  | 45      | 27          |
| ICG 10092  | FST                | Zimbabwe          | 88 (71)              | 1.64                            | 75                  | 53                  | 48      | 28          |
| ICG 13539  | HYP                | Togo              | 98 (84)              | 1.71                            | 80                  | 66                  | 51      | 23          |
| ICG 8797   | HYP                | Zambia            | 94 (76)              | 1.97                            | 76                  | 81                  | 48      | 24          |
| ICG 2708   | HYP                | Australia         | 92 (74)              | 1.68                            | 74                  | 58                  | 50      | 22          |
| ICG 4331   | HYP                | India             | 96 (82)              | 1.95                            | 77                  | 53                  | 47      | 25          |
| ICG 11631  | HYP                | India             | 84 (67)              | 1.84                            | 72                  | 54                  | 51      | 19          |
| ICG 9515   | HYP                | Mozambique        | 96 (82)              | 2.16                            | 76                  | 55                  | 49      | 25          |
| ICG 2773   | HYP                | Tanzania          | 92 (74)              | 1.64                            | 76                  | 53                  | 48      | 19          |
| ICG 10567  | PRU                | Peru              | 92 (74)              | 1.33                            | 70                  | 53                  | 50      | 24          |
| ICG 10945  | PRU                | Peru              | 88 (70)              | 2.08                            | 67                  | 57                  | 50      | 24          |
| ICG 11088  | PRU                | Peru              | 92 (74)              | 1.83                            | 66                  | 54                  | 48      | 22          |
| ICG 11911  | VUL                | Mali              | 94 (80)              | 1.26                            | 74                  | 54                  | 52      | 19          |
| ICG 11579  | VUL                | Sri Lanka         | 85 (67)              | 1.39                            | 72                  | 49                  | 51      | 23          |
| ICG 1899   | VUL                | Uganda            | 92 (74)              | 1.27                            | 67                  | 43                  | 44      | 28          |
| Control    |                    |                   |                      |                                 |                     |                     |         |             |
| Gangapuri  | FST                | India             | 84 (66)              | 0.85                            | 73                  | 46                  | 47      | 24          |
| ICGS 44    | VUL                | India             | 43 (37)              | 1.47                            | 77                  | 58                  | 49      | 23          |
| ICGS 76    | HYP                | India             | 50 (45)              | 1.71                            | 76                  | 62                  | 49      | 22          |
| M 13       | HYP                | India             | 50 (45)              | 1.54                            | 69                  | 63                  | 50      | 23          |
| SE±        |                    |                   | ±15.09 (11.41)       | ±0.295                          | ±2.96               | ±5.44               | ±0.93   | ±1.16       |
| Trial mean |                    |                   | 47 (42)              | 1.39                            | 74                  | 57                  | 49      | 23          |
| CV(%)      |                    |                   | 32.1 (27.0)          | 26.7                            | 5.0                 | 11.9                | 2.4     | 6.3         |

\* AEQ, *aequatoriana*, FST, *fastigiata*, HYP, *hypogaea*, PRU, *peruviana*, and VUL, *vulgaris*

\*\* Germination test was carried out in laboratory and germination was recorded 15 days after incubation in *hypogaea* and 10 days in all other botanical varieties

\* Figures in brackets are arc sine transformed values

and width were recorded on 10 mature pods and shelling percentage on 200 g pods. The 100 randomly selected mature seeds were taken to record seed weight which were later on used to determine oil and protein contents. Seed length and width was recorded on 10 mature seeds.

A phenotypic distance matrix was created by calculating the differences between each pair of entries

for each characteristic. The diversity index was calculated by averaging all the differences in the phenotypic values for each trait divided by the respective range (Johns *et al.* 1997). Hierarchical cluster analysis was performed following Ward (1963) by Statistica software.

In 480 accessions, germination ranged from 0 to 10%, in 331 from 21 to 40%, in 254 from 41 to 60%,

in 296 from 61 to 80%, and in 343 from 81 to 100% compared to 43% in ICGS 44, 84% in Gangapuri, and 50% in both ICGS 76 and M 13. The 343 accessions with 81-100% germination consisted of 25 cultivars, 93 breeding lines, 164 land races, and 61 others. Botanically, they represented, 4 *aequatorina*, 97 *fastigiata*, 11 *peruviana*, 20 *vulgaris*, and 211 *hypogaea*. This indicated that tolerance to low temperature is not restricted to any particular group of botanical variety nor it is confined to any geographical region as botanical varieties have evolved from different regions.

The low temperature tolerant landraces differed for various agronomic traits and showed a wide range of variability for traits of economic importance like, yield (0.38- 2.31 t/ha), shelling percentage (55-80), 100-seed weight (24-81 g), and oil (43-54%) and protein (16-30%) contents. Several land races showed an excellent combination of pod yield, shelling percentage, 100-seed weight, and oil and protein contents. The data on selected tolerant land races from the five botanical varieties is given in Table 1. Broad sense heritability for tolerance to low temperature at germination was estimated to be 88%. These land races need to be further evaluated for germination at lower temperature in laboratory and for agronomic traits in replicated field trials.

The cluster analysis using diversity index delineated 164 tolerant landraces and control cultivar Gangapuri, which is a land race from Khargone, Madhya Pradesh in India, into seven clusters. The number of land races varied from five in Cluster 1 to 44 in Cluster 3. There was no pattern of clustering on the basis of botanical varieties in most of the clusters. The mean phenotypic diversity index of the 165 tolerant landraces was 0.222. The minimum diversity index (0.051) was observed

between ICG 4235 (*hypogaea* from India) and ICG 4389 (*hypogaea* from India) to 0.519 between ICG 1710 (*peruviana* from Peru) and ICG 9037 (*hypogaea* from Cote d'Ivoire). Selected diverse lines can be identified for use in the improvement program to develop high yielding low temperature tolerant cultivars and to broaden the crop genetic base.

## References

- Bell MJ, R Shorter and R Mayer (1991) Cultivar and environmental effects on growth and development of peanuts (*Arachis hypogaea* L.). I. Emergence and flowering. *Field Crops Res.* **27**: 17-33.
- Bunting AH, RW Gibbons and JC Wynne (1985) Groundnut (*Arachis hypogaea* L.) In: RJ Summerfield and EH Roberts (ed.) *Grain Legume Crops*, Collins, London, England, pp 747-800.
- Ellis RH, TD Hong and EH Roberts (1985) The conduct of seed germination tests. In: *Handbook of Seed Technology for Genebanks*. Vol. I. Principles and Methodology. International Board of Plant Genetic Resources, Rome, pp 94-198.
- Johns MA, PW Skroch, J Nienhuis, P Hinrichsen, G Bascur and C Munoz-Schick. 1997. Gene pool classification of common bean land races from Chile based on RAPD and morphological data. *Crop Sci.* **17**: 605-613.
- Ketring DL (1984) Temperature effects on vegetative and reproductive development of peanut. *Crop Sci.* **24**: 877-882.
- Ketring DL, RH Brown, GA Sullivan and BB Johnson (1982) In: *Growth Physiology Peanut Science and Technology* HE Pattee and CT Young (ed.) *Am. Peanut Res. Edu. Soc.*, Yoakum, Tx, USA, pp 411-457.
- Saxena NP, M Natarajan and MS Reddy (1983) Chickpea, pigeonpea, and groundnut. In: *Potential Productivity of Field Crops under Different Environments*. IRRI, Los Baños, Laguna, Philippines, pp 281-305.
- Upadhyaya HD, R Ortiz, PJ Bramel and Sube Singh. 2001. Development of a groundnut core collection using taxonomical, geographical and morphological descriptors. *Genetic Res. Crop Evol.* (in press).
- Ward J (1963) Hierarchical grouping to optimize an objective function. *J. Am. Stat. Assoc.* **38**: 236-244.

## Genetic Diversity in Sesame (*Sesamum indicum* L.)

**PK Singh**

CS Azad University of Agriculture and Technology, Crop Research Farm, Mauranipur-284204, Uttar Pradesh

**Keywords:** Sesame (*Sesamum indicum* L.), Genetic diversity, Analysis of variance

Sesame is probably the most ancient oil seed crop known and used by man and is mainly taken as rainfed *Kharif* crop in India. The average yield of sesame in the country is low (about 300 kg/ha) due to the various agro-production constraints including low yield potential of sesame varieties. Improvement in seed yield is normally achieved by selecting the desirable genotypes from the segregating generations of diverse crosses. The divergence analysis using  $D^2$  statistic is a powerful tool for quantifying the degree of divergence. Hence, the present investigation was carried out to measure the genetic diversity to identify the suitable parents of sesame for hybridization programme.

Forty six genetically diverse genotypes of sesame comprising 21 entries from Uttar Pradesh and 25 from seven different states of India (Table 1) were grown in RBD with three replications during *Kharif*, 1998. Each plot consisted of two rows of 4 m length and spaced 30 cm apart, with a plant to plant distance of 15 cm. All the recommended agronomic practices were followed to raise the crop. Data were recorded on 10 random plants for six characters viz. - plant height (cm), days to flowering, days to maturity, number of productive capsules/plant, 1000-seed weight (g) and seed yield/plot (g). Data were analysed using Mahalanobis  $D^2$ -statistic and genotypes were grouped into clusters (Spark, 1973).

The analysis of variance showed significant differences among the genotypes for all the traits thus, validating the further genetic analysis. Forty six genotypes of sesame were grouped into eight clusters (Table 1). Cluster V was the largest and consisted of 13 genotypes followed by cluster I with 8 genotypes. Cluster II and VIII, each 6 genotypes whereas, cluster III and VI accounted for 5 genotypes each. Cluster IV was unique since it contains only one genotype. The grouping pattern did not show any relationship between genetic divergence and geographic diversity. Murty and Arunachalam (1966) reported the genetic drift and selection in different environment could cause greater diversity than geographical distance. Similar observations have also been reported by Thangavelu and Rajasekaran (1983), Swain and Dikshit (1997) and Joel *et al.* (1998). Thus,

**Table 1. Distribution of 46 sesame genotypes in 8 clusters**

| Cluster | No. of Genotypes | Genotypes                                                                                | Origin                                                 |
|---------|------------------|------------------------------------------------------------------------------------------|--------------------------------------------------------|
| I       | 8                | OS-15, OS-18, SIK-004, SIK-113, AT-78, AT-79, AT-81                                      | Bhubaneswar (Ori.)<br>Jalgaon (Mah.)<br>Amareli (Guj.) |
| II      | 6                | RT-247, RT-293, TKG-21, JTS-8, JTS-14-1, MT-9                                            | Mandore (Raj.)<br>Tikamgarh (MP)<br>Mauranipur (UP)    |
| III     | 5                | OS-10, ORM-17, OS-2, MAH-60, AT-80                                                       | Bhubaneswar (Ori.)<br>Jalgaon (Mah.)<br>Amareli (Guj.) |
| IV      | 1                | JTS-25                                                                                   | Tikamgarh (MP)                                         |
| V       | 13               | MT-8, MT-12, MT-13, MT-14, MT-19, MT-20, MT-21, MT-24, MT-25, MT-41, MT-66, T-13, RT-283 | Mauranipur (UP)<br>Kanpur (UP)<br>Mandore (Raj.)       |
| VI      | 5                | MT-2, MT-32, MT-34, MT-75, RT-281                                                        | Mauranipur (UP)<br>Mandore (Raj.)                      |
| VII     | 2                | VS-9501, VS-9701                                                                         | Vridhachalam (TN)                                      |
| VIII    | 6                | MT-7, MT-18, MT-22, MT-23, RS-160, TC-25                                                 | Mauranipur (UP)<br>Rewa (UP)<br>Gurdaspur (Punjab)     |

selection of genotypes for hybridization with a view to get transgressive segregants of practical utility should be based on genetic diversity rather than geographical diversity. Contribution of different characters towards genetic divergence revealed the highest contribution of 1000-seed weight followed by seed yield/plot (Table 2). This is in conformity with the findings of Joel *et al.*

**Table 2. Average distance of cluster members from cluster centroids and between cluster centroids in 8 clusters of sesame**

| Clusters | I    | II   | III  | IV   | V    | VI   | VII  | VIII |
|----------|------|------|------|------|------|------|------|------|
| I        | 1.09 | 3.89 | 2.12 | 7.34 | 2.39 | 3.46 | 5.03 | 3.24 |
| II       |      | 1.21 | 3.34 | 4.49 | 2.07 | 2.11 | 4.86 | 2.64 |
| III      |      |      | 1.22 | 6.57 | 2.62 | 3.78 | 3.64 | 3.67 |
| IV       |      |      |      | 0.00 | 5.96 | 5.84 | 6.72 | 4.98 |
| V        |      |      |      |      | 0.98 | 1.59 | 4.24 | 1.92 |
| VI       |      |      |      |      |      | 1.39 | 4.91 | 2.43 |
| VII      |      |      |      |      |      |      | 1.66 | 3.93 |
| VIII     |      |      |      |      |      |      |      | 1.44 |

(1998). The inter- and intra- cluster distance amongst the cluster revealed the lowest intra-cluster distance of cluster V, whereas maximum intra-cluster distance was observed in cluster VII. Maximum inter-cluster distance was observed between cluster I and IV followed by between IV and VII indicating that the genotypes included in these clusters are genetically more divergent. The average cluster means for six traits (Table 3) indicated that the genotypes indicated in cluster I were of early flowering and maturity type with average height whereas, genotypes included in cluster VII are of late maturity duration. Genotypes in cluster VI had highest mean seed yield/plot followed by the only one genotype of cluster IV with maximum number of productive capsules/plant. Based on the present findings, it can be concluded that the genotypes grouped in clusters, I, IV and VII hold good promises diverse parents to get desirable segregants for developing high yielding short duration varieties of sesame with moderate plant height.

#### References

- Joel AJ, S Alarmelu and S Thangavelu (1998) Genetic diversity in sesame (*Sesamum indicum* L.). *J. Oilseeds Res.* **15**: 71-75.
- Murty BR and V Arunachalam (1966) The nature of divergence in relation to breeding systems in some crop plants. *Indian J. Genet.* **26**: 188-198.
- Spark DN (1973) Algorithm as 58. *Appl. Statist.* **21**: 126-130.
- Swain D and UN Dikshit (1997) Genetic divergence in *rabi* sesame (*Sesamum indicum* L.). *Indian J. Genet.* **57**: 296-300.
- Thangavelu MS and S Rajasekaran (1983) Genetic divergence in *Sesamum* (*S. indicum* L.). *Madras Agric. J.* **70**: 211-214.

**Table 3. Cluster mean and per cent contribution of six characters of divergence in sesame**

| Clusters              | Plant height | Days to 50% flowering | Days to maturity | No. of productive capsules/plant | 1000-seed weight (g) | Seed yield/plot (g) |
|-----------------------|--------------|-----------------------|------------------|----------------------------------|----------------------|---------------------|
| I                     | 111.21       | 34.79                 | 75.92            | 34.79                            | 2.78                 | 45.04               |
| II                    | 137.11       | 35.1                  | 82.11            | 41.50                            | 2.66                 | 166.67              |
| III                   | 116.87       | 37.60                 | 77.30            | 34.53                            | 2.54                 | 159.67              |
| IV                    | 152.00       | 40.67                 | 83.33            | 62.00                            | 2.50                 | 178.33              |
| V                     | 126.44       | 36.00                 | 82.07            | 36.13                            | 0.280                | 108.64              |
| VI                    | 119.33       | 36.00                 | 82.07            | 36.13                            | 02.83                | 199.87              |
| VII                   | 108.33       | 43.50                 | 88.00            | 35.00                            | 0.249                | 039.00              |
| VIII                  | 128.00       | 40.67                 | 83.50            | 42.50                            | 02.84                | 110.61              |
| Per cent contribution | 0.29         | 05.60                 | 03.38            | 00.97                            | 61.354               | 028.41              |

## Genetic Studies in Sesame as a Pre-breeding Approach

**PK Singh**

CS Azad University of Agriculture and Technology, Crop Research Farm, Mauranipur, Jhansi-284204, Uttar Pradesh

**Key Words:** Genetic analysis, Pre-breeding, Sesame, Seed yield

Sesame (*Sesamum indicum* L.) is an ancient and most important oil crop of India because it contains more than 50% high quality oil and known as “queen of oilseed crops”. However, it has not contributed its best to the current bright oilseed scenario mainly due to its low yield level. So, there is an urgent need for bringing about genetic improvement in yield potential. The knowledge of genetic analysis helps in formulation of an efficient breeding programme, hence, the present study was undertaken to study the genetics of seed yield and yield attributes in sesame to generate pre-breeding information.

Seven genetically diverse genotypes of sesame viz.- T-4, MT-2, TRS-9, RT-274, RT-264, AT-09 and DSS-

13 were crossed in all possible combinations excluding reciprocals. The parents along with their 21F<sub>1</sub>s were grown in a randomized block design with three replication during *Kharif*, 1998 at Crop Research Farm, Mauranipur. Each entry was sown in a single row of 5 m length having 30 x 15 cm crop geometry. A single non-experimental row was grown all around the experimental area to neutralize the border effect. Recommended agronomic practices were adopted. Data were recorded on five randomly selected plants in each row for seven metric traits (Table 1). Genetic components of variation were calculation for seed yield and its components following Hayman (1954).

The estimates of genetic components of variation

(1998). The inter- and intra- cluster distance amongst the cluster revealed the lowest intra-cluster distance of cluster V, whereas maximum intra-cluster distance was observed in cluster VII. Maximum inter-cluster distance was observed between cluster I and IV followed by between IV and VII indicating that the genotypes included in these clusters are genetically more divergent. The average cluster means for six traits (Table 3) indicated that the genotypes indicated in cluster I were of early flowering and maturity type with average height whereas, genotypes included in cluster VII are of late maturity duration. Genotypes in cluster VI had highest mean seed yield/plot followed by the only one genotype of cluster IV with maximum number of productive capsules/plant. Based on the present findings, it can be concluded that the genotypes grouped in clusters, I, IV and VII hold good promises diverse parents to get desirable segregants for developing high yielding short duration varieties of sesame with moderate plant height.

#### References

- Joel AJ, S Alarmelu and S Thangavelu (1998) Genetic diversity in sesame (*Sesamum indicum* L.). *J. Oilseeds Res.* **15**: 71-75.
- Murty BR and V Arunachalam (1966) The nature of divergence in relation to breeding systems in some crop plants. *Indian J. Genet.* **26**: 188-198.
- Spark DN (1973) Algorithm as 58. *Appl. Statist.* **21**: 126-130.
- Swain D and UN Dikshit (1997) Genetic divergence in *rabi* sesame (*Sesamum indicum* L.). *Indian J. Genet.* **57**: 296-300.
- Thangavelu MS and S Rajasekaran (1983) Genetic divergence in *Sesamum* (*S. indicum* L.). *Madras Agric. J.* **70**: 211-214.

**Table 3. Cluster mean and per cent contribution of six characters of divergence in sesame**

| Clusters              | Plant height | Days to 50% flowering | Days to maturity | No. of productive capsules/plant | 1000-seed weight (g) | Seed yield/plot (g) |
|-----------------------|--------------|-----------------------|------------------|----------------------------------|----------------------|---------------------|
| I                     | 111.21       | 34.79                 | 75.92            | 34.79                            | 2.78                 | 45.04               |
| II                    | 137.11       | 35.1                  | 82.11            | 41.50                            | 2.66                 | 166.67              |
| III                   | 116.87       | 37.60                 | 77.30            | 34.53                            | 2.54                 | 159.67              |
| IV                    | 152.00       | 40.67                 | 83.33            | 62.00                            | 2.50                 | 178.33              |
| V                     | 126.44       | 36.00                 | 82.07            | 36.13                            | 0.280                | 108.64              |
| VI                    | 119.33       | 36.00                 | 82.07            | 36.13                            | 02.83                | 199.87              |
| VII                   | 108.33       | 43.50                 | 88.00            | 35.00                            | 0.249                | 039.00              |
| VIII                  | 128.00       | 40.67                 | 83.50            | 42.50                            | 02.84                | 110.61              |
| Per cent contribution | 0.29         | 05.60                 | 03.38            | 00.97                            | 61.354               | 028.41              |

## Genetic Studies in Sesame as a Pre-breeding Approach

**PK Singh**

CS Azad University of Agriculture and Technology, Crop Research Farm, Mauranipur, Jhansi-284204, Uttar Pradesh

**Key Words:** Genetic analysis, Pre-breeding, Sesame, Seed yield

Sesame (*Sesamum indicum* L.) is an ancient and most important oil crop of India because it contains more than 50% high quality oil and known as “queen of oilseed crops”. However, it has not contributed its best to the current bright oilseed scenario mainly due to its low yield level. So, there is an urgent need for bringing about genetic improvement in yield potential. The knowledge of genetic analysis helps in formulation of an efficient breeding programme, hence, the present study was undertaken to study the genetics of seed yield and yield attributes in sesame to generate pre-breeding information.

Seven genetically diverse genotypes of sesame viz.- T-4, MT-2, TRS-9, RT-274, RT-264, AT-09 and DSS-

13 were crossed in all possible combinations excluding reciprocals. The parents along with their 21F<sub>1</sub>s were grown in a randomized block design with three replication during *Kharif*, 1998 at Crop Research Farm, Mauranipur. Each entry was sown in a single row of 5 m length having 30 x 15 cm crop geometry. A single non-experimental row was grown all around the experimental area to neutralize the border effect. Recommended agronomic practices were adopted. Data were recorded on five randomly selected plants in each row for seven metric traits (Table 1). Genetic components of variation were calculation for seed yield and its components following Hayman (1954).

The estimates of genetic components of variation

Table 1. Estimates of genetic components for seed yield and yield attributes in sesame

| Source                                 | Plant height (cm) | Days to maturity | No. of primary branches/plant | No. of capsules/plant | Capsules on main stem | 1000-seed weight (g) | Seed yield/plant (g) |
|----------------------------------------|-------------------|------------------|-------------------------------|-----------------------|-----------------------|----------------------|----------------------|
| D                                      | 327.72**          | 16.69*           | 0.72**                        | 87.63                 | 9.87                  | 0.16**               | 2.29                 |
| H <sub>1</sub>                         | 662.21**          | 85.33*           | 2.37**                        | 868.54*               | 92.77                 | 0.37**               | 81.33*               |
| H <sub>2</sub>                         | 467.78**          | 59.07**          | 1.54**                        | 789.53**              | 66.24**               | 0.28**               | 73.00**              |
| h <sup>2</sup>                         | 751.78**          | 34.72**          | 0.58                          | 1248.87**             | 40.00**               | 0.03                 | 150.99*              |
| F                                      | 269.91**          | 26.28            | 1.38*                         | 123.83                | 12.45                 | 0.17                 | -1.32                |
| E                                      | 1.12              | 0.30             | 0.18*                         | 5.02                  | 2.53                  | 0.00                 | 0.59                 |
| (H <sub>1</sub> /D) <sup>1/2</sup>     | 1.42              | 2.26             | 1.81                          | 3.15                  | 3.07                  | 1.54                 | 5.96                 |
| H <sub>2</sub> /4H <sub>1</sub>        | 0.18              | 0.17             | 0.16                          | 0.23                  | 0.18                  | 0.19                 | 0.22                 |
| (4DH <sub>1</sub> ) <sup>1/2</sup> + F | 1.82              | 2.07             | 3.24                          | 1.58                  | 1.52                  | 2.07                 | 0.91                 |
| (4DH <sub>1</sub> ) <sup>1/2</sup> - F |                   |                  |                               |                       |                       |                      |                      |
| h <sup>2</sup> /H <sub>2</sub>         | 1.61              | 0.59             | 0.38                          | 1.58                  | 0.60                  | 0.12                 | 2.07                 |
| Heritability (NS)                      | 45.23             | 21.69            | 29.71                         | 10.28                 | 9.84                  | 43.40                | 2.63                 |

\*, \*\* Significant at P= 0.05 and P = 0.01 level, respectively.

presented in Table 1 revealed that D components (additive variation) was non-significant for number of capsules/plant, number of capsules on main stem and seed yield/plant. The H<sub>1</sub> components *i.e.* dominance variation was highly significant and larger in magnitude than D components for all the traits indicating the predominant role of dominance component in the inheritance of these traits. Similar reports were made by Murty and Hashim (1973), Dixit (1976) and Godawat and Gupta (1985) who found that relative contribution of dominant gene action was higher than additive gene action. The positive and significant value of h<sup>2</sup> for all the traits except primary branches/plant and 1000-seed weight indicated that dominance was in positive direction.

The estimates of (H<sub>1</sub>/D)<sup>1/2</sup> was greater than unity for all the characters suggesting the presence of over dominance. The highly significant H<sub>2</sub> values were smaller than H<sub>1</sub> and H<sub>2</sub>/4H<sub>1</sub> ratio was less than 0.25, confirming the unequal allelic frequencies and asymmetrical distribution of positive and negative alleles among the parents and in F<sub>1</sub>. (4DH<sub>1</sub>)<sup>1/2</sup> + F/(4DH<sub>1</sub>)<sup>1/2</sup> - F ratio which measures the proportion of dominant and recessive genes

in parents was less than unity for seed yield/plant, greater than unity for the remaining traits, showing an excess of recessive genes for seed yield/plant which was further confirmed by the negative value of F for seed yield/plant. Heritability in narrow sense was very low for seed yield/plant, whereas for the remaining traits it was moderate.

It is concluded that there is preponderance of dominance genetic variance for seed yield and yield components, hence, top priority should be given on the development of hybrids in sesame.

#### References

- Dixit RK (1976) Inheritance of yield and its components in sesame. *Indian J. Agric. Sci.* **46**: 187-191.
- Godwat SI and SC Gupta (1985) Inheritance of grain yield and its components in sesame. *J. Oilseeds Res.* **2**: 260-267.
- Hayman BI (1954) The analysis of variance of diallele tables. *Biometrics* **10**: 235-244.
- Murty DS and M Hashim (1973) Diallel analysis of gene action for quantitative characters in sesame. Paper presented at the Second General Congress of SABRAO, New Delhi.

## Genetic Variation, Correlation and Path-Coefficient Analysis for Seed Yield and Quality Characters in Grain Amaranth

**PK Verma, MK Deen, SN Gupta and GD Sharma<sup>1</sup>**

Medical, Aromatic and Under-utilized Plants Section, Department of Plant Breeding, CCS Haryana Agricultural University, Hisar-125044, Haryana

**Key Words:** Grain Amaranth (*A. hypochondriacus*), Protein, Phosphorous, Correlation

Grain amaranth (*Amaranthus hypochondriacus*) is one of the important under-utilized plants of food and multiple uses. It has potentiality to withstand adverse weather changes, particularly severe moisture stress. Besides, it can be grown in wide range of agro-climatic conditions viz.-high rainfall area to low rainfall, from sea-shore to high altitudes and thus, is suitable for sustainable agriculture (Joshi, 1991). It is a crop of poor people who depend for their food on marginal lands. It is the richest source of protein (16%) and three amino acids (lysine, methionine and tryptophan) in comparison to the cereal crops viz.-barley, maize, rice, wheat and buckwheat. It is also a rich source of fat (21%), calcium (0.49%), phosphorous (0.60%), iron (17.5%) and total food energy (391 calories) in comparison to other common cereals (Joshi and Rana, 1991). Keeping this in view, the present investigation was carried out under Haryana agro-climatic conditions.

A set of 68 genotypes of indigenous origin grain amaranth germplasm lines procured from Akola centre of NBPGR were sown in a single row of 2 m length in randomized block design with 2 replications during *rabi* season at the experimental farm of the Department of Plant Breeding. Row-to-row and plant-to-plant spacing were 45 and 10 cm, respectively. Plant height and grain yield/plant were recorded on 5 plants basis in each replication, while quality analysis for protein and phosphorous content were conducted in laboratory as per the standard procedures of AOAC (1985). The data were subjected to correlation and path-coefficient analysis as per the procedures of Miller *et al.* (1958) and Dewey and Lu (1959), respectively. The path-coefficient analysis was based on phenotypic correlation coefficients.

A perusal of results with regard to different parameters of variability correlation and path co-efficient analysis for different traits have been presented in Table 1.

**Seed yield/plant:** Seed yield being highly complex and environmentally affected character recorded wide range of variability (4.9 to 31.9 g/plant) and the highest phenotypic and genotypic coefficient of variation (PCV and GCV). Accession IC 95453 recorded the highest seed yield/plant (31.9 g), followed by IC 35778 (26.5 g), IC 35634 (25.3 g), IC 35746 (22.3) and IC 35574 (20.4 g) as against 11.4 g of GA-1 (check). The highest heritability (98.89%) and genetic advance as per cent of mean or genetic gain (95.76%) in respect of this character revealed better chances of further improvement through selection.

**Plant height:** It ranged from 33.7 to 113.2cm with overall mean of 68.5 cm. Genotype IC 95453 (113.2cm) was found to be the tallest, followed by IC 35522, IC 35746. IC 35622, IC 95455 and IC 35778. PCV and GCV were comparable, indicating vulnerability to environmental variation in respect of plant height. Heritability (97.64%) and genetic advance as per cent of mean (46.98%) were also quite high, revealing better chances of further improvement for this trait. Plant height had positive and highly significant phenotype correlation with seed yield/plant. Plant height also had maximum and highly significant direct effects on seed yield. Therefore, plant height is an important criterion for selection resulting in increased seed yield.

**Protein content:** It ranged from 10.9 to 15.7% with population means of 15.0%. Accessions IC 95307, IC 55661 IC 35634, IC 95465, IC 35522, IC 95622 and IC 35595 were the superior genotypes with more than 15% protein content. Low PCV and heritability resulted in poor genetic gain (9.47%). It also had non-significant phenotypic correlation and direct effects on seed yield, indicating little scope for further improvement with regards to protein content.

**Phosphorous content:** Wide range of variability was recorded for this character (0.36 to 0.64%) and greater PCV. Accession with high phosphorous content were IC 35719, IC 35584, IC 35681, IC 55145, IC 35735,

<sup>1</sup> Present Address: Project Coordinator (UUC), National Bureau of Plant Genetic Resources, New Delhi-110012

**Table 1. Parameters of genetic variation, heritability, genetic gain, phenotypic correlation coefficients and direct effects of different characters on seed yield in grain amaranth**

| Parameters                                      | Plant Height<br>(cm) | Protein<br>content (%) | Phosphorus<br>content (%) | Seed yield/<br>plant (g) |
|-------------------------------------------------|----------------------|------------------------|---------------------------|--------------------------|
| Mean                                            | 68.5                 | 14.0                   | 0.48                      | 12.00                    |
| Range                                           | 33.7                 | 10.9                   | 0.36                      | 4.9                      |
|                                                 | 113.2                | 15.7                   | 0.64                      | 31.9                     |
| PCV (%)                                         | 23.36                | 6.10                   | 12.78                     | 47.01                    |
| GCV (%)                                         | 23.08                | 5.29                   | 11.68                     | 46.75                    |
| Heritability %<br>(Broad sense)                 | 97.64                | 75.39                  | 83.46                     | 96.89                    |
| Genetic gain (%)                                | 46.98                | 9.47                   | 21.98                     | 95.76                    |
| Phenotypic correlation<br>with seed yield/plant | 0.405**              | 0.113                  | -0.146                    | —                        |
| Direct effects on seed yield                    | 0.408                | 0.080                  | -0.154                    | —                        |
| Better genotypes over<br>released variety GA-1  | IC 95353             | IC 95307               | IC 35719                  | IC 95453                 |
|                                                 | IC 35522             | IC 55661               | IC 35584                  | IC 35778                 |
|                                                 | IC 35746             | IC 35634               | IC 35681                  | IC 35634                 |
|                                                 | IC 35622             | IC 95465               | IC 55145                  | IC 35746                 |
|                                                 | IC 95455             | IC 35422               | IC 35735                  | IC 35574                 |
|                                                 | IC 35778             | IC 95622               | IC 35778                  |                          |
|                                                 |                      | IC 35595               | IC 35453                  |                          |
|                                                 |                      |                        | IC 95578                  |                          |
|                                                 |                      |                        | IC 35697                  |                          |
|                                                 |                      |                        | IC 35686                  |                          |
| Performance of released variety GA-1            | 58.6                 | 13.6                   | 0.42                      | 11.4                     |

\*\* Highly significant at 1% level of significance

35778, IC 35453, IC 95578, IC 35697, IC 35686 (0.56% and above). Moderately high heritability (83.46%) and genetic gain (21.98%) revealed a little scope for further genetic upgradation for this character. Path coefficient analysis and correlation studies revealed its negative association with seed yield.

In view of the non-significant correlation and low direct effects of quality character (protein and phosphorous contents) with seed yield/plant, it is evident that amaranth seed yield has no effect on protein and phosphorous content. However, plant height and seed yield have been found positively and highly significantly associated; and plant height had high positive direct effects on seed yield. Similar results had been reported earlier by Pandey (1981) and Joshi (1986). Hence, plant height can serve as one of the important criteria to select for higher seed yield, which is further evident from the fact that three accessions, namely, IC 95353 IC 35778 and IC 35746 were tall as well as high seed yielders. On the other hand, accession IC 35634 had suitable combination of high seed yield and protein content; and another line IC 35522 had high plant height and protein content,

confirming no significant correlation between the two characters. However, accession IC 35634 is a rare combination of high seed yield and high protein content, which can be used as a donor parent in hybridization programme.

## References

- AOAC (1985) *Official Methods of Analysis*. Association of Official Analytical Chemists, Washington DC.
- Dewey DR and KH Lu (1959) Correlation and path-coefficient analysis of components of created wheat grass and seed production. *Agron. J.* **51**: 515-518.
- Joshi BD (1986) Genetic variability in grain Amaranths. *Indian J. Agric. Sci.* **56**: 574-576.
- Joshi BD (1991) Grain amaranths in the Himalayas. *Indian J. Plant Genet. Resour.* **4**: 45-54.
- Joshi BD and RS Rana (1991) Grain Amaranths: The Future Food Crop *Sci. Monograph No. 3*. NBPGR, Shimla.
- Miller PA, VC William, HF Robinson and RS Comstock (1958) Evaluation of genotypic, phenotypic and environmental variances and co-variances in upland cotton and their application in selection. *Agron. J.* **59**: 128-131.
- Pandey PM (1981) Path analysis in *Amaranthus hypochondriacus* L. *Sci. Cul.* **47**: 64-66.

## Genotypic Variation for Oil Content and its Quality in Lemongrass Germplasm

**PK Verma, MK Deen, SN Gupta and CS Tyagi**

Medicinal, Aromatic and Under-utilized Plants Section, Department of Plant Breeding, CCS Haryana Agricultural University, Hisar-125004, Haryana

Lemongrass is an important essential oil bearing aromatic grass. It consists of different species viz.- *Cymbopogon flexuosus* Staf. (East Indian type), *Cymbopogon pendulus* (Jammu type), *Cymbopogon citratus* (West Indian type) and *Cymbopogon khasianus*. Different species vary with regards to chemical composition of the essential oil. The essential oil is a source of an aromatic chemical citral, which is precursor for synthesizing  $\alpha$ -ionone (used in perfumery, flavouring and cosmetic industries) and  $\beta$ -ionone (used in manufacture of vitamin A). Besides, lemongrass essential oil has insecticidal, bactericidal and medicinal properties, while dried leaves are used in herbal teas. India had important position in International market earlier in exporting lemongrass oil to the tune of 18000 tons. Therefore, thorough screening of available materials of lemongrass for oil quality is an important aspect to deal in by the researchers.

Twelve (12) genotypes of lemongrass collected from different parts of the country are maintained vegetatively at the experimental area of the Medicinal and Aromatic Plants section in the Department of Plant Breeding. Different genotypes were harvested and oil quantity and oil quality was estimated during the cut

taken in July, 1998. Oil quantity was estimated on basis of one kilogram freshly harvested herb sample through Calevanger's apparatus. The oil quality was analysed through gas chromatography (GC) for chemical composition of the oil on the basis of geraniol, geranyl acetate, geranial and citral content in freshly extracted oil.

Wide range of variability was recorded for all the characters under study (Table 1).

**Oil contents (%):** The oil content on fresh weight basis varied from 0.16 to 0.70%. The highest oil content was recorded for the variety CKP-25 (0.70%), followed by RRL-82 (0.56%), HL-3 (0.36%), RRL-16 (0.34%), HL-2 (0.32%), and HL-9 (0.30%). The remaining genotypes yielded lower oil content i.e. less than 0.30%.

**Geraniol content:** It ranged from 1.2 to 31.6%. HL-9 recorded the highest geraniol content (31.6%), followed by HL-1 and HL-2 (12.8%), RRL-82 (7.8%), RRL-16 (6.3%) and CKP-25 (4.0%).

**Geranyl Acetate (%):** It varied between 0.7 to 9.8%. The highest contents was recorded for HL-10 (9.8%), followed by CKP-25 (7.3%), HL-1 (7.0%) and HL-2 (6.9%).

**Table 1. Oil content and its chemical composition in lemongrass germplasm**

| S.No. | Genotypes | Oil content* (%) | Geraniol content (%) | Geranyl acetate (%) | Geranial/ Citral 'a' content (%) | Neral content (%) | Citral content (%) | Total (%) |
|-------|-----------|------------------|----------------------|---------------------|----------------------------------|-------------------|--------------------|-----------|
| 1.    | RRL-16    | 0.34             | 6.3                  | 3.0                 | 42.3                             | 30.0              | 72.3               | 81.6      |
| 2.    | RRL-82    | 0.56             | 7.8                  | 7.0                 | 6.8                              | 29.4              | 74.1               | 86.7      |
| 3.    | HL-1      | 0.18             | 12.8                 | 7.0                 | 6.8                              | 2.3               | 9.1                | 28.9      |
| 4.    | HL-2      | 0.32             | 12.8                 | 6.9                 | 6.8                              | 2.5               | 9.3                | 29.0      |
| 5.    | HL-3      | 0.36             | 2.2                  | 1.5                 | 47.3                             | 32.3              | 79.6               | 83.3      |
| 6.    | HL-4      | 0.25             | 3.7                  | 0.7                 | 39.8                             | 29.3              | 69.1               | 73.5      |
| 7.    | HL-6      | 0.22             | 3.3                  | 0.7                 | 43.9                             | 30.9              | 74.8               | 77.8      |
| 8.    | HL-7      | 0.20             | 1.2                  | 2.3                 | 5.7                              | 1.6               | 7.3                | 10.8      |
| 9.    | HL-8      | 0.26             | 3.7                  | 0.8                 | 42.8                             | 30.3              | 73.1               | 77.6      |
| 10.   | HL-9      | 0.30             | 31.6                 | 4.5                 | 15.5                             | 1.2               | 16.7               | 52.8      |
| 11.   | HL-10     | 0.16             | 2.6                  | 9.8                 | 15.4                             | 1.4               | 16.8               | 29.2      |
| 12.   | CKP-25    | 0.70             | 4.0                  | 7.3                 | 42.8                             | 30.1              | 72.9               | 84.2      |
|       | Mean      | 0.32             | 7.7                  | 4.1                 | 29.5                             | 18.4              | -                  | -         |
|       | Range     | 0.16 - 0.70      | 1.2-31.6             | 0.7-9.8             | 5.7-47.3                         | 1.2-32.3          | 7.3-79.6           | -         |

\* Oil content on fresh weight basis

**Geranial or Citral 'a' content (%)**: It is the major constituent of lemongrass oil. It ranged from 5.7 to 47.3%. The promising genotypes were HL-3 (47.3%), RRL-82 (44.7%), HL-6 (43.9%), HL-8 and CKP-25 (42.8%), RRL-16 (42.3%) and HL-4 (39.8%).

**Neral or citral 'b' content (%)**: It is the next important constituent of the lemongrass oil. It varied from 1.2 to 32.3%. The highest citral 'b' or neral content was found in HL-3 (32.3%), followed by HL-6 (30.9%), HL-8 (30.3%), CKP-25 (30.1%) and RRL-16 (30.0%).

**Citral (Geranial + Neral) content (%)**: It ranged from 7.3 to 79.6%. HL-3 recorded the highest citral content (79.6%), followed by HL-6 (74.8%), RRL-82 (74.1%), HL-8 (73.1%), CKP-25 (72.9%), RRL-16 (72.3%) and HL-4 (69.1%).

The four constituents under study generally constitute the major portion of the lemongrass oil quality. The total composition of freshly extracted essential oil from lemongrass based on these four constituents ranged between 10.8 to 86.7%, indicating that the genotypes with lower total may have constituents other than geranial and neral contents. Genotypes RRL-82 (86.7%), CKP-25 (84.2%), HL-3 (83.3%), RRL-16 (81.6%), HL-6

(77.8%), HL-8 (77.6%) and HL-4 (73.5%) have geranial and citral as the major components. Hence, these genotypes except RRL-82, RRL-16 (*C. pendulus*) and CKP-25 (*C. khasianus* × *C. pendulus*) may belong to one species i.e. *C. flexuosus* (Maheshwari, 1995). Genotypes HL-1, HL-2 and HL-10 with lower content of geranial and neral may belong to another species. HL-9 (31.6% geraniol) and HL-7 may belong to two different species. Bhattacharya *et al.* (1998) also reported that freshly distilled oil from lemongrass (*C. flexuosus*) contained higher concentrations of geranial (53.11%) and neral (33.21%), which is the quality of good lemongrass oil. The present investigation thus revealed the presence of enough genetic variability in the available genotypes of lemongrass from quality point of view.

## References

- Bhattacharya AK, PN Kaur and BR Rajeswara Rao (1998) Effect of prolonged storage on the quality of lemongrass (*Cymbopogon flexuosus*). Nees ex (Stend. Wats.) essential oil. *J. of Essential Oil Bearing Plants* 1: 104-109.
- Maheshwari ML (1995) Quality and Chemistry of Essential Oils. In: KL Chadha and Rajender Gupta (ed.) *Advances in Horticulture*. Vol. 11—Medicinal and Aromatic Plants. Malhotra Publishing House, New Delhi, pp 154-197.

## Status of Resistant Germplasm in Tobacco and *Nicotiana* Species

**RVS Rao, T Venkateswarlu, K Sarala and TGK Murthy**

*Division of Crop Improvement, Central Tobacco Research Institute, Rajahmundry-533105, Andhra Pradesh*

**Key Words:** *Nicotiana* species, Sources of resistance

In India, *Nicotiana tabacum* and *N. rustica* are the two important tobacco species that are widely cultivated and consumed in various forms. Depending upon use and the method of curing, tobacco has been classified into 9 different types viz.- FCV (Flue Cured Virginia), burley, bidi, chewing, cheroot, natu, hookah, snuff and cigar (wrapper and filler).

In most of the tobacco growing countries including India, pest and pathogen continue to be a major problem in its cultivation, storage and processing. Tobacco is attacked by a number of diseases and insect pests during various stages of crop growth resulting in considerable yield losses. Among the insect pests aphid, leaf eating caterpillar, budworm and white fly and among pathogens

tobacco mosaic virus (TMV), black shank and nematodes are economically important.

The responsibility for collection, conservation, maintenance and characterization of tobacco germplasm in India lies with the Central Tobacco Research Institute (CTRI), Rajahmundry, which is also designated as National Active Germplasm Site (NAGS) under the National Network on Conservation for Plant Genetic Resources. At present, a total of 1847 germplasm accessions are being maintained and evaluated for morphology, yield, physical and chemical characteristics of leaf, and disease/pest resistance. At CTRI, sources of resistance have been identified in the tobacco germplasm for various diseases viz.- TMV (313 lines), TDV (35), TEV (10),

**Geranial or Citral 'a' content (%)**: It is the major constituent of lemongrass oil. It ranged from 5.7 to 47.3%. The promising genotypes were HL-3 (47.3%), RRL-82 (44.7%), HL-6 (43.9%), HL-8 and CKP-25 (42.8%), RRL-16 (42.3%) and HL-4 (39.8%).

**Neral or citral 'b' content (%)**: It is the next important constituent of the lemongrass oil. It varied from 1.2 to 32.3%. The highest citral 'b' or neral content was found in HL-3 (32.3%), followed by HL-6 (30.9%), HL-8 (30.3%), CKP-25 (30.1%) and RRL-16 (30.0%).

**Citral (Geranial + Neral) content (%)**: It ranged from 7.3 to 79.6%. HL-3 recorded the highest citral content (79.6%), followed by HL-6 (74.8%), RRL-82 (74.1%), HL-8 (73.1%), CKP-25 (72.9%), RRL-16 (72.3%) and HL-4 (69.1%).

The four constituents under study generally constitute the major portion of the lemongrass oil quality. The total composition of freshly extracted essential oil from lemongrass based on these four constituents ranged between 10.8 to 86.7%, indicating that the genotypes with lower total may have constituents other than geranial and neral contents. Genotypes RRL-82 (86.7%), CKP-25 (84.2%), HL-3 (83.3%), RRL-16 (81.6%), HL-6

(77.8%), HL-8 (77.6%) and HL-4 (73.5%) have geranial and citral as the major components. Hence, these genotypes except RRL-82, RRL-16 (*C. pendulus*) and CKP-25 (*C. khasianus* × *C. pendulus*) may belong to one species i.e. *C. flexuosus* (Maheshwari, 1995). Genotypes HL-1, HL-2 and HL-10 with lower content of geranial and neral may belong to another species. HL-9 (31.6% geraniol) and HL-7 may belong to two different species. Bhattacharya *et al.* (1998) also reported that freshly distilled oil from lemongrass (*C. flexuosus*) contained higher concentrations of geranial (53.11%) and neral (33.21%), which is the quality of good lemongrass oil. The present investigation thus revealed the presence of enough genetic variability in the available genotypes of lemongrass from quality point of view.

## References

- Bhattacharya AK, PN Kaur and BR Rajeswara Rao (1998) Effect of prolonged storage on the quality of lemongrass (*Cymbopogon flexuosus*). Nees ex (Stend. Wats.) essential oil. *J. of Essential Oil Bearing Plants* 1: 104-109.
- Maheshwari ML (1995) Quality and Chemistry of Essential Oils. In: KL Chadha and Rajender Gupta (ed.) *Advances in Horticulture*. Vol. 11—Medicinal and Aromatic Plants. Malhotra Publishing House, New Delhi, pp 154-197.

## Status of Resistant Germplasm in Tobacco and *Nicotiana* Species

**RVS Rao, T Venkateswarlu, K Sarala and TGK Murthy**

*Division of Crop Improvement, Central Tobacco Research Institute, Rajahmundry-533105, Andhra Pradesh*

**Key Words:** *Nicotiana* species, Sources of resistance

In India, *Nicotiana tabacum* and *N. rustica* are the two important tobacco species that are widely cultivated and consumed in various forms. Depending upon use and the method of curing, tobacco has been classified into 9 different types viz.- FCV (Flue Cured Virginia), burley, bidi, chewing, cheroot, natu, hookah, snuff and cigar (wrapper and filler).

In most of the tobacco growing countries including India, pest and pathogen continue to be a major problem in its cultivation, storage and processing. Tobacco is attacked by a number of diseases and insect pests during various stages of crop growth resulting in considerable yield losses. Among the insect pests aphid, leaf eating caterpillar, budworm and white fly and among pathogens

tobacco mosaic virus (TMV), black shank and nematodes are economically important.

The responsibility for collection, conservation, maintenance and characterization of tobacco germplasm in India lies with the Central Tobacco Research Institute (CTRI), Rajahmundry, which is also designated as National Active Germplasm Site (NAGS) under the National Network on Conservation for Plant Genetic Resources. At present, a total of 1847 germplasm accessions are being maintained and evaluated for morphology, yield, physical and chemical characteristics of leaf, and disease/pest resistance. At CTRI, sources of resistance have been identified in the tobacco germplasm for various diseases viz.- TMV (313 lines), TDV (35), TEV (10),

black shank (73), powdery mildew (26), brown spot (7), frog eye spot (26) and nematode (26), and pests viz.- leaf eating caterpillar (14), budworm (5), white fly (7), stem borer (1) and aphids (9) (Nagarajan and Reddy, 1982; Anjaneyulu *et al.* 1985; Ramjilal *et al.* 1988). The lines possessing multiple pest/disease resistance are given in Table 1.

**Table 1. Tobacco lines having multiple resistance to pests and pathogens**

| Cultivars/lines                                 | Resistant to                         |
|-------------------------------------------------|--------------------------------------|
| BST x JMR, BST3 x JMR, BSF1-6 x JMR             | Black shank and tobacco mosaic virus |
| BSF1-13 x JMR. Line L-1128 to L.1137 (13 lines) | Black shank and root-knot            |
| Bhavya, Vishali spl., BS, Anand-119, GT-5       | Aphids and caterpillar               |
| BSRB-1 and BSRB-2                               | Black shank and TMV                  |
| BGT-17, BGT x JMR                               | Caterpillar and TMV                  |

Wild *Nicotiana* species are important sources for resistance to various diseases and insect pests. The researches conducted identified a number of *Nicotiana* species having higher degree of resistance/immunity to several diseases (Table 2). Species incompatibility comes in the way of utilization of interspecific hybridization for incorporation of resistance in cultivated tobacco. However, the incompatibility barriers have been overcome through biotechnological approaches and useful genes have been incorporated into tobacco cultivars.

## References

Anjaneyulu C, K Nagarajan, TSN Reddy and Ramjilal (1985) Reaction of tobacco germplasm and *Nicotiana* species to frog eye spot (*Cercospora nicotianae* E II & EV) disease of tobacco. *Tob. Res.* 11: 105-109.

**Table 2. *Nicotiana* species resistant to pests and pathogens**

| Disease/pest   | Resistant species                                                                                                                                                                                                                                                                                                            |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TMV            | <i>N. glutinosa</i> , <i>N. goodspeedii</i> , <i>N. ingulba</i> , <i>N. nesophila</i> , <i>N. repanda</i> , <i>N. simulens</i> , <i>N. solanifolia</i> , <i>N. stocktonii</i> , <i>N. undulata</i> , <i>N. wiganodioides</i> and <i>N. benthamiana</i>                                                                       |
| TDV            | <i>N. glutinosa</i> , <i>N. nesophila</i> , <i>N. repanda</i> , <i>N. solanifolia</i> , <i>N. plumbaginifolia</i>                                                                                                                                                                                                            |
| TEV            | <i>N. glauca</i> , <i>N. knightiana</i> , <i>N. maritima</i> , <i>N. otophora</i> , <i>N. palmeri</i> , <i>N. paniculata</i> , <i>N. sylvestris</i> , <i>N. trigonophilla</i> , <i>N. undulata</i>                                                                                                                           |
| Powdery mildew | <i>N. longiflora</i> , <i>N. maritima</i> , <i>N. nesophila</i> , <i>N. nudicaulis</i> , <i>N. palmeri</i> , <i>N. umbratica</i> , <i>N. gossei</i> , <i>N. ingulba</i> , <i>N. debneyi</i> , <i>N. glauca</i> , <i>N. glutinosa</i> , <i>N. repanda</i> , <i>N. simulens</i> , <i>N. trigonophilla</i> , <i>N. undulata</i> |
| Black shank    | <i>N. longiflora</i> , <i>N. maritima</i> , <i>N. nesophila</i> , <i>N. plumbaginifolia</i> , <i>N. suaveolens</i>                                                                                                                                                                                                           |
| Root-knot      | <i>N. amplexicaulis</i> , <i>N. nudicaulis</i> , <i>N. repanda</i> , <i>N. megalosiphon</i>                                                                                                                                                                                                                                  |
| Anthracnose    | <i>N. amplexicaulis</i> , <i>N. exigua</i> , <i>N. langsdorffii</i> , <i>N. palmeri</i> , <i>N. simulens</i> , <i>N. stocktonii</i> , <i>N. suaveolens</i> , <i>N. debneyi</i> , <i>N. nudicaulis</i> , <i>N. longiflora</i>                                                                                                 |
| Brown spot     | <i>N. exigua</i> , <i>N. glutinosa</i> , <i>N. longiflora</i> , <i>N. repanda</i> , <i>N. plumbaginifolia</i> , <i>N. debneyi</i>                                                                                                                                                                                            |
| Frog eye spot  | <i>N. longiflora</i> , <i>N. plumbaginifolia</i> , <i>N. repanda</i> , <i>N. undulata</i> , <i>N. alata</i> , <i>N. debneyi</i> , <i>N. nudicaulis</i>                                                                                                                                                                       |
| Aphids         | <i>N. gossei</i>                                                                                                                                                                                                                                                                                                             |
| Caterpillar    | <i>N. benthamiana</i> , <i>N. gossei</i>                                                                                                                                                                                                                                                                                     |

Nagarajan K and TSN Reddy (1982) Note on reactions of *Nicotiana* species and varieties to important diseases in India. *Indian J. Agric. Sci.* 52: 791-795.

Ramjilal, K Nagarajan and GVG Krishnamurthy (1988) Response of *Nicotiana* species and varieties to the root knot nematode, *Meloidogyne javanica* (Treub) Chitwood. *Tob. Res.* 14: 128-131.

## Seed Variability in Ber (*Zizyphus* Species) Collected from Different Localities of India

AK Srivastava, SP Singh\* and HK Singh

Department of Horticulture, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad-224229, Uttar Pradesh

Ber (*Zizyphus mauritiana* Lamk.) is grown under rainfed conditions in arid and semi-arid regions. It is becoming very popular because of its pleasant taste and nutritive value. The improved cultivars are budded on wild stocks. The rootstocks generally used are *Zizyphus rotundifolia*, *Z. mauritiana* var. Tikadi, *Z. mauritiana* var. Sukhawani, *Z. mummularia*, *Z. spinichristii*, *Z. regosa*, *Z. xylocarpa* and *Z. oenolia* (Chundawat and Shrivastava, 1978; Bankar and Prasad, 1992 and Annon, 2000). Seed size has been found to be under strong genetic influence that is mainly maternal. Seed weight and size offer a rough approximation to the supply of potential energy available for the seedling. The seed weight gives an idea of the good reserves available to the embryo for its growth and development and size affects the vigour and establishment of a plant species (Shukla *et al.* 2000).

Further, there is paucity of information on seed viability potential, seed germination, seedling growth and vigour of various ber rootstocks to be used for

plant multiplication. Therefore, an attempt was made to study the variability in seed trait, germination and vigour of different *Zizyphus* species.

Five ber species namely, *Z. oenolia*, *Z. mummularia*, *Z. rotundifolia*, *Z. mauritiana* var. Tikadi and *Z. mauritiana* var. Sukhawani were evaluated at Department of Horticulture, Institute of Science, Varanasi during the year 1990-2000. The seeds were collected from CAZRI, Jodhpur; CCS, HAU, Hisar; IIAH, Bikaner and Dryland Agricultural Research Station GAU, Sardar Krushinagar, (Gujarat). Well-matured and ripe stones were collected from plus tree during March, 1999. Seeds (Kernel) were extracted by breaking the stones and stored in plastic containers. For seed variability studies, seed weight, size, thickness, viability and germination percentage, time taken for commencement of germination and full germination, earliness, index, growth and vigour index were recorded. Weight of seed was taken from electronic balance, while size of seed was recorded with Vernier

Table 1. Mean values for various seed traits, germination and seedling growth in different *Zizyphus* species

| Species                            | Seed Weight (mg) | Seed length (mm) | Seed breadth (mm) | Seed thickness (mm) | Time taken for commencement of germination (Days) | Time taken for full germination (Days) | Viability (%) | Germination | Shoot length 18 DAS | Root length 18 DAS | Earliness Index | Vigour Index |
|------------------------------------|------------------|------------------|-------------------|---------------------|---------------------------------------------------|----------------------------------------|---------------|-------------|---------------------|--------------------|-----------------|--------------|
| <i>Z. oenolia</i>                  | 70.51            | 4.55             | 3.51              | 1.89                | 3.25                                              | 15.00                                  | 85.00         | 56.00       | 3.37                | 3.10               | 0.600           | 368.32       |
| <i>Z. mummularia</i>               | 85.00            | 5.75             | 5.00              | 2.00                | 3.00                                              | 13.50                                  | 86.00         | 60.95       | 4.26                | 3.96               | 0.620           | 513.75       |
| <i>Z. rotundifolia</i>             | 180.00           | 6.75             | 5.75              | 2.50                | 2.25                                              | 11.00                                  | 100.00        | 74.35       | 6.91                | 6.46               | 0.761           | 994.18       |
| <i>Z. mauritiana</i>               | 176.00           | 7.77             | 5.02              | 2.45                | 2.25                                              | 11.00                                  | 96.50         | 71.84       | 6.80                | 6.41               | 0.702           | 949.27       |
| var. Tikadi                        |                  |                  |                   |                     |                                                   |                                        |               |             |                     |                    |                 |              |
| <i>Z. mauritiana</i> var Sukhawani | 162.00           | 6.34             | 5.78              | 2.31                | 3.00                                              | 13.00                                  | 93.40         | 70.12       | 5.44                | 5.08               | 0.650           | 727.35       |
| Mean                               | 134.70           | 6.23             | 5.01              | 2.23                | 2.75                                              | 12.70                                  | 92.18         | 66.77       | 5.35                | 5.00               | 0.666           | 710.57       |
| Range                              | 70.51            | 4.55             | 3.51              | 1.89                | 2.25                                              | 11.00                                  | 85.00         | 56.00       | 3.37                | 3.10               | 0.600           | 368.32       |
|                                    | 180.00           | 7.77             | 5.78              | 2.50                | 3.25                                              | 15.00                                  | 100.00        | 74.35       | 6.91                | 6.46               | 0.761           | 994.18       |
| Variance                           | 11.10            | 1.90             | 0.36              | 0.24                | 0.15                                              | 0.20                                   | 7.81          | 6.05        | 0.84                | 0.64               | 0.001           | 380.19       |
| SEm $\pm$                          | 1.49             | 0.60             | 0.27              | 0.22                | 0.17                                              | 0.20                                   | 1.25          | 1.10        | 0.41                | 0.36               | 0.015           | 8.72         |
| CD (P=0.05)                        | 3.43             | 1.38             | 0.62              | NS                  | 0.42                                              | 0.49                                   | 2.90          | 2.53        | 0.94                | 0.83               | 0.034           | 20.10        |

DAS: Days after sowing

\*Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, Uttar Pradesh

calliper. Viability of seed was estimated by tetrazolium test. Seeds were germinated in autoclaved petridishes (190 cm), inside layered with filter paper. The whole set i.e. 5 species/3 replications were evaluated daily. Time taken for commencement of germination and for full germination were recorded in each replication. Shoot length and root length were recorded 18 days after sowing when there was no further improvement in per cent seed germination. Earliness index was recorded following the method given by Bavappa *et al.* (1964) and vigour index was calculated as per method suggested by Abdul-Baki and Anderson (1973).

The mean, range and variance of five species for 12 characters are presented in Table 1. The range of seed weight varied from 70.51 mg in *Z. oenoplia* to 180.00 mg in *Z. rotundifolia* seed length (4.55 in *Z. oenoplia* to 7.77 mm in *Z. mauritiana* var. Tikadi); seed breadth (3.51 in *Z. oenoplia* to 5.78 mm in *Z. mauritiana* var. Sukhawani); seed thickness (1.89 in *Z. oenoplia* to 2.50 mm in *Z. rotundifolia*. Time taken for commencement of germination 2.25 in *Z. rotundifolia* 3.25 days in *Z. oenoplia*. Time taken for full germination (11.00 in *Z. rotundifolia* to 15.00 days in *Z. oenoplia*). Range for seed viability (85.00 to 100.00%), Germination (56.00 to 74.95%), shoot length (3.37 to 6.91 cm), root length (3.10 to 6.46 cm), earliness index (0.600 to 0.761) and vigour index (368.32 to 994.18) were recorded with *Z. oenoplia* and *Z. rotundifolia*, respectively.

Data revealed that significantly maximum values for seed weight (180.00 mg), seed thickness (2.50 mm), viability (100%), germination (74.35%), shoot length (6.91 cm), root length (6.46 cm), earliness index (0.761)

and vigour index (994.18) were recorded with *Z. rotundifolia* followed by *Z. mauritiana* var. Tikadi and *Z. mauritiana* var. Sukhawani while, lowest value was recorded with *Z. oenoplia*. Seed length (7.77 cm) and seed breadth (5.78 cm) were found significantly maximum with *Z. mauritiana* var. Tikadi and *Z. mauritiana* var. Sukhawani. Time taken for commencement of germination (2.25 days) and time taken for full germination (11.00 days) were recorded significantly minimum with *Z. rotundifolia* and *Z. mauritiana* var. Tikadi. Maximum time taken for both the traits were recorded with *Z. oenoplia*. Estimates of phenotypic variance were high for vigour index, seed weight, seed length, viability and seed germination. In character association analysis (Table 2) some of the important combinations showed positive and significant relationship such as seed weight with seed germination, seedling height and vigour index; seed germination with earliness index and vigour index; Time taken for commencement of germination with time taken for full germination and seedling height and diameter with vigour index. However, negative and significant correlation was recorded between time taken for commencement of germination with vigour index and seedling diameter. Relationship between heavy and bolder seeds with high seed germination and seedling vigour have also been reported in case of mango (Giri, 1966) and *Prosopis cineraria* (Shukla, 2000).

Based on the present study, it can be concluded that a significant amount of genetic variability for various seed traits is present in *Zizyphus* species. Seed weight was found to be associated positively with seed germination and seedling vigour. Seeds of *Z. rotundifolia* followed

**Table 2. Correlation coefficient for 8 characters of *Zizyphus* species**

| Characters                                        | Seed weight (mg) | Seed germination (%) | Time taken for full germination (days) | Time taken for commencement of germination (days) | Earliness Index | Vigour Index | Seedling height (cm) |
|---------------------------------------------------|------------------|----------------------|----------------------------------------|---------------------------------------------------|-----------------|--------------|----------------------|
| Seed germination (%)                              | 0.9547*          | —                    | —                                      | —                                                 | —               | —            | —                    |
| Time taken for full germination (days)            | -0.7288          | -0.8157              | —                                      | —                                                 | —               | —            | —                    |
| Time taken for Commencement of Germination (days) | -0.7967          | -0.9039              | 0.9939*                                | —                                                 | —               | —            | —                    |
| Earliness Index                                   | 0.7767           | 0.9586*              | -0.8696                                | -0.9459                                           | —               | —            | —                    |
| Vigour Index                                      | 0.9583*          | 0.9536*              | -0.9279                                | -0.9688*                                          | 0.9055          | —            | —                    |
| Seedling height (cm)                              | 0.9586*          | 0.8652               | -0.8917                                | -0.9043                                           | 0.7683          | 0.9672*      | —                    |
| Seedling diameter (cm)                            | 0.8139           | 0.8185               | -0.2933                                | -0.9834*                                          | 0.7971          | 0.9604*      | 0.9639*              |

\* Significant at 5% level

by *Z. mauritiana* var Tikadi had high expression of most of the seed traits. Thus, the study of genetic variability and inter relationship of characters may lead to effective selection of rootstock for commercial multiplication of ber plants.

#### References

- Abdul Baki AA and JD Anderson (1973) Vigour determination in soybean seed multiple criteria. *Crop Sci.* **13**: 630-633.
- Anonymous (2000) Proceedings, Tenth Group Workers Meeting of All India Co-ordinated Research Project on Arid Zone Fruits held at Acharya NG Ranga Agricultural University, Hyderabad.
- Banker GJ and RN Prasad (1992) Relationship between stomatal distribution and growth of ber root stock. *Indian J. Hortic.* **49**: 169-373.
- Bavappa KVA, PR Ramchandrar and E Valappan (1964) Correlation studies in *Areca catechu* L. Time of germination, Bartlett's index, vigour of sprouts and seedling. *Areca nut J.* **15**: 62-66.
- Chundawat BS and HC Srivastava (1978) *Haryana Mein Ber ki Kheti*. Hindi. Directorate of Extension, Haryana Agricultural University, Hisar, 38p.
- Giri A and MN Chaudhary (1996) Relation of mango stone weight to its germination and seedling vigour. *Pakistan J. Sci.* **18**: 148-50.
- Pareek OP (1978) *Grow Ber for Higher Income in Arid Region*. Central Arid Zone Research Institute, Jodhpur, Leaflet No. 1, p 4.
- Shukla JK, A Chauhan, PK Kasera, S Mohammed and DD Chawan (2000) Seed variability in *Prosopis cineraria* collected from different localities of Indian desert, *Sci. Cult.* **66**: 163-164.

## Partial Resistance among Fastigiata Germplasm of Groundnut and their Utility in Rapid Screening for Rust

**AL Rathna Kumar\*, P Balasubramanian and V Muralidharan**

Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu

**Key Words:** *Puccinia arachidis*, Groundnut, Germplasm, Screening

Rust disease of groundnut caused by *Puccinia arachidis* Speg. has gained much attention because of its rapid spread to almost all the major groundnut growing countries. Efforts to find genetic resistance have been successful and several sources have been identified. Most (90%) of the resistant sources belong to only fastigiata germplasm (*Arachis hypogaea* sub-species *fastigiata*). Before exploiting resistant germplasm in breeding programmes, it becomes essential to understand the differences in the components of resistance and the nature of relationship among them. Hence, an experiment was conducted to understand the components of resistance in 15 fastigiata germplasm lines and four highly susceptible genotypes following detached leaf technique (Subrahmanyam *et al.* 1980).

The experimental material consisted of a fully expanded undamaged leaf excised with intact petiole through the pulvinous from each plant at the third node from the terminal bud of the main stem. The leaves were washed with sterile water and inserted in a layer

of sterilized sand in plastic trays (45x30x14 cm). The sand was moistened with Hogland's nutrient solution and for each genotype four replications were maintained. The uredospores were collected from the diseased plants of TMV 2 using a cyclone spore collector. Suspensions of uredospores were prepared (50000 spores/ml) in sterile water containing the wetting agent Tween 80 (0.2 ml/l of water). The spore suspensions were atomized over the leaves inside the tray and covered with 250 gauge polythene sheets. The trays were then placed in plant growth chamber adjusted to 25°C and a 12 h photoperiod. Five components of rust resistance namely incubation period, infection frequency, number of pustules, pustule diameter and rust score were recorded from 10 plants selected at random from each of the four replications for a monocyclic infection.

For the purpose of comparison the genotypes were placed according to their mean field rust score as resistant (scores of 2.0-3.0), moderately resistant (3.1-7.0) and susceptible (7.1-9.0). Significant genotypic differences existed between and within the germplasm lines for each resistance component. Incubation period differed

\* Scientist, National Research Centre for Groundnut, PB No. 5, Junagadh-362001, Gujarat

by *Z. mauritiana* var Tikadi had high expression of most of the seed traits. Thus, the study of genetic variability and inter relationship of characters may lead to effective selection of rootstock for commercial multiplication of ber plants.

### References

- Abdul Baki AA and JD Anderson (1973) Vigour determination in soybean seed multiple criteria. *Crop Sci.* **13**: 630-633.
- Anonymous (2000) Proceedings, Tenth Group Workers Meeting of All India Co-ordinated Research Project on Arid Zone Fruits held at Acharya NG Ranga Agricultural University, Hyderabad.
- Banker GJ and RN Prasad (1992) Relationship between stomatal distribution and growth of ber root stock. *Indian J. Hortic.* **49**: 169-373.
- Bavappa KVA, PR Ramchandrar and E Valappan (1964) Correlation studies in *Areca catechu* L. Time of germination, Bartlett's index, vigour of sprouts and seedling. *Areca nut J.* **15**: 62-66.
- Chundawat BS and HC Srivastava (1978) *Haryana Mein Ber ki Kheti*. Hindi. Directorate of Extension, Haryana Agricultural University, Hisar, 38p.
- Giri A and MN Chaudhary (1996) Relation of mango stone weight to its germination and seedling vigour. *Pakistan J. Sci.* **18**: 148-50.
- Pareek OP (1978) *Grow Ber for Higher Income in Arid Region*. Central Arid Zone Research Institute, Jodhpur, Leaflet No. 1, p 4.
- Shukla JK, A Chauhan, PK Kasera, S Mohammed and DD Chawan (2000) Seed variability in *Prosopis cineraria* collected from different localities of Indian desert, *Sci. Cult.* **66**: 163-164.

## Partial Resistance among Fastigiata Germplasm of Groundnut and their Utility in Rapid Screening for Rust

**AL Rathna Kumar\*, P Balasubramanian and V Muralidharan**

Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu

**Key Words:** *Puccinia arachidis*, Groundnut, Germplasm, Screening

Rust disease of groundnut caused by *Puccinia arachidis* Speg. has gained much attention because of its rapid spread to almost all the major groundnut growing countries. Efforts to find genetic resistance have been successful and several sources have been identified. Most (90%) of the resistant sources belong to only fastigiata germplasm (*Arachis hypogaea* sub-species *fastigiata*). Before exploiting resistant germplasm in breeding programmes, it becomes essential to understand the differences in the components of resistance and the nature of relationship among them. Hence, an experiment was conducted to understand the components of resistance in 15 fastigiata germplasm lines and four highly susceptible genotypes following detached leaf technique (Subrahmanyam *et al.* 1980).

The experimental material consisted of a fully expanded undamaged leaf excised with intact petiole through the pulvinous from each plant at the third node from the terminal bud of the main stem. The leaves were washed with sterile water and inserted in a layer

of sterilized sand in plastic trays (45x30x14 cm). The sand was moistened with Hogland's nutrient solution and for each genotype four replications were maintained. The uredospores were collected from the diseased plants of TMV 2 using a cyclone spore collector. Suspensions of uredospores were prepared (50000 spores/ml) in sterile water containing the wetting agent Tween 80 (0.2 ml/l of water). The spore suspensions were atomized over the leaves inside the tray and covered with 250 gauge polythene sheets. The trays were then placed in plant growth chamber adjusted to 25°C and a 12 h photoperiod. Five components of rust resistance namely incubation period, infection frequency, number of pustules, pustule diameter and rust score were recorded from 10 plants selected at random from each of the four replications for a monocyclic infection.

For the purpose of comparison the genotypes were placed according to their mean field rust score as resistant (scores of 2.0-3.0), moderately resistant (3.1-7.0) and susceptible (7.1-9.0). Significant genotypic differences existed between and within the germplasm lines for each resistance component. Incubation period differed

\* Scientist, National Research Centre for Groundnut, PB No. 5, Junagadh-362001, Gujarat

Table 1. Components of resistance to *Puccinia arachidis* in groundnut fastigiate genotypes

| Description of genotypes |         | Incubation period (days) | Infection frequency (lesions/cm <sup>2</sup> ) | Pustule diameter (mm) | No. of pustules/leaf | Rust score |
|--------------------------|---------|--------------------------|------------------------------------------------|-----------------------|----------------------|------------|
| Identity                 | ICG No. |                          |                                                |                       |                      |            |
| NCAc 17090               | 1697    | 19.3                     | 5.9                                            | 0.68                  | 1.3                  | 2.2        |
| PI 476183                | 10053   | 18.3                     | 8.1                                            | 0.63                  | 1.3                  | 2.4        |
| PI 393646                | 7986    | 18.1                     | 6.7                                            | 0.57                  | 1.6                  | 2.4        |
| PI 407454                | 7898    | 18.5                     | 4.7                                            | 0.57                  | 1.1                  | 2.8        |
| EC 76446 (292)           | 2716    | 17.5                     | 6.2                                            | 0.59                  | 2.1                  | 2.8        |
| PI 314817                | 7882    | 15.2                     | 3.2                                            | 0.49                  | 2.4                  | 3.0        |
| PI 393643                | 7895    | 14.7                     | 5.5                                            | 0.73                  | 3.0                  | 3.0        |
| PI 381622                | 7885    | 13.0                     | 6.9                                            | 0.94                  | 3.4                  | 3.0        |
| PI 393517                | 7889    | 13.8                     | 6.7                                            | 0.49                  | 3.2                  | 3.2        |
| PI 393531                | 7893    | 11.4                     | 4.5                                            | 0.51                  | 4.0                  | 3.4        |
| PI 275745                | 1702    | 11.2                     | 21.2                                           | 1.31                  | 6                    | 4.0        |
| NCNc 17135               | 1707    | 10.8                     | 22.2                                           | 1.8                   | 8                    | 4.5        |
| EC 76446                 | 2716    | 9.8                      | 22.3                                           | 1.9                   | 10                   | 5.1        |
| NCAc 2240                | 5043    | 9.3                      | 23.6                                           | 1.1                   | 11                   | 5.8        |
| NCAc 17133               | 7013    | 7.3                      | 23.2                                           | 2.2                   | 14                   | 7.0        |
| TMV 2                    | —       | 7.3                      | 24.8                                           | 2.3                   | 11                   | 9.0        |
| TMV 10                   | —       | 7.8                      | 23.9                                           | 2.2                   | 13                   | 9.0        |
| JL 24                    | —       | 7.2                      | 25.1                                           | 2.1                   | 12                   | 9.0        |
| Robut 33-1               | —       | 7.8                      | 24.6                                           | 2.2                   | 13                   | 9.0        |
| LSD                      |         | 0.4                      | 1.2                                            | 0.03                  | 1.0                  | 0.20       |

markedly between resistant and moderately resistant and susceptible groups and was found to be more in case of resistant germplasm (Table 1). In addition, the resistant genotypes had lesser infection frequency, number of pustules which were smaller in size in comparison to the moderately resistant and susceptible germplasm indicating the operation of partial/horizontal resistance (Vanderplank, 1968) and is similar to slow rusting reported by several investigators of cereal rust (Hooker, 1967, Parlevliet, 1976) and in leaf spot of groundnut (Aquino, 1995).

Under environmental conditions favourable for disease development, even small differences in number of lesions, incubation period and sporulation measured as number of pustules/spores may contribute to significant differences between the cultivars in disease severity and rate of disease progress (Ringer, 1995) and hence these components can be effectively used to screen large germplasm epiphytotically in a short time without the confounding effect of other diseases in the field especially the disease like leafspot.

The inter-relationship studies elicited through correlation matrix revealed that incubation period and

infection frequency exhibited a negative relationship with the field rust score and can be used as an important criteria to select genotypes in the areas where disease epidemic is less or occurrence of the disease is rare. In the absence of the proper understanding on which component should be emphasized in breeding for rust resistance and in the absence of proper development of disease pressure these components may be useful.

## References

- Aquino VM (1995) Late leafspot progression on peanut as affected by components of partial resistance. *Plant Disease* **79**: 74-78.
- Subrahmanyam P, RW Gibbons, SN Nigam and VR Rao (1980) Screening methods and further sources of resistance to peanut rust. *Peanut Sci.* **7**: 10-12.
- Hooker AL (1967) The genetics and expression of resistance in plants to rusts of the genus *Puccinia*. *Ann. Rev. Phytopathol.* **5**: 163-182.
- Parlevliet JE (1976) Evaluation of concept of horizontal resistance in barley/*Puccinia hordei* host-pathogen relationship. *Phytopathology* **66**: 494-497.
- Ringer CE (1995) Infection cycle components and disease progress of grey leaf spot on field corn. *Plant Disease* **79**: 24-28.
- Vanderplank JE (1968) *Disease Resistance in Plant*. Acad. Press, NY, 206p.

## Differential Chemosensory Responses in Wild, Unadapted Groundnut Germplasm and Susceptible Cultivar to Rust (*Puccinia arachidis* Speg.)

AL Rathnakumar\* and P Balasubramanian

Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu

**Key Words:** *Puccinia arachidis*, Groundnut, Super oxide radicals

Rust is a serious disease causing severe yield losses in many groundnut-growing countries of the world. Genetic resistance to this disease in the cultivated groundnut is almost lacking. However, several species of the genus *Arachis* are immune or resistant to this disease (Subramanyam *et al.* 1980) and offer immense scope to breed cultivars having wider and differential genetic resistance. Before utilizing these sources of resistance in the breeding programmes, understanding the mechanisms of resistance is essential. Oxidative stress has been one of the various defence responses implicated in the disease resistance and have consequently been the subject of much research. However, with reference to groundnut, studies are meagre. Groundnut offers a unique opportunity, as all the three types of disease reaction classes are available in their gene pool. Hence, an experiment was carried out to understand the role of the oxidative stress in one immune wild *Arachis* species (*Arachis cardinasii*), a resistant and unadapted land race (NcAc 17090) and a susceptible check (TMV 2).

Since it is difficult to measure the short-lived super oxide radicals produced as a defense response, the activities of scavenger enzymes that utilize these radicals namely super oxide dismutase (SOD) and peroxidase (Po) were estimated quantitatively.

The experimental materials consisted of a fully expanded undamaged leaf excised with intact petiole through the pulvinous from each plant at the third node from the terminal bud of the main stem. The leaves were washed with sterile water and inserted in a layer of sterilized sand in plastic trays (45 x 30 x 14 cm). The sand was moistened with Hogland's nutrient solution. For each genotype four replications were maintained. The uredospores were collected from the diseased plants of TMV 2 using a cyclone spore collector. Suspensions of uredospores were prepared (50000 spores/ml) in sterile water containing the

wetting agent Tween 80 (0.2 ml/lit of water). The spore suspensions were atomized over the leaves inside the tray and covered with 250 gauge polythene sheets. The trays were then placed in plant growth chamber adjusted to 25°C and a 12 h photoperiod. The enzyme assays were carried out at 1, 3, 5, 7, 10 and 14 days after inoculation. The activity of superoxide dismutase enzyme was measured by the method of superoxide mediated ferricytochrome reduction (McCord and Fridovich, 1969) and one unit of SOD activity was defined as that which inhibited 50% of the reaction rate/cm<sup>2</sup> leaf area. Peroxidase activity was measured following the method of Hammerschmidt *et al.* (1982) and expressed as increase in absorbance at 470 nm/min/g of fresh leaf tissue.

The super oxide dismutase (SOD) and peroxidase (PO) enzymes were active from day one after inoculation, reached the peak within third and fifth day, respectively, declined rapidly thereafter and dropped down to a very low level by 14 days after inoculation. The activities of these two enzymes were initially very low in case of susceptible genotype, but increased from 5th day onwards, reached the peak by the 10th day and thereafter declined rapidly (Fig. 1).

Rapid generation of superoxide and accumulation of hydrogen peroxide are characteristic features of the hypersensitive response following the perception of pathogen avirulence signal. These oxidants act not only as protective agents of the cells against the pathogen, but also function as a substrate for oxidative cross-linking as a threshold trigger for hypersensitive cell death. However, in groundnut rust, these radicals may be channelised for the lignification of the host cell wall, which in turn may act as a physical/chemical barrier for further pathogen ingress (Rathnakumar and Balasubramanian, 2000).

Subramanyam *et al.* (1983) have reported that in both the wild and cultivated groundnut the rust uredosori germinated on the leaf surfaces and the fungus entered

\*Scientist, National Research Centre for Groundnut, PB. No. 5, Junagadh-362001, Gujarat, India

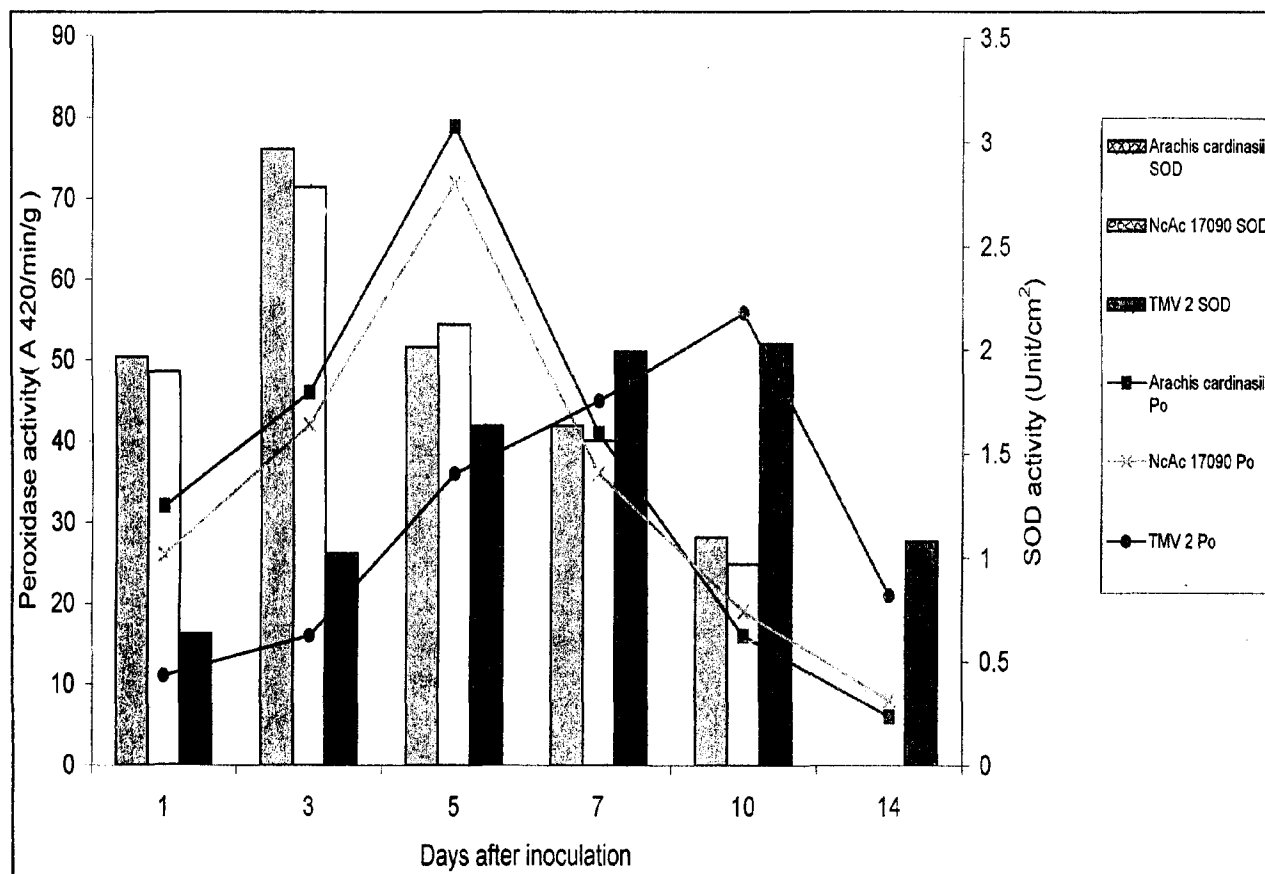


Fig. 1. Activities of Superoxide Dismutase and Peroxidase following Uredospore Inoculation

through the stomata irrespective of whether a genotype was immune, resistant and susceptible and in the immune species the fungus died shortly after entering the sub stomatal cavity. The present study clearly indicated through the enzyme activities that the super oxide radicals were produced in all the three reaction classes but much earlier in the immune and resistant genotypes and at a much later stage in the susceptible genotype.

The study has also shown that in the susceptible cultivar, although the enzyme activities were comparable to that of immune or resistant germplasm, the accumulation of toxic products occurred at a time and speed that could not contain the development of the disease indicating that susceptibility is not due to the lack of genes for resistance. It is proposed that in groundnut rust two distinct chemosensory perception systems—one for immunity and the other for susceptibility may operate.

The study also indicated that these two enzymes may be used as biochemical markers of rust resistance

for preliminary screening of large number of germplasms under epiphytotic conditions.

## References

- Hammerschmidt R, EM Nuckles and J Kuc (1982) Association of enhanced peroxidase activity with induced resistance of cucumber to *Colletotrichum lagenarium*. *Physiol. Plant Pathol.* **20**: 73-82.
- McCord JM and I Fridovich (1969) Assay of Superoxide dismutase. *J. Biol. Chem.* **244**: 6048.
- Rathnakumar AL and P Balasubramanian (2000) Induction of Lignin in the resistance of groundnut to rust *Puccinia arachidis* (Speg). Paper presented at National symposia on Emerging trends in Agricultural Biochemistry, Regulation of metabolic pathways for Crop Improvement and Recent Developments in Green Vegetation and Leaf Protein Research, CS Azad University of Agric. Technol., 84p.
- Subrahmanyam P, RW Gibbons, SN Nigam and VR Rao (1980) Screening methods and further sources of resistance to peanut rust. *Peanut Sci.* **7**: 10-12.
- Subrahmanyam P, D McDonald, RW Gibbons and PVS Rao (1983) Components of resistance to *Puccinia arachidis* in peanuts. *Phytopathology* **73**: 253-256.

## Coconut Genetic Resources – Genetic and Molecular Approaches

**MJ Ratnambal, PM Khumaran, V Arunachala, V Nirai, Anuradha Upadhyay and VA Parthasarathy**  
*Central Plantation Crops Research Institute, Kasaragod-671124, Kerala*

**Key Words:** Coconut, Germplasm, Isozymes, Palms, RAPD

*Coconut (Cocos nucifera L.)* is one of the most important palms of the world. It is presumed that the generic name *Cocos* as well as name 'coconut' are derived from the Spanish word 'coco' meaning monkey face probably a reference to three scars on the base of the shell resembling a monkey's face (Rosengarten, 1984). The origin of coconut was placed by Martius (1850) on the West Coast of Central America near Isthmus of Panama. On the basis of evidences for cultivation of coconuts in Sri Lanka by about 300 BC as well as the discovery of a fossil (Pliocene) *cocos* in New Zealand (Hill, 1929) and in the deserts of Rajasthan (Kaul, 1951), the theory of Central American origin has been disputed. Early Spanish explorers discovered the cultivation of coconut on the Pacific coast of Panama in pre-Colombian times. The available evidence point to the domestication of coconut in the Indo-Pacific area (de Candolle, 1886; Beccari, 1970; Vavilov, 1951; Corner, 1966 and Child, 1974). According to the most widely accepted theory, the origin of coconut is in the old world, somewhere in the South-East Asia or Pacific Island from where it might have been transported to other regions either by man or sea currents.

In coconut there are two distinct varieties namely tall and dwarfs. Tall palms, sometimes referred as var. *typica* are the most commonly cultivated in all the coconut growing areas in the world. They generally grow to a height of 25-30 m and have a comparatively long pre-bearing age of 6-10 years. They are normally cross-pollinated.

Fruit is generally medium to large in size and nuts mature within a period of 12 months. The copra content is usually over 150 g/nut and oil percentage varies from 66-70. The common tall varieties found in India are West Coast Tall, East Coast Tall, Tiptur Tall, Orissa Tall, Lakshadweep Ordinary, Andaman Ordinary *etc.*

Dwarf palms sometimes referred to as var. *nana* (Griff.) Nar., are characterized by their short stature. They are quicker to come to bearing (3-4 years) and short-lived. They have thin trunks without a swollen base

or 'bole' and fully developed fronds rarely exceed four meters. Dwarfs are identified by the colour of their fruits. They are presumed to have originated from tall palms either through mutation (Menon and Pandalai, 1958) or by breeding in talls (Swaminathan and Nambiar, 1961). In India three important dwarf types found are: Chowghat Green Dwarf, Chowghat Orange Dwarf (from Kerala) Gangabondam Green Dwarf (from Andhra Pradesh).

Among the coconut growing nations, India is the first country to initiate coconut research in the world. Collection, conservation and evaluation of coconut germplasm were done to exploit the high yielding potential in some of the germplasm accessions.

The earliest exotic introduction into the country was in 1924 from the Philippines, Malaysia, Fiji, Indonesia, Sri Lanka and Vietnam. The germplasm exchange programme was intensified in 1952 and in 1958, survey for selection of indigenous germplasm was started.

At present Central Plantation Crops Research Institute (CPCRI), Kasaragod, India is maintaining the world's largest assemblage of germplasm comprising of 270 accessions out of which 120 are exotic types. The exotic collection comprises of 96 talls, 23 dwarfs and one semi tall and the indigenous collection includes 133 talls and 17 dwarfs. The exotic collections are from 27 countries of South and South-East Asia, Caribbean Island, Ocean Island, Pacific Ocean Island and African countries.

During 1981, with financial assistance of IPGRI, 23 accessions were collected from 6 Pacific Ocean countries and these are being maintained at CARI, Andamans (erstwhile World Coconut Germplasm Centre under CPCRI). During 1997, under ADB Phase-I, 15 accessions were collected as embryos from 3 Indian Ocean Islands viz. - Seychelles, Mauritius and Madagascar. Under ADB Phase-II in 2000, 8 accessions were collected from 3 Indian Ocean islands viz. - Maldives, Re-union and Comoros. During 2001, 2 accessions were collected from Sri Lanka.

Out of the total 270 accessions, passport data has been entered in the CGRD for 242 accessions and

characterization for 74 accessions. The characterized germplasm has been catalogued in two publications. Coconut Descriptor Part-I was published in 1994 which describes 48 accessions while, Coconut Descriptors Part-II describing 26 accessions was released as CD-ROM during 2000.

The CPCRI has been identified as the implementing agency for the establishment of the International Coconut Genebank for South Asia (ICG-SA). A compact block of about 100 palms in each accession is being established, which would enable to hold enough population for further study and supply to other member countries.

Fourteen cultivars were planted at ICG-SA during 1998 and 15 cultivars during 1999 at a population rate of 45/90 seedlings/accession.

Prospection and collection visits were intensified in the past five years to preserve the coconut diversity available in the country and the Indian Ocean islands. Thirty-one exotic collections were made from six islands of Indian Ocean region. Exploration, prospection and collecting activities were intensified in several parts of India – Orissa (10), West Bengal (11), Tamil Nadu (1), Kerala (25), Goa and Maharashtra (12), Andaman and Nicobar Islands (47), Lakshadweep Islands (11), which helped to enrich our indigenous collections in the gene bank.

Some of the useful collections made in these visits include Guelle rose having pink coloured embryos (marker), Coco Gra Tall, a Macapuno type jelly like endosperm elite high yielding accessions from Kerala, accessions having freak traits such as horned fruits, beaked fruits, etc.

Studies on genetic erosion of coconut genetic resources is presently undertaken in recent exploration trips to investigate the extent of loss of diversity. Different indicators such as area under the crop, competition from other crops, area under traditional varieties and high yielding hybrids/varieties, knowledge of land races by the local people etc.

Breeding programmes in the country utilise the rich diversity collected by CPCRI from India and abroad as well as AICRP (Palms) centres. Evaluation and selection of the accessions led to the recommendation/release of varieties viz. - Chowghat Orange dwarf (tendernut purpose), Chandrakalpa (Lakshdweep Ordinary), VPM-3 (Andaman Ordinary), Philippines ordinary, Kamarupa, (Assam Tall). Hybridization programmes utilise the accessions such as Gangabondam, Laccadive Ordinary,

Philippines Ordinary, Malayan Yellow Dwarf as one of the parents in recently released successful hybrids.

Biochemical (isozymes) and molecular markers are widely used for characterisation and cataloguing of germplasm in different crops. In coconut, isozymes and RAPD makers have been identified to differentiate and classify coconut accessions.

Eight talls and six dwarfs were studied for isozyme polymorphism using seven enzyme systems. Intra population and inter-population variation was observed with PPO, EST, PER, MDH, ADH and GOT. Enzyme polymorphism was higher in Talls as compared to Dwarf populations possibly due to their breeding nature.

Among dwarfs, GDD showed highest enzymes polymorphism while GBGD showed least enzyme polymorphism. Within each enzyme system differences in inter-population variation were observed between cultivars except in ACP and ADH. For EST, MOD showed highest intra-population variation, while MYD, GDD and GBGD did not show any variation. In case of PER, only GDD showed intra-population variation while for MDSH, only MODE showed intra-population variation. For PPO, GDD showed highest intra-population variation, while both CGD and GBGD had least variation. A comparison of polymorphic indices indicates that PPO showed highest polymorphism followed by GOT, EST, PER and MDH, respectively.

Of the eight tall genotypes studied, JVT showed maximum enzyme polymorphism while SNRT showed least polymorphism. All enzyme system (except ACP) detected intra-population variation. For EST and PER, JVT showed highest intra-population variation, while it was absent in SNRT. For PPO, PHOT showed greater intra-population variation, while it was low in SNRT. In case of MDH, ADOT showed highest variation, followed by WCT, JVT, LCT, PHOT and KPDT and LMT while it was absent in SNRT. For ADH, ADQT showed maximum variation, while it was least in KPDT and absent in SNRT and LMT. A comparison of polymorphic indices of the talls indicates that, PER showed maximum polymorphism followed by PPO, MDH, ADH, EST, respectively.

RAPD markers were used to characterise the coconut germplasm. Hundred primers were screened for their ability to detect polymorphism in coconut. Only 34% primers were polymorphic. The number of polymorphic bands/primer ranged from 1-16.

To understand the intra-population variation in coconut, DNA from 81 palms was amplified with 8 polymorphic primers. These primers are OPA4, OPA10, OPB1, OPB5, OPC2, OPC5, OPC9 and OPE2.

Proportion of polymorphic bands for each accession as well as for exotic and indigenous accessions was calculated. Genetic diversity was estimated by using Shannon information index.

Eight primer detected 77 polymorphic markers in 81 palms. The number of markers for each primer varied between 7 (OPA 4, OPB 1, OPC 5) to 15 (OPB 5) with an average of 9.6 markers/primer. However, the number of markers present in an accession varied between 46 (COD) to 71 (Kappadam). The proportion of polymorphic bands among tall accessions varied between 22 (GPT) to 71 (KAP) with an average of 49%, whereas among the dwarfs, it varied between 20 (KTD) to 44 (MOD) with an average of 36%.

The average diversity for all the accessions ( $H_T$ ) was 0.214. The average diversity ( $H_o$ ) for individual accession 0.057 (KTD) to 0.196 (PHT). The mean within population ( $H_M$ ) diversity was 1.120. The proportion of total diversity found within population ( $H_M/H_T$ ) was found to be 0.56. Thus, the proportion of between population diversity was 0.44.

When considering only all tall accessions (13 Nos.) the genetic diversity was 0.125, a little higher than  $H_T$  (0.124), whereas the genetic diversity of the dwarf accession was calculated to be 0.118.

The average genetic diversity for indigenous accession was 0.209 which was lower than that of exotic accession (0.225 indicating more variation among exotic collection).

The RAPD data was used to calculate similarity coefficient for 81 palms. Similarity coefficient data was used to construct a dendrogram of genetic relationship by UPGMA method using NTSYS (Ver. 1.7) package.

In dendrogram dwarf accessions formed two main groups (III and IV) whereas tall accessions were clustered in three main groups (I, II, V) which were further subdivided into many subgroups. Gangabondam, an intermediate type was clustered with tall accessions.

Coconut, being an important oil crop with diverse uses, has great scope for research. India, being the host country for the International Coconut Gene Bank, houses about 270 accessions. These accessions have been evaluated for their genetic and molecular variations. Even though, some of the accessions have been used for breeding purposes, research would be intensified for using these conserved germplasm for exploitation of various desirable traits such as high copra content, optimum loric acid content, dwarfness, tolerance to drought, mite attack and root (wilt) disease.

## References

- Beccari O (1970) The origin and dispersal of *Cocos nucifera* Phillp. *J. Sci.* **14**: 295-367.
- Child R (1974) *Coconuts* 2<sup>nd</sup> edition, Longman Group Ltd., London, 335p.
- Corner EJH (1966) *The Natural History of Palm*. Weidenfeld and Nicolson, London, 393p.
- De Candolle A (1886) *Origin of Cultivated Plants*. Hafner Pub. Co. New York, 428p.
- Hill AW (1929) The original home and mode of dispersal of the coconut. *Nature* **124**: 133-134, 151-153.
- Kaul KN (1951) A palm fruit from Kapurdi. Jodhpur, Rajasthan Desert *Cocos Sahnii* ssp. *Curr. Sci.* **10**: 138
- Martius CFP (1850) *Historia Naturalis Palmarum* **3**: 1823-1850
- Menon KPV and KM Pandalai (1958) *The Coconut Palm—A Monograph*, Indian Central Coconut Committee, Ernakulam, 384p.
- Rosengarten F (1984) *The Book of Edible Nuts*. Walker and Company, New York, 384p.
- Swaminathan MS and Nambiar MC (1961) Cytology and origin of the dwarf coconut palm. *Nature* **192**: 85-86.
- Vovilov NI (1951) The origin, variation and the breeding of cultivated plants. *Chronica Botanica* **13**: 1366.

## Morpho-physiological and Cytological Evaluation of Radish

**Chandreshwar Prasad**

University Department of Botany, Vinoba Bhave University, Hazaribag-825201, Jharkhand

**Key Words:** Characterization, Chromocentres, Fertilization value, Pollen fertility, Radish

Although morphological characteristics of some Indian varietal populations of radish (*Raphanus sativus* L.) are known to some extent (Prasad, 1980; Williams, 1985), they are not well studied. Therefore, one of the objectives of the present work was to characterize and evaluate ten populations of radish on the basis of their morpho-physiological and cytological characteristics. The populations which constituted the material for present investigation are: White Green Top (GT), Japanese White (JW), Kalamkati Red (KR), Scarlet Globe (SG), Rainy Season Red (RR), Pusa Himani (PH), Chinese White (CW), Jaunpur Giant (JG), Contai Long (CL) and Punjab Selection 5 (PS-5). To make comparative study the plants were raised from the seeds in controlled condition in rows at a distance of 35-40 cm during September-April, 1998-1999 in the field at Hazaribag. Following characteristics were taken into consideration: per cent seed germination (PSG), seedling morphology which included mean hypocotyl length (MHL), mean cotyledon area (MCA) and relative width of cotyledon (RWC%), number of robed leaf (MNLB), number of branches/plant (MNB), days to flower, mean number of ovules/pistil (MNO), mean number of seeds/silique (MNS),

fertilization value (FV %), pollen fertility (PPF), mean number of chromocentres/nucleus (MNC) and meiotic chromosome abnormalities (MCA).

PSG is based on 1000 seeds in each population. MHL was obtained from measurement of 100 randomly selected seedlings after the appearance of the first true leaf. At the same time, length and width of the cotyledons were also measured in order to calculate MCA. MNLB was computed by counting the number of lobes in 10 leaves from each of 25 plants. To score MNB number of secondary branches developing from the main axis was counted. Days to flower were scored as appearance of first flower from sowing. Total 625 pistils (25 from each plant of 25 plants in each population) were dissected out carefully to score MNO. MNS was scored by counting the number of seeds in 625 silique (25 from each plant of the 25 plants in each population). The ratio of MNS to MNO gave FV. For PPF, acetocarmine technique was used considering about 2000 pollen grains in each population. For MNC only stigma of the pistils were stained and squashed in 1.5% acetocarmine in 100 receptive cells/plant. NICA at metaphase-I and anaphase-I was studied in 200 PMCs.

**Table 1. Variation in morpho-physiological and cytological traits in the varietal populations of radish**

| Characters             | GT               | JW               | KR              | SG               | RR               | PH               | CW               | JG               | CL               | PS-5             |
|------------------------|------------------|------------------|-----------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|                        | Mean $\pm$ SE    | Mean $\pm$ SE    | Mean $\pm$ SE   | Mean $\pm$ SE    | Mean $\pm$ SE    | Mean $\pm$ SE    | Mean $\pm$ SE    | Mean $\pm$ SE    | Mean $\pm$ SE    | Mean $\pm$ SE    |
| 100-Seed wt. (g)       | 0.6 $\pm$ 0.03   | 0.7 $\pm$ 0.01   | 0.6 $\pm$ 0.02  | 0.5 $\pm$ 0.01   | 0.8 $\pm$ 0.01   | 0.6 $\pm$ 0.00   | 0.7 $\pm$ 0.01   | 30.8 $\pm$ 0.01  | 0.9 $\pm$ 0.01   | 0.7 $\pm$ 0.01   |
| PSG                    | 90.0 $\pm$ 0.95  | 83.8 $\pm$ 1.16  | 89.5 $\pm$ 0.96 | 93.0 $\pm$ 0.81  | 96.2 $\pm$ 0.87  | 86.6 $\pm$ 1.08  | 77.1 $\pm$ 1.33  | 82.9 $\pm$ 1.19  | 87.6 $\pm$ 1.04  | 72.3 $\pm$ 1.41  |
| MHL (cm)               | 52.4 $\pm$ 0.83  | 41.4 $\pm$ 0.95  | 48.0 $\pm$ 0.74 | 30.1 $\pm$ 0.41  | 30.1 $\pm$ 0.41  | 35.6 $\pm$ 0.95  | 29.4 $\pm$ 0.77  | 25.2 $\pm$ 0.48  | 25.1 $\pm$ 0.60  | 40.2 $\pm$ 0.84  |
| MCA (mm <sup>2</sup> ) | 91.4 $\pm$ 1.93  | 100.0 $\pm$ 1.69 | 124 $\pm$ 1.89  | 79.0 $\pm$ 1.50  | 90.0 $\pm$ 1.37  | 116.4 $\pm$ 2.33 | 110.2 $\pm$ 2.01 | 96.3 $\pm$ 2.17  | 85.3 $\pm$ 1.85  | 92.0 $\pm$ 1.60  |
| RWC (%)                | 178.0 $\pm$ 3.80 | 123.0 $\pm$ 2.10 | 119.0 $\pm$ 1.8 | 136.0 $\pm$ 1.90 | 125.0 $\pm$ 1.90 | 123.0 $\pm$ 2.20 | 122.0 $\pm$ 1.90 | 118.0 $\pm$ 2.50 | 112.0 $\pm$ 2.40 | 108.0 $\pm$ 1.90 |
| MNLL                   | 12.5 $\pm$ 0.25  | 11.6 $\pm$ 0.28  | 5.7 $\pm$ 0.25  | 8.6 $\pm$ 0.43   | 6.4 $\pm$ 0.31   | 11.0 $\pm$ 0.22  | 9.6 $\pm$ 0.26   | 8.2 $\pm$ 0.25   | 10.7 $\pm$ 0.29  | 12.4 $\pm$ 0.24  |
| MNB                    | 7.8 $\pm$ 0.26   | 6.6 $\pm$ 0.21   | 5.9 $\pm$ 0.19  | 14.2 $\pm$ 0.30  | 6.2 $\pm$ 0.16   | 7.1 $\pm$ 0.21   | 6.4 $\pm$ 0.13   | 6.9 $\pm$ 0.16   | 6.8 $\pm$ 0.23   |                  |
| Days to flower         | 100              | 92               | 81              | 130              | 70               | 110              | 90               | 94               | 93               |                  |
| MNO                    | 6.7 $\pm$ 0.08   | 6.6 $\pm$ 0.07   | 6.3 $\pm$ 0.06  | 7.8 $\pm$ 0.07   | 7.4 $\pm$ 0.068  | 10 $\pm$ 0.07    | 7.8 $\pm$ 0.17   | 7.8 $\pm$ 0.10   | 8.2 $\pm$ 0.07   |                  |
| MNS                    | 6.6 $\pm$ 0.18   | 7.8 $\pm$ 0.21   | 5.7 $\pm$ 0.13  | 5.4 $\pm$ 0.50   | 5.7 $\pm$ 0.07   | 6.5 $\pm$ 0.15   | 7.4 $\pm$ 0.22   | 7.5 $\pm$ 0.22   | 6.7 $\pm$ 0.16   |                  |
| PSS                    | 94.4 $\pm$ 1.46  | 94.3 $\pm$ 1.48  | 94.8 $\pm$ 1.40 | 91.6 $\pm$ 1.76  | 92.3 $\pm$ 1.67  | 96.0 $\pm$ 1.24  | 96.3 $\pm$ 1.71  | 99.2 $\pm$ 0.57  | 95.6 $\pm$ 1.30  | Did not flower   |
| FV(%)                  | 99.0 $\pm$ 2.90  | 88.0 $\pm$ 3.30  | 89.0 $\pm$ 2.20 | 69.0 $\pm$ 2.00  | 77.0 $\pm$ 1.20  | 80.0 $\pm$ 1.90  | 95.0 $\pm$ 3.50  | 96.0 $\pm$ 0.02  | 82.0 $\pm$ 2.10  | even after       |
| PPF                    | 99.1 $\pm$ 0.02  | 98.7 $\pm$ 0.02  | 97.0 $\pm$ 0.01 | 92.0 $\pm$ 0.02  | 99.0 $\pm$ 0.01  | 95.0 $\pm$ 0.01  | 96.6 $\pm$ 0.02  | 98.6 $\pm$ 0.02  | 94.1 $\pm$ 0.02  | 180 days         |
| MNC                    | 13.1 $\pm$ 0.12  | 14.2 $\pm$ 0.12  | 13.3 $\pm$ 0.15 | 12.6 $\pm$ 0.14  | 12.9 $\pm$ 0.17  | 14.6 $\pm$ 0.14  | 15.2 $\pm$ 0.16  | 12.4 $\pm$ 0.10  | 14.1 $\pm$ 0.17  |                  |
| MCA (%) at             |                  |                  |                 |                  |                  |                  |                  |                  |                  |                  |
| i. Metaphase-I         | 56.0 $\pm$ 1.54  | 4.5 $\pm$ 1.46   | 7.5 $\pm$ 1.86  | 15.0 $\pm$ 2.52  | 4.5 $\pm$ 1.47   | 9.5 $\pm$ 2.07   | 7.0 $\pm$ 1.80   | 5.0 $\pm$ 1.54   | 11.5 $\pm$ 2.25  |                  |
| ii. Anaphase-II        | 7.0 $\pm$ 1.80   | 5.0 $\pm$ 5.14   | 8.5 $\pm$ 1.97  | 16.0 $\pm$ 2.59  | 4.5 $\pm$ 1.47   | 10.0 $\pm$ 2.12  | 8.0 $\pm$ 1.92   | 7.5 $\pm$ 1.86   | 13.5 $\pm$ 2.42  |                  |

The population showed inter-population variation in various characters studied (Table 1). Radish is suitable for genetical study of the seedling characters (Prasad and Dayal, 1993) which are quite sharp and distinct in this species. The seedling counts give better genetic ratio than the adult plant counts due to lesser effect of the environment on such characters. The data of present investigation demonstrated that the populations of radish differed considerably among themselves in PSG, MHL, MCA and RWC due to their genotypic peculiarities. The populations having greater MHL had smaller NICA and *vice-versa*. This indicated that MHL is negatively correlated with MCA. Whether hypocotyl length has any correlation with root size in radish is not known. However, JG characterized by the largest roots also had the longest hypocotyl (Prasad, 1980). A seedling of PS-5 had three cotyledons, the extra being slightly smaller than the normal ones. Occurrence of abnormal seedling may be regarded as an indicator of polyembryony (Tokumasu, 1972). Our results also demonstrated that different populations of radish vary among themselves in some other vegetative attributes like MNLB and MNB. Whether these parameters have any relation with the other components of fertility is not known.

The populations differed in fertility components as well. It is remarkable that FV in all the populations is above 69%. The seed set in radish appears to be a genotypic function (Prasad and Dayal, 1994a). The pollen fertility in these populations also showed significant inter-varietal differences. In contrast to the fertilization value, pollen fertility in all the populations is quite high, above 92%. Some sort of parallelism does exist between pollen fertility and meiotic chromosome behavior (Prasad and Dayal 1994b), but this can hardly be generalised. Nwankiti (1970) is of the opinion that all type of chromosome abnormalities are not related with pollen sterility.

There are some reports on cytological investigations in radish (Richharia, 1937; Mukherjee, 1979; Sharma and Dutta, 1961; Dayal, 1979; Prasad and Dayal, 1994 b). The amount and distribution of chromocentres in radish are under the control of the genotype and are related with homo- and heterozygosity (Dayal and Prasad, 1981,

1983). The present study demonstrates that the inter-varietal variation in this heterochromatin phenotype points to the varying degree of heterochromatization. Meiosis was more or less normal in the populations and was of asynchronous type.

Thus, the present study shows that the populations of radish vary genotypically among themselves in a number of morpho-physiological and cytological attributes. Heterosis has been a phenomenon of great interest to plant breeders and the degree of heterosis is closely associated with genetic diversity of the parental forms and, therefore, inter-varietal hybridization becomes more significant from the viewpoint of effective exploitation of additive and non-additive genetic variability.

## References

- Dayal N (1979) Cytogenetical studies in the inbred lines of radish and their hybrids. II. Meiotic Irregularities *Cytologia* **44**: 1.
- Dayal N and C Prasad (1981) Cytogenetic studies on chromocentres in radish (*Raphanus sativus* L.) I. Varietal populations and their F<sub>1</sub> hybrids. *Bionature* **1**: 59-62.
- Dayal N and C Prasad (1983) Genetic regulation of chromocentres in radish (*R. sativus* L.). *Cytologia* **48**: 245-252.
- Mukherjee P (1979) Karyotype variation in nine strains of Indian radish (*Raphanus sativus* L.). *Cytologia* **44**: 347-352.
- Nwankiti O (1970) Cytogenetic and breeding studies with *Brassica*-I, Cytogenetic experiments with *Brassica napocampestris*. *Hereditas* **66**: 109-126.
- Prasad C (1980) Cytogenetic Investigations in Indian Radishes. Ph.D. Thesis, Ranchi University, Ranchi.
- Prasad C and N Dayal (1993) Genetical studies on seedling morphology in radish (*Raphanus sativus* L.). *Columban J. Life Sci.* **12**: 115-121.
- Prasad C and N Dayal (1994a) Fertilization value in radish in two modes of pollination. *Geobios New Reports* **13**: 175-179.
- Prasad C and N Dayal (1994b) Meiotic chromosome abnormalities in radish (*Raphanus sativus* L.). *Geobios New Reports* **13**: 101-105.
- Richharia RH (1937) Cytological investigations of *Raphanus sativus*. *Brassica oleracea* and their F<sub>1</sub> and F<sub>2</sub> hybrids. *J. Genet.* **34**: 19-44.
- Sharma AK and KB Dutta (1961) Inter-strain difference in karyotype of *Raphanus sativus* L. *Indian Agric.* **5**: 151-159.
- Tokumasu S (1972) Cytogenetical study on the origin of twin plants found in the progeny of an aneuploid in *Brassica napus* Japan *J. Breed.* 334-339.
- Williams PH (ed. 1985) *Gr GC Resource Book*. Wisconsin, USA.

## Variability in Chilli (*Capsicum*) Rom. of Central and South Kerala

MC Narayanankutty, ML Jyothi, S Leenakumari, M Musthafa

Regional Agricultural Research Station, Pattambi, Kerala

**Key Words:** Bacterial wilt, Characterization, Chilli, Germplasm, Kerala

Chillies (*Capsicum*) Rom. are believed to have established well in the tropics about five centuries back. India is the largest producer and consumer of chilli. Considerable variability exists in the different cultivated species across the country. With India as a signatory to the WTO it has become imperative to preserve our genetic wealth in order to safeguard our rights on them.

An exploration was conducted in the central and southern districts of Kerala namely, Palakkad, Thrissur, Ernakulam, Alappuzha, Kottayam, Kollam and Thiruvananthapuram during 1999-2000 and 52 accessions of *Capsicum annuum*, 11 of *Capsicum frutescens* and 8 of *Capsicum chinense* was collected. These germplasm were raised at Regional Agricultural Research Station, Pattambi (Kerala) for characterization on 28 qualitative characters and 11 quantitative traits. Incidence of bacterial wilt and chilli mosaic on the collected types were also evaluated.

Considerable variability exists in the germplasm. Market demand for high pungency chillies had created interest in the cultivation of *Capsicum frutescens* and *Capsicum chinense*. Variability in some important qualitative characters in the three species is given in Table 1. Stem colour was green in 80% of *C. annuum*, 75% of *C. chinense* and all the accessions of *C. frutescens*. Greenish purple colour was observed in 20% of *C. annuum* and 25% *C. chinense* accessions. Stem pubescence was sparse or intermediate in all the collected genotypes. Purple pigmentation in the nodal region was observed in 69% accessions of *C. annuum*, 78% of accession of *C. frutescens* had no pigmentation in the nodal region, while 75% accessions of *C. chinense* had light purple to dark purple pigmentation. Branching was dense in 25% of *C. annuum*, 20% of *C. frutescens* and 42% of *C. chinense*. Dense tillering was also observed in one type under each of the species. Leaf density was intermediate or dense in most of the collected types. Leaf colour varied between light green to dark green. Flowers were erect in 25% of *C. annuum*, 50% of *C. frutescens* and 14% of *C. chinense*. In *C. annuum* and *C. chinense* pendent flowers were

predominant. White corolla colour was predominant in *C. annuum* and *C. chinense*, while Yellow corolla colour in *C. frutescens*. Two genotypes of *C. annuum* had white flowers, with purple margin. Two inserted stigma were observed in three accessions of *C. annuum*.

Fruit colour intermediate state was green, white or purple. In *C. chinense*, one accession had light orange coloured fruit. Mature fruit colour was predominantly red in all the collected types while one accession in *C. frutescens* and *C. chinense* had orange coloured fruit. Globular fruits were observed in accession of *C. annuum*

**Table 1. Variability in some qualitative characters of chilli accessions**

| Character                   | Frequency of distribution under each category (%) |                            |                          |
|-----------------------------|---------------------------------------------------|----------------------------|--------------------------|
|                             | <i>Capsicum annuum</i>                            | <i>Capsicum frutescens</i> | <i>Capsicum chinense</i> |
| Stem colour                 |                                                   |                            |                          |
| Green                       | 80.7                                              | 100                        | 75.0                     |
| Greenish purple             | 19.3                                              | 0                          | 25.0                     |
| Nodal anthocyanin           |                                                   |                            |                          |
| None                        | 30.6                                              | 77.8                       | 25.0                     |
| Light purple                | 32.3                                              | 11.1                       | 25.0                     |
| Dark purple                 | 37.1                                              | 11.1                       | 50.0                     |
| Leaf colour                 |                                                   |                            |                          |
| Light green                 | 33.0                                              | 50.0                       | 28.5                     |
| Dark green                  | 77.0                                              | 50.0                       | 71.4                     |
| Corolla colour              |                                                   |                            |                          |
| White                       | 82.9                                              | 16.7                       | 71.4                     |
| Purple                      | 4.2                                               | 0                          | 14.3                     |
| Yellow                      | 8.5                                               | 83.3                       | 14.3                     |
| White with purple margin    | 4.2                                               | 0                          | 0                        |
| Fruit colour                |                                                   |                            |                          |
| Green                       | 82.3                                              | 57.1                       | 71.4                     |
| Purple                      | 0                                                 | 0                          | 14.3                     |
| White                       | 17.4                                              | 2.9                        | 14.3                     |
| Fruit colour (mature stage) |                                                   |                            |                          |
| Orange                      | 0                                                 | 14.3                       | 14.3                     |
| Light red                   | 2.3                                               | 14.3                       | 0                        |
| Dark red                    | 97.6                                              | 71.4                       | 85.6                     |

and *C. chinense*. Triangular shaped fruits were observed in three *C. annuum* accessions, one *C. frutescens* and two *C. chinense* accessions. One accession under *C. annuum* had wrinkled fruit surface, vegetative characters, plant height and canopy width varied substantially. Variation was also observed in leaf length and leaf width. Fruit length ranged from 3.4 to 16.0 cm in *C. annuum*, 2.3 to 6 cm in *C. frutescens* and 3.9 to 10.9 in *C. chinense*. Fruit weight ranged from 0.7 to 7.4 g in *C. annuum*, 2.3 to 4.8 g in *C. frutescens* and 1.9 to 4.0 g in *C. chinense*. Seed weight also varied significantly. In *C. annuum*, 1000-seed weight ranged between 2.6 to 7.5 g whereas 3.1 to 4.2 g in *C. frutescens* and 2.1 to 3.5 g in *C. chinense*. Non-additive gene action had been reported for characters like plant height and fruit length (Rao and Chhonkar, 1983).

In Kerala, bacterial wilt and mosaic are serious problems in chilli cultivation. Susceptibility of collected accessions to bacterial wilt as well as chilli mosaic was also recorded during the evaluation. Eight accessions (four each from *C. annuum* and *C. chinense*) were free from bacterial wilt. Whereas 9 accessions of *C. annuum* were free from chilli mosaic. These genotypes may prove

**Table 2. Variability in some quantitative attributes of chilli accessions**

| Characters           | Range                  |                            |                          |
|----------------------|------------------------|----------------------------|--------------------------|
|                      | <i>Capsicum annuum</i> | <i>Capsicum frutescens</i> | <i>Capsicum chinense</i> |
| Plant height (cm)    | 27.0-82.5              | 47.2-76.9                  | 46-71                    |
| Canopy (cm)          | 24.5-77.0              | 37.0-78.5                  | 44-106                   |
| Stem length (cm)     | 6.5-49.0               | 20.5-44.5                  | 27.3-47.3                |
| Stem diameter (cm)   | 2.0-5.1                | 2.2-3.9                    | 2.4-3.7                  |
| Leaf length (cm)     | 7.8-17.9               | 9.6-22.1                   | 11.9-17.4                |
| Leaf width (cm)      | 2.4-8.3                | 3.2-9.1                    | 3.3-7.5                  |
| Fruit length (cm)    | 3.4-16.6               | 2.3-6.0                    | 3.9-10.9                 |
| Fruit width (cm)     | 0.4-2.4                | 0.7-2.2                    | 1.1-2.4                  |
| Pedicel length (cm)  | 1.8-6.3                | 2.0-2.5                    | 2.8-5.6                  |
| Fruit weight (g)     | 0.7-8.9                | 2.3-4.8                    | 1.9-4.0                  |
| 1000-seed weight (g) | 2.6-7.5                | 3.1-4.2                    | 2.1-3.5                  |

helpful in developing resistant varieties. Highest/plant yield was recorded in three accessions collected from Palakkad district.

#### References

- Rao PV and Chhonkar (1983) Components of genetic variances for five quantitative characters in chilli. *South Indian Hortic.* 31: 15-19.

## Evaluation of Guava Germplasm for the Incidence of Spiralling Whitefly, *Aleurodicus dispersus* Russell

**PV Rami Reddy and C Vasugi**

Division of Plant Genetic Resources, Indian Institute of Horticultural Research, Hessaraghatta Lake P.O., Bangalore-560089, Karnataka

**Key Words:** *Aleurodicus dispersus*, Spiralling whitefly, Guava germplasm

The spiralling whitefly, *Aleurodicus dispersus* Russell (*Homoptera: Aleyrodidae*) is an exotic pest which was reported to have entered India through Sri Lanka in mid nineties (Ranjith *et al.* 1998). Within a span of a couple of years after its first report of occurrence in Kerala, Tamil Nadu and Karnataka (Palaniswamy *et al.* 1995; Mani and Krishnamurthy, 1996), its menace on a wide range of crops including guava, has grown to an alarming level. Recently the pest caused havoc among guava growers in Andhra Pradesh. The eggs, laid in circular fashion, pupae and adults of this insect are found on the lower surface of leaves as conspicuous

white cottony cushion coating. Nymphs and adults suck sap from leaves making them turn yellow resulting in stunted plant growth. Owing to its recent introduction, an effective IPM package for the whitefly is yet to be standardised. Except for recording a list of host plants across the country, studies on varietal preference are yet to be taken up. Hence, an attempt has been made to screen guava germplasm for their variable susceptibility to this alien pest. The information generated on these lines would go a longway in breeding resistant varieties.

Twenty-five guava germplasm collections (Table 1) including popular cultivars, exotic collections and a species

and *C. chinense*. Triangular shaped fruits were observed in three *C. annuum* accessions, one *C. frutescens* and two *C. chinense* accessions. One accession under *C. annuum* had wrinkled fruit surface, vegetative characters, plant height and canopy width varied substantially. Variation was also observed in leaf length and leaf width. Fruit length ranged from 3.4 to 16.0 cm in *C. annuum*, 2.3 to 6 cm in *C. frutescens* and 3.9 to 10.9 in *C. chinense*. Fruit weight ranged from 0.7 to 7.4 g in *C. annuum*, 2.3 to 4.8 g in *C. frutescens* and 1.9 to 4.0 g in *C. chinense*. Seed weight also varied significantly. In *C. annuum*, 1000-seed weight ranged between 2.6 to 7.5 g whereas 3.1 to 4.2 g in *C. frutescens* and 2.1 to 3.5 g in *C. chinense*. Non-additive gene action had been reported for characters like plant height and fruit length (Rao and Chhonkar, 1983).

In Kerala, bacterial wilt and mosaic are serious problems in chilli cultivation. Susceptibility of collected accessions to bacterial wilt as well as chilli mosaic was also recorded during the evaluation. Eight accessions (four each from *C. annuum* and *C. chinense*) were free from bacterial wilt. Whereas 9 accessions of *C. annuum* were free from chilli mosaic. These genotypes may prove

**Table 2. Variability in some quantitative attributes of chilli accessions**

| Characters           | Range                  |                            |                          |
|----------------------|------------------------|----------------------------|--------------------------|
|                      | <i>Capsicum annuum</i> | <i>Capsicum frutescens</i> | <i>Capsicum chinense</i> |
| Plant height (cm)    | 27.0-82.5              | 47.2-76.9                  | 46-71                    |
| Canopy (cm)          | 24.5-77.0              | 37.0-78.5                  | 44-106                   |
| Stem length (cm)     | 6.5-49.0               | 20.5-44.5                  | 27.3-47.3                |
| Stem diameter (cm)   | 2.0-5.1                | 2.2-3.9                    | 2.4-3.7                  |
| Leaf length (cm)     | 7.8-17.9               | 9.6-22.1                   | 11.9-17.4                |
| Leaf width (cm)      | 2.4-8.3                | 3.2-9.1                    | 3.3-7.5                  |
| Fruit length (cm)    | 3.4-16.6               | 2.3-6.0                    | 3.9-10.9                 |
| Fruit width (cm)     | 0.4-2.4                | 0.7-2.2                    | 1.1-2.4                  |
| Pedicel length (cm)  | 1.8-6.3                | 2.0-2.5                    | 2.8-5.6                  |
| Fruit weight (g)     | 0.7-8.9                | 2.3-4.8                    | 1.9-4.0                  |
| 1000-seed weight (g) | 2.6-7.5                | 3.1-4.2                    | 2.1-3.5                  |

helpful in developing resistant varieties. Highest/plant yield was recorded in three accessions collected from Palakkad district.

#### References

- Rao PV and Chhonkar (1983) Components of genetic variances for five quantitative characters in chilli. *South Indian Hortic.* 31: 15-19.

## Evaluation of Guava Germplasm for the Incidence of Spiralling Whitefly, *Aleurodicus dispersus* Russell

**PV Rami Reddy and C Vasugi**

Division of Plant Genetic Resources, Indian Institute of Horticultural Research, Hessaraghatta Lake P.O., Bangalore-560089, Karnataka

**Key Words:** *Aleurodicus dispersus*, Spiralling whitefly, Guava germplasm

The spiralling whitefly, *Aleurodicus dispersus* Russell (*Homoptera: Aleyrodidae*) is an exotic pest which was reported to have entered India through Sri Lanka in mid nineties (Ranjith *et al.* 1998). Within a span of a couple of years after its first report of occurrence in Kerala, Tamil Nadu and Karnataka (Palaniswamy *et al.* 1995; Mani and Krishnamurthy, 1996), its menace on a wide range of crops including guava, has grown to an alarming level. Recently the pest caused havoc among guava growers in Andhra Pradesh. The eggs, laid in circular fashion, pupae and adults of this insect are found on the lower surface of leaves as conspicuous

white cottony cushion coating. Nymphs and adults suck sap from leaves making them turn yellow resulting in stunted plant growth. Owing to its recent introduction, an effective IPM package for the whitefly is yet to be standardised. Except for recording a list of host plants across the country, studies on varietal preference are yet to be taken up. Hence, an attempt has been made to screen guava germplasm for their variable susceptibility to this alien pest. The information generated on these lines would go a longway in breeding resistant varieties.

Twenty-five guava germplasm collections (Table 1) including popular cultivars, exotic collections and a species

Table 1. Incidence of *Aleurodicus dispersus* on different guava germplasm collections during the year 2000 and 2001

| Variety/Line            | White fly population/10 shoots (immature + adults) |                 |          | % shoot infestation |                  |          |
|-------------------------|----------------------------------------------------|-----------------|----------|---------------------|------------------|----------|
|                         | 2000                                               | 2001            | Mean (P) | 2000                | 2001             | Mean (I) |
| Smooth green            | 10.99<br>(3.38)                                    | 8.99<br>(3.08)  | 10.00    | 20.33<br>(26.78)    | 18.33<br>(25.33) | 19.33    |
| Portugal                | 65.99<br>(8.15)                                    | 71.66<br>(8.49) | 68.82    | 70.66<br>(57.21)    | 74.66<br>(59.78) | 72.66    |
| Mirzapur seedling       | 15.22<br>(3.96)                                    | 18.33<br>(4.34) | 16.77    | 32.33<br>(34.66)    | 36.66<br>(37.26) | 34.49    |
| Florida seedling        | 29.92<br>(7.76)                                    | 21.77<br>(4.72) | 25.84    | 20.00<br>(26.56)    | 19.33<br>(26.09) | 19.66    |
| Behat coconut           | 23.66<br>(4.91)                                    | 16.66<br>(4.14) | 20.16    | 35.66<br>(36.66)    | 27.66<br>(31.72) | 31.66    |
| Karela                  | 8.88<br>(3.06)                                     | 5.99<br>(2.55)  | 7.43     | 20.66<br>(26.99)    | 14.33<br>(22.25) | 17.49    |
| Superior sour lucidum   | 11.77<br>(3.50)                                    | 10.33<br>(3.29) | 11.05    | 24.33<br>(29.55)    | 21.66<br>(27.72) | 23.00    |
| <i>Psidium guinense</i> | 9.62<br>(3.18)                                     | 5.33<br>(2.41)  | 23.00    | 16.33<br>(23.84)    | 14.33<br>(22.25) | 15.33    |
| Nasik                   | 5.77<br>(2.50)                                     | 3.66<br>(2.04)  | 4.71     | 18.33<br>(25.36)    | 16.33<br>(23.84) | 17.33    |
| Pear shaped             | 21.44<br>(4.68)                                    | 17.33<br>(4.22) | 19.38    | 22.66<br>(28.41)    | 17.66<br>(24.84) | 20.16    |
| Sindh                   | 19.88<br>(4.51)                                    | 15.77<br>(4.03) | 17.82    | 26.33<br>(30.88)    | 21.33<br>(27.52) | 23.83    |
| Seedless                | 17.88<br>(4.28)                                    | 15.33<br>(3.98) | 16.60    | 28.66<br>(32.36)    | 27.66<br>(31.72) | 28.16    |
| Hafsi                   | 12.21<br>(3.56)                                    | 10.21<br>(3.27) | 11.21    | 18.66<br>(25.58)    | 15.33<br>(22.06) | 17.00    |
| Bangalore local         | 47.66<br>(6.94)                                    | 41.88<br>(6.51) | 44.77    | 67.33<br>(55.20)    | 60.33<br>(50.96) | 63.83    |
| White flesh             | 19.99<br>(4.53)                                    | 20.99<br>(4.64) | 20.49    | 34.33<br>(35.88)    | 32.66<br>(34.85) | 33.66    |
| Spear acid              | 0.00<br>(0.71)                                     | 1.33<br>(1.35)  | 0.66     | 0.00<br>(0.00)      | 5.66<br>(13.75)  | 2.83     |
| Banaras                 | 7.88<br>(2.89)                                     | 6.44<br>(2.63)  | 7.16     | 12.33<br>(20.56)    | 7.33<br>(15.71)  | 9.83     |
| Allahabad Safeda        | 3.99<br>(2.12)                                     | 2.54<br>(1.74)  | 3.26     | 12.33<br>(20.56)    | 6.33<br>(14.57)  | 9.33     |
| Lucknow-49              | 17.33<br>(4.22)                                    | 14.22<br>(3.84) | 15.77    | 26.33<br>(30.88)    | 20.66<br>(26.99) | 23.50    |
| Red flesh               | 36.33<br>(6.07)                                    | 29.66<br>(5.49) | 32.99    | 35.33<br>(36.48)    | 27.33<br>(31.53) | 31.33    |
| Arka Amulya             | 3.99<br>(2.12)                                     | 2.77<br>(1.81)  | 3.38     | 10.66<br>(19.05)    | 7.33<br>(15.71)  | 8.99     |
| Arka Mridula            | 4.77<br>(2.30)                                     | 5.33<br>(2.41)  | 5.05     | 12.33<br>(20.56)    | 6.33<br>(14.57)  | 9.33     |
| Ec 147034               | 24.77<br>(5.03)                                    | 22.88<br>(4.84) | 23.82    | 41.33<br>(40.02)    | 36.66<br>(37.26) | 38.99    |
| Ec 147036               | 40.55<br>(6.40)                                    | 36.33<br>(6.07) | 38.44    | 72.66<br>(58.46)    | 65.33<br>(53.92) | 68.99    |
| Ec 147039               | 8.54<br>(3.01)                                     | 4.33<br>(2.19)  | 6.43     | 32.66<br>(34.85)    | 24.66<br>(9.77)  | 28.66    |
| SEm                     | 0.61                                               | 0.54            |          |                     |                  |          |
| CD at 5%                | 1.81                                               | 1.63            |          |                     |                  |          |
| C.C. between P & I      |                                                    |                 |          | R = + 0.756         |                  |          |

Figures in parantheses are square root of  $x=0.5$  (population) and angular transformed values (%)

were evaluated for the incidence of *A. dispersus* during years 2000 and 2001 at Indian Institute of Horticultural Research, Bangalore. Observations were recorded from three trees of about 10-year-old in each variety. Each tree was considered one replication. The population counts of nymphs, pupae and adults of whitefly were taken from 10 randomly selected shoots in each tree at monthly intervals during the peak season *i.e.* March-May. Besides pest population, the extent of incidence in terms of per cent shoot infestation was also calculated.

The data were subjected to statistical analysis. Based on the extent of shoot infestation guava varieties were grouped as—highly susceptible (>50%), susceptible (25-50%), moderately susceptible (10-25%) and least susceptible (<10%).

From the data presented in Table 2, it is evident that the germplasm collections of guava varied significantly in their reaction to *A. dispersus* incidence. In both the years under study, the variety Spear acid recorded the least incidence (0.00 in 2000 and 3.33 in 2001) while the varieties Portugal, Bangalore local and EC 147036 were the most preferred ones with more than 50% shoot infestation. In terms of population counts, higher total number of pupae and adult was recorded from Portugal and least from Spear acid and Allahabad Safeda. Among the popular cultivars, Allahabad Safeda, Arka Amulya and Arka Mridula were under least susceptible group (<10% shoot infestation) while Lucknow-49 was under moderately susceptible group (10-25%). There was a

**Table 2. Grouping of guava germplasm collections according to their reaction to spiralling whitefly**

| Group                           | Varieties/Lines                                                                                                       |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Least susceptible (<10%)        | Allahabad Safeda, Arka Amulya, Arka Mridula, Banaras, Spear acid                                                      |
| Moderately susceptible (10-25%) | Florida, Hafsi, Karela, Lucknow-49, Nasik, Pear shaped, <i>P. guinense</i> Sindh, Smooth green, Superior sour lucidum |
| Susceptible (25-50%)            | Behat coconut, Mirzapur seedling, Redflesh, Seedless whiteflesh EC 147034, EC 147039                                  |
| Highly susceptible (>50%)       | Bangalore local, Portugal, EC 147036                                                                                  |

significant positive correlation ( $r = + 0.756$ ) between population of whitefly and percent shoot infestation indicating the quick dispersed tendency of insect within a preferred variety. Detailed studies to correlate the incidence of *A. dispersus* with morphological and biochemical parameters of leaves in different varieties are in progress.

#### References

- Mani M and A Krishnamurthy (1996) Spiralling whitefly and its natural enemies on guava in Karnataka. *Insect Environment* 2: 12.
- Palaniswamy MS, KS Pillai, RR Nair and C Mohandas (1995) A new cassava pest in India. *Cassava Newsllett.* 19: 6-7.
- Ranjith AM, DS Rao and J Thomas (1996) New host records of the mealy whitefly, *Aleurodicus dispersus* in Kerala. *Insect Environment* 2: 35.

## Characterisation and Intra-group Cluster Analysis of *Musa* Sub-group Pisang Awak (ABB)

**S Uma, P Theriappan, M Dayarani, B Shyam and S Sathiamoorthy**

National Research Centre for Banana, # 17, Ramalinganagar South Extension, Vayalur Road, Trichy-620017, Tamil Nadu

**Key Words:** Banana, Characterisation, *Musa acuminata*, *Musa balbisiana*

Bananas are the most important among food crops worldwide. They include diverse types such as dessert, cooking and roasting bananas. Bananas are also scientifically referred to by their genome groupings. The crop encompasses a range of diploids, triploids and tetraploids. These are categorised into different genomic

groups on the basis of their ploidy levels and the genomes, which they contain. Simmonds and Shepherd (1955) suggested that the present day bananas originated from two wild and seedy species, *Musa acuminata* colla (2n=22) and *Musa balbisiana* colla (2n=22) which are native to South-East Asia, resulting in a series of diploid,

were evaluated for the incidence of *A. dispersus* during years 2000 and 2001 at Indian Institute of Horticultural Research, Bangalore. Observations were recorded from three trees of about 10-year-old in each variety. Each tree was considered one replication. The population counts of nymphs, pupae and adults of whitefly were taken from 10 randomly selected shoots in each tree at monthly intervals during the peak season *i.e.* March-May. Besides pest population, the extent of incidence in terms of per cent shoot infestation was also calculated.

The data were subjected to statistical analysis. Based on the extent of shoot infestation guava varieties were grouped as—highly susceptible (>50%), susceptible (25-50%), moderately susceptible (10-25%) and least susceptible (<10%).

From the data presented in Table 2, it is evident that the germplasm collections of guava varied significantly in their reaction to *A. dispersus* incidence. In both the years under study, the variety Spear acid recorded the least incidence (0.00 in 2000 and 3.33 in 2001) while the varieties Portugal, Bangalore local and EC 147036 were the most preferred ones with more than 50% shoot infestation. In terms of population counts, higher total number of pupae and adult was recorded from Portugal and least from Spear acid and Allahabad Safeda. Among the popular cultivars, Allahabad Safeda, Arka Amulya and Arka Mridula were under least susceptible group (<10% shoot infestation) while Lucknow-49 was under moderately susceptible group (10-25%). There was a

**Table 2. Grouping of guava germplasm collections according to their reaction to spiralling whitefly**

| Group                           | Varieties/Lines                                                                                                       |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Least susceptible (<10%)        | Allahabad Safeda, Arka Amulya, Arka Mridula, Banaras, Spear acid                                                      |
| Moderately susceptible (10-25%) | Florida, Hafsi, Karela, Lucknow-49, Nasik, Pear shaped, <i>P. guinense</i> Sindh, Smooth green, Superior sour lucidum |
| Susceptible (25-50%)            | Behat coconut, Mirzapur seedling, Redflesh, Seedless whiteflesh EC 147034, EC 147039                                  |
| Highly susceptible (>50%)       | Bangalore local, Portugal, EC 147036                                                                                  |

significant positive correlation ( $r = + 0.756$ ) between population of whitefly and percent shoot infestation indicating the quick dispersed tendency of insect within a preferred variety. Detailed studies to correlate the incidence of *A. dispersus* with morphological and biochemical parameters of leaves in different varieties are in progress.

#### References

- Mani M and A Krishnamurthy (1996) Spiralling whitefly and its natural enemies on guava in Karnataka. *Insect Environment* 2: 12.
- Palaniswamy MS, KS Pillai, RR Nair and C Mohandas (1995) A new cassava pest in India. *Cassava Newsllett.* 19: 6-7.
- Ranjith AM, DS Rao and J Thomas (1996) New host records of the mealy whitefly, *Aleurodicus dispersus* in Kerala. *Insect Environment* 2: 35.

## Characterisation and Intra-group Cluster Analysis of *Musa* Sub-group Pisang Awak (ABB)

**S Uma, P Theriappan, M Dayarani, B Shyam and S Sathiamoorthy**

National Research Centre for Banana, # 17, Ramalinganagar South Extension, Vayalur Road, Trichy-620017, Tamil Nadu

**Key Words:** Banana, Characterisation, *Musa acuminata*, *Musa balbisiana*

Bananas are the most important among food crops worldwide. They include diverse types such as dessert, cooking and roasting bananas. Bananas are also scientifically referred to by their genome groupings. The crop encompasses a range of diploids, triploids and tetraploids. These are categorised into different genomic

groups on the basis of their ploidy levels and the genomes, which they contain. Simmonds and Shepherd (1955) suggested that the present day bananas originated from two wild and seedy species, *Musa acuminata* colla (2n=22) and *Musa balbisiana* colla (2n=22) which are native to South-East Asia, resulting in a series of diploid,

triploid and tetraploid bananas. The resulting genomic groups were classified as AA, AB, AAA, AAB, ABB, AABB, AAAB, ABBB, BB with the letters A and B representing *Musa acuminata* and *M. balbisiana*, respectively.

India is endowed with rich agrobiodiversity, having 356 major and minor plant species and their wild relatives native to this country. The Indian sub-continent in the South-Asian region is believed to be the centre of origin and diversity for the genus *Musa*. Sustainable exploitation of these resources would require effective strategies for their identification and conservation (Singh *et al.* 2001).

The *Musa* germplasm collections have been studied to assess the complete representation of the range of diversity of bananas in the countries, to set priorities for further collection and to reduce duplication. Since there is no test for clonal identity, many clones have been collected several times under different names from various agro-ecological conditions of the country. Classification and identification have become further complicated by the fact that many morphological characters are greatly influenced by the growing conditions. Numerical taxonomic analysis (Simmonds and Shepherd, 1955; Silayoi and Chomchalow, 1987) utilising key morphological characters generates information on their genetic constitution. But this needs further characterization techniques for effective grouping and studying their performance details.

The present study is undertaken on Pisang Awak sub group a triploid with ABB as its genomic constituent. It is one of the major commercial clone of the country. Being hardy, it is widely adopted for cultivation by the marginal farmers across the country. Its wider distribution, under varying agro-climatic conditions resulted in greater diversity. At NRCB, Trichy, 48 accessions have been collected under this group.

The genus *Musa* comprises both cultivated and the wild taxa. The cultivated taxa have been spread by human agency far from their original centres. Keeping this in view, NRCB, Trichy has carried out exploration trips to various parts of the Indian sub-continent and collected different lines of *Musa* belonging to both wild and cultivated types. Further efforts were also made to collect exotic lines from all over the world through international organisations and agencies. In all, 907 accessions belonging to different genomic groups have been collected and are being maintained in our field genebank. Accessions have also been characterised morpho-taxonomically.

A character is a feature of an organism that can be measured, counted or otherwise assessed. Simple two-state qualitative characters for example colour of the compound tepal – cream or pink, were coded as binary *i.e.* by scoring 1 if that character is present and 0 if that character is absent. The data were computed and analysed using NTSYS package.

In the present study due to multivariate analysis of morphological variation among the *Musa* accessions, it is possible to classify the Pisang Awak (ABB) accessions into identifiable clone sets. The objective of this study was to assess phenotypic variation in (the genuinity) accurate classification within the groups. This is used to assess the relatedness and distance of sample characterized. A total of 18 qualitative parameters are found to differ among accessions. These accessions exhibit the traits over generations without visual modifications. The traits are: colour of the pseudostem, colour of the upper surface of leaves, nature of leaves, peduncle, position of bunch, appearance of bunch, rachis, colour of the male bract, colour of the compound tepal, colour of the free tepal, position of stamen, colour of pollen sac, position of fruits, length of fruits, colour of finger, fruit peel colour and apex of the fruit. In this communication, grouping of different accessions belonging to Pisang Awak subgroup is described.

The group includes members like Kostha Bontha, Pey Kunnan, Boodi Bale, Karpooravalli, Kanthali, Nukula Bontha *etc.* The group is characterised by robust, pink-pigmented pseudostem, droopy leaves and curved laminar edges. Bunch is pendulous, compact and cylindrical with geometrically cylindrical arrangement of hands around the peduncle. Variability among the members of this group is observed with respect to male flower and fruit parameters among others.

For this study, 48 accessions belonging to Pisang Awak (ABB) subgroup were considered. Morpho-taxonomic characterisation and Simmonds and Shepherd score card categorised these accessions under ABB while tentative key for classification developed at this centre enabled them under Pisang Awak subgroup. The characters most responsible for the variation pattern found in Pisang Awak and extent of similarity and dissimilarity was worked out.

According to the cluster analysis of matrix of distance co-efficients, two distinct groups were clear involving Bhurkel 1, 2., Karpooravalli 1, 2., Mas, Jammulapalm collection, Chinia and other involving Octoman, Bothi

Bale 1, 2, 3., Bhurkel 3, mas, Vellapalayankodan, Eni Komban and Amritapani. Of all the collections Shail Kela, Chinia 1, Poombidian and Kechulepa had distinct independent clustering. In many cases, the names and the actual accession did not go together due to wrong labelling at the secondary centres of collection.

Small clusters of three to four members were noticed varying especially for one or more traits. The genotypes included in a cluster have exhibited less variations within themselves where as genotypes of one main cluster had a wide variation between individuals of another cluster. Pisang Awak group being highly female fertile, produces ample seeds in open-pollinated conditions. The seed

progenies thus developed have contributed greatly for the present variation. Molecular characterisation will further elucidate the genetic relatedness among the genotypes.

#### References

- Silayoi B and N Chomchalow (1987) Cytotaxonomic and morphological studies of Thai banana cultivars. In: GJ Persley and EA De Langhe *Proceedings of Banana and Plantain Breeding Strategies* (ed.) 288p.
- Simmonds NW and K Shepherd (1955) The Taxonomy and origin of the cultivated bananas. *J. Linn. Soc. Bot.* **55**: 302-312.
- Singh HP, S Uma and S Sathiamoorthy (2001) A Tentative Key for Identification and Classification of Indian Bananas. 61p.

## Estimates of Gene Effects for Grain Yield and its Components in Bread Wheat

**RC Singh\* and BP Singh**

*Department of Botany, SGN Khalsa College, Sri Ganganagar-335001, Rajasthan*

**Key Words:** Epistatic, Additive, Dominance, Duplicate, Interaction and Components

Bread wheat is one of the important cereal crop of millions of people in the world and it is also being utilized as animal feed in some states of India. Therefore, genetic improvement of crop varieties is one of the tool to fulfil the future demand of wheat. Before initiation of any successful breeding program for improvement of grain yield and its components, it is essential to know precisely the genetic architecture of particular trait having economic value. Thus, estimation of relative magnitude of different gene effects, their interactions have immense value to the breeders as they provide useful information for choosing appropriate breeding procedures for future improvement of the traits.

The six generations [ $P_1$ ,  $P_2$ ,  $F_1$ ,  $F_2$ ,  $BC_1$  and  $BC_2$ ] of two crosses namely UP-301 x RAJ-3077 and CPAN-3004 x HD-2329 were planted under irrigated conditions with normal application of fertilizer (120 kg N and 40 kg  $P_2O_5$ /hectare) in RBD with 4 replications. Each plot consisted of 5 rows of  $P_1$ ,  $P_2$  and  $F_1$ , 10 rows of  $BC_1$  and  $BC_2$  and 15 rows of  $F_2$  population. The rows were kept 20 cm apart from each other with 15 cm plant

to plant distance. Border rows were also provided at the beginning as well as the end of experimental rows in each block.

At maturity the data on 10 randomly selected plants in  $P_1$ ,  $P_2$  and  $F_1$  generations is 30. In  $F_2$ ,  $BC_1$  and  $BC_2$  for days to heading, days to maturity, plant height, effective tillers/plant, flat leaf area, spike length, spikelets/spike, 1000-grain weight, harvest index and grain yield/plant were recorded during *rabi*-1994-95. The data were subjected to individual scaling test (Mather, 1949) and joint scaling test (Cavalli, 1952) to detect the presence of gene interaction while weighted least square method was applied to estimate six genetic parameters. In case where three parameter mode was found inadequate, six parameter model suggested by Jinks and Jones (1958) was applied.

Statistical analysis of data of six generations of both the crosses revealed that additive (d) and dominance (h) had important role in the inheritance of characters under study with preponderance of dominance as reported earlier by Amawate and Behl (1995).

Results of individual (Mather, 1949) and joint scaling test (Cavalli, 1952) indicated that epistasis also had

\* Present Address: Agriculture Research Station, Fatehpur-Shekhawati, Dist. Sikar-332301, Rajasthan

Bale 1, 2, 3., Bhurkel 3, mas, Vellapalayankodan, Eni Komban and Amritapani. Of all the collections Shail Kela, Chinia 1, Poombidian and Kechulepa had distinct independent clustering. In many cases, the names and the actual accession did not go together due to wrong labelling at the secondary centres of collection.

Small clusters of three to four members were noticed varying especially for one or more traits. The genotypes included in a cluster have exhibited less variations within themselves where as genotypes of one main cluster had a wide variation between individuals of another cluster. Pisang Awak group being highly female fertile, produces ample seeds in open-pollinated conditions. The seed

progenies thus developed have contributed greatly for the present variation. Molecular characterisation will further elucidate the genetic relatedness among the genotypes.

#### References

- Silayoi B and N Chomchalow (1987) Cytotaxonomic and morphological studies of Thai banana cultivars. In: GJ Persley and EA De Langhe *Proceedings of Banana and Plantain Breeding Strategies* (ed.) 288p.
- Simmonds NW and K Shepherd (1955) The Taxonomy and origin of the cultivated bananas. *J. Linn. Soc. Bot.* **55**: 302-312.
- Singh HP, S Uma and S Sathiamoorthy (2001) A Tentative Key for Identification and Classification of Indian Bananas. 61p.

## Estimates of Gene Effects for Grain Yield and its Components in Bread Wheat

**RC Singh\* and BP Singh**

*Department of Botany, SGN Khalsa College, Sri Ganganagar-335001, Rajasthan*

**Key Words: Epistatic, Additive, Dominance, Duplicate, Interaction and Components**

Bread wheat is one of the important cereal crop of millions of people in the world and it is also being utilized as animal feed in some states of India. Therefore, genetic improvement of crop varieties is one of the tool to fulfil the future demand of wheat. Before initiation of any successful breeding program for improvement of grain yield and its components, it is essential to know precisely the genetic architecture of particular trait having economic value. Thus, estimation of relative magnitude of different gene effects, their interactions have immense value to the breeders as they provide useful information for choosing appropriate breeding procedures for future improvement of the traits.

The six generations [ $P_1$ ,  $P_2$ ,  $F_1$ ,  $F_2$ ,  $BC_1$  and  $BC_2$ ] of two crosses namely UP-301 x RAJ-3077 and CPAN-3004 x HD-2329 were planted under irrigated conditions with normal application of fertilizer (120 kg N and 40 kg  $P_2O_5$ /hectare) in RBD with 4 replications. Each plot consisted of 5 rows of  $P_1$ ,  $P_2$  and  $F_1$ , 10 rows of  $BC_1$  and  $BC_2$  and 15 rows of  $F_2$  population. The rows were kept 20 cm apart from each other with 15 cm plant

to plant distance. Border rows were also provided at the beginning as well as the end of experimental rows in each block.

At maturity the data on 10 randomly selected plants in  $P_1$ ,  $P_2$  and  $F_1$  generations is 30. In  $F_2$ ,  $BC_1$  and  $BC_2$  for days to heading, days to maturity, plant height, effective tillers/plant, flat leaf area, spike length, spikelets/spike, 1000-grain weight, harvest index and grain yield/plant were recorded during *rabi*-1994-95. The data were subjected to individual scaling test (Mather, 1949) and joint scaling test (Cavalli, 1952) to detect the presence of gene interaction while weighted least square method was applied to estimate six genetic parameters. In case where three parameter mode was found inadequate, six parameter model suggested by Jinks and Jones (1958) was applied.

Statistical analysis of data of six generations of both the crosses revealed that additive (d) and dominance (h) had important role in the inheritance of characters under study with preponderance of dominance as reported earlier by Amawate and Behl (1995).

Results of individual (Mather, 1949) and joint scaling test (Cavalli, 1952) indicated that epistasis also had

\* Present Address: Agriculture Research Station, Fatehpur-Shekhawati, Dist. Sikar-332301, Rajasthan

**Table 1. Individual scaling test and joint scaling test values of chi-square for grain yield/plant and other related characters of Bread Wheat (*Triticum aestivum* L.)**

| Characters                  | UP-301 x RAJ-3077   |                   |                   |                | CPAN-3004 x HD-2329 |                   |                   |                |
|-----------------------------|---------------------|-------------------|-------------------|----------------|---------------------|-------------------|-------------------|----------------|
|                             | Scaling test values |                   |                   |                | Scaling test values |                   |                   |                |
|                             | A                   | B                 | C                 | X <sup>2</sup> | A                   | B                 | C                 | X <sup>2</sup> |
| Days to heading             | -2.25±<br>0.69**    | 4.00±<br>0.71**   | 4.75±<br>2.04*    | 54.19**<br>—   | -8.50±<br>1.61**    | -3.25±<br>1.38*   | -5.25±<br>2.27*   | 28.20**<br>—   |
| Days to maturity            | -3.75±<br>2.53      | -1.75±<br>1.31    | -29.5±<br>2.53**  | 162.23**<br>—  | -2.25±<br>1.84      | -0.25±<br>1.91    | -16.0±<br>2.94**  | 30.69**<br>—   |
| Plant height                | -41.15±<br>1.16**   | 3.25±<br>1.15*    | -6.90±<br>2.36*   | 1313.40**<br>— | -3.25±<br>1.38      | -1.75±<br>2.11    | -43.60±<br>2.01** | 472.58*<br>—   |
| Effective tillers/<br>plant | 2.83±<br>0.68**     | 2.93±<br>0.69**   | -2.70±<br>1.44    | 76.58**<br>—   | 2.65±<br>0.53**     | 2.75±<br>0.37**   | -5.30±<br>1.00**  | 142.21**<br>—  |
| Flag leaf area              | 4.15±<br>0.49**     | -9.65±<br>0.81**  | -16.20±<br>1.29** | 335.25**<br>—  | 17.13±<br>0.39**    | 15.60±<br>0.42**  | 5.08±<br>1.01**   | 3216.8**<br>—  |
| Spike length (cm)           | -0.15±<br>0.28      | 0.80±<br>0.26**   | -2.65±<br>0.51*8  | 41.01**<br>—   | 1.70±<br>0.43**     | 1.63±<br>0.37**   | -7.20±<br>0.64**  | 220.27*<br>—   |
| Spikelets/spike             | -0.74±<br>1.20      | 1.95±<br>0.59**   | -4.10±<br>-.73**  | 53.49**<br>—   | 0.25±<br>0.29       | -0.15±<br>0.31    | -1.60<br>0.40**   | 27.01**<br>—   |
| 1000-grain<br>weight (g)    | 3.35±<br>3.07       | -12.40±<br>3.02** | 8.80±<br>4.98     | 20.80**<br>—   | -1.28±<br>1.25      | -12.85±<br>1.38** | -14.82±<br>2.27** | 122.14**<br>—  |
| Harvest Index               | 3.38±<br>0.49*8     | 1.0±<br>0.39*     | -9.77±<br>1.27**  | 207.23**<br>—  | -16.13±<br>1.54**   | -11.83±<br>1.20** | -33.25=<br>2.20*8 | 251.84**<br>—  |
| Grain yield/<br>plant       | 16.48±<br>1.84**    | 6.23±<br>1.53**   | -11.0±<br>3.02**  | 325.10**<br>—  | 7.80**<br>1.18**    | 0.30±<br>1.09     | -26.0=<br>2.43*8  | 202.11**<br>—  |

\*, \*\* Significant at 5% and 1% levels, respectively

greater role in the inheritance (Table 1). As regards gene interactions, additive x additive was present in all the characters in both the crosses except days to heading in UP-301 x RAJ-3077, 1000-grain wt. and harvest index in CPAN-3004 x HD-2329. However, the direction of additive x additive was positive in all the characters except days to heading in CPAN-3004 x HD-2329, indicating presence of transgressive segregates in the successive generations. The frequency of additive x dominance (j) was less marked in comparison to additive x additive (i) and dominance x dominance (l).

The gene interaction additive x dominance (j) was found to act in positive direction in almost all the characters but negative estimates were also observed in days to heading, spike length, spikelets/spike, in UP-301 x RAJ-3077 (Table 2) while days to heading and harvest index in cross CPAN-3004 x HD-2329 which indicated that sum of the interaction effect from dispersed pairs of genes was more than the remaining effects from associated pairs of genes. The similar results were also

reported by Singh *et al.* (1984).

Dominance x dominance (l) had significantly greater role in the inheritance of almost all the characters except 1000-grain wt. in UP-301 x RAJ-3077 and days to maturity in CPAN-3004 x HD-2329 as reported earlier by Amawate and Behl (1995) and Katheria and Sharma (1996).

Among the cases where type of epistasis existed, only duplicate type of epistasis was found to explain the variation as reported by Srivastava *et al.* (1981).

On the basis of the above results, selection in later segregating generations would be effective and recombination breeding is suggested to improve the crop.

## References

- Amawate JS and PN Behl (1995) Genetical analysis of some quantitative components of yield in bread wheat. *Indian J. Genet.* 55: 120-125.
- Cavalli LL (1952) Quantative Inheritance In: ECB Rieve and CH Waadington (ed.) HMSO, London, pp 135-144.

Table 2. Estimates of genetic parameters in cross I(UP-301 x RAJ-3077) and cross II(CPAN-3004 x HD-2329)

| Characters              | Cross | Gene action   |               |               |               |              |               | X <sup>2</sup> for 3 parameter | Type of Epistasis |
|-------------------------|-------|---------------|---------------|---------------|---------------|--------------|---------------|--------------------------------|-------------------|
|                         |       | M             | d             | H             | I             | j            | l             |                                |                   |
| Days to heading         | I     | 94.62±0.19**  | 1.13±0.19**   | 3.10±0.99**   | —             | -6.25±0.90** | -2.21±1.02*   | 54.19**                        | D                 |
|                         | II    | 102.37±1.97** | 1.13±0.19**   | -22.62±5.39** | -6.00±1.96**  | -5.25±1.63** | 17.75±3.89**  | 28.20**                        | D                 |
| Days to maturity        | I     | 108.70±2.43** | 0.38±0.43     | 53.15±6.36**  | 25.20±2.47**  | —            | -2.10±4.30**  | 162.23**                       | D                 |
|                         | II    | 128.34±1.37** | 1.68±0.26**   | 13.44±1.80**  | 7.23±1.41**   | —            | —             | 30.69**                        | -                 |
| Plant height (cm)       | I     | 45.35±2.54**  | -19.80±0.42** | 126.74±5.97** | 44.80±2.50**  | 44.40±1.58** | -82.70±3.56** | 1313.4**                       | D                 |
|                         | II    | 57.06±2.88**  | 7.90±0.31**   | 70.26±7.59**  | 37.98±2.86**  | —            | -32.37±4.82** | 472.6**                        | D                 |
| Effective tillers/plant | I     | 1.08±1.06     | -0.89±0.16**  | 23.39±2.48**  | 8.45±1.04**   | —            | -14.19±1.74** | 76.58**                        | D                 |
|                         | II    | 0.49±1.03     | 0.88±0.14**   | 30.56±2.33**  | 10.73±1.101** | —            | -16.17±1.36** | 142.22**                       | D                 |
| Flag leaf area          | I     | 28.08±1.12**  | -8.45±0.38**  | 27.25±2.62**  | 10.70±1.05**  | 13.80±0.89** | -5.20±1.60**  | 335.50**                       | D                 |
|                         | II    | 1.64±0.88     | -1.49±0.19**  | 95.52±1.94**  | 27.65±0.86**  | 1.52±0.47**  | -60.38±1.16** | 3216.9**                       | D                 |
| Spike length (cm)       | I     | 7.35±0.59     | 0.33±0.6**    | 9.38±1.43**   | 3.30±0.59**   | -0.95±0.37   | -3.95±0.87**  | 41.01*8                        | D                 |
|                         | II    | 0.15±0.72     | 0.51±0.06**   | 26.90±1.83**  | 10.50±0.72**  | —            | -13.80±1.17** | 220.27**                       | D                 |
| Spikelets/spike         | I     | 13.84±1.27**  | 1.75±0.21**   | 13.53±3.64**  | 5.31±1.25*8   | -2.69±1.22*  | -6.52±2.41*   | 53.49**                        | D                 |
|                         | II    | 18.00±0.43**  | 1.02±0.10*8   | 4.66±1.14**   | 1.78±0.41*    | —            | -1.91±0.75*   | 27.01**                        | D                 |
| 1000-grain weight (g)   | I     | 33.90±2.14**  | -2.10±0.69**  | 9.91±2.38**   | 5.33±2.29*    | 16.00±4.23*8 | —             | 20.80**                        |                   |
|                         | II    | 43.49±0.23**  | -2.90±0.23**  | 11.92±1.55**  | —             | 11.61±1.82** | 14.41±1.53**  | 122.14**                       | D                 |
| Harvest Index           | I     | 31.26±1.12**  | -521±0.20**   | 33.64±2.37**  | 14.15±1.10**  | 2.38±0.48**  | -18.53±1.38*8 | 207.23**                       | D                 |
|                         | II    | 49.33±0.13**  | 3.30±0.13**   | -25.69±1.62** | —             | -4.78±1.75*  | 29.57±1.87**  | 251.84**                       | D                 |
| Grain yield/plant       | I     | -11.55±1.94** | -3.33±0.45**  | -95.75±5.11** | 33.70±1.89**  | 10.25±1.58** | -56.40±3.98** | 325.08**                       | D                 |
|                         | II    | -1105±2.50**  | 3.00±0.39*8   | 94.20±5.81**  | 34.10±2.47**  | 7.50±1.47*8  | -42.20±3.49** | 202.11*8                       | D                 |

\*,\*\* Significant at 5% and 1% levels, respectively D=Duplicate

Katheria KB and RK Sharma (1996) Genetic analysis for earliness, plant height and kernel weight in two bread wheat. *Indian J. Genet.* **56**: 548-552.

Mather K (1949) *Biometrical Genetics*. Mathuen and Co., London.

Singh G, GS Nanda and KS Gill (1984) Inheritance of yield and its components in five crosses of spring wheat. *Indian J. Agric. Sci.* **54**: 943-49.

Srivastava RB, OP Luthra D Singh and KC Goyal (1981) Genetic Architecture of yield, harvest index and related traits in wheat. *Cereal Res. Commu.* **9**: 31-37.

## Performance of Different Citrus Rootstocks in the Citrus Germplasm Repository

**Awtar Singh, IP Singh and Shyam Singh**

National Research Centre for Citrus, Post Bag No. 464, Shankar Nagar PO, Nagpur-440010, Maharashtra

**Key Words:** Citrus Rootstocks, Evaluation

Most of the commercial *Citrus* species are propagated on a rootstock, which imparts resistance/tolerance to many biotic and abiotic stresses and also determines the fruit quality of the scion variety. Rough lemon (*Citrus jambhiri* Lush.) is the most commonly used rootstock for citrus, but it is susceptible to phytophthora diseases

and citrus nematode (Fouque *et al.* 1977, Whiteside and Knorr, 1979, Passos and Cunhasobrinho, 1981, Agarwal, 1982). Development of a new rootstock is a difficult and time consuming process (Barrett, 1977). Therefore, collection of rootstocks from different indigenous and foreign sources and their evaluation under the target

Table 2. Estimates of genetic parameters in cross I(UP-301 x RAJ-3077) and cross II(CPAN-3004 x HD-2329)

| Characters              | Cross | Gene action   |               |               |               |              |               | X <sup>2</sup> for 3 parameter | Type of Epistasis |
|-------------------------|-------|---------------|---------------|---------------|---------------|--------------|---------------|--------------------------------|-------------------|
|                         |       | M             | d             | H             | I             | j            | l             |                                |                   |
| Days to heading         | I     | 94.62±0.19**  | 1.13±0.19**   | 3.10±0.99**   | —             | -6.25±0.90** | -2.21±1.02*   | 54.19**                        | D                 |
|                         | II    | 102.37±1.97** | 1.13±0.19**   | -22.62±5.39** | -6.00±1.96**  | -5.25±1.63** | 17.75±3.89**  | 28.20**                        | D                 |
| Days to maturity        | I     | 108.70±2.43** | 0.38±0.43     | 53.15±6.36**  | 25.20±2.47**  | —            | -2.10±4.30**  | 162.23**                       | D                 |
|                         | II    | 128.34±1.37** | 1.68±0.26**   | 13.44±1.80**  | 7.23±1.41**   | —            | —             | 30.69**                        | -                 |
| Plant height (cm)       | I     | 45.35±2.54**  | -19.80±0.42** | 126.74±5.97** | 44.80±2.50**  | 44.40±1.58** | -82.70±3.56** | 1313.4**                       | D                 |
|                         | II    | 57.06±2.88**  | 7.90±0.31**   | 70.26±7.59**  | 37.98±2.86**  | —            | -32.37±4.82** | 472.6**                        | D                 |
| Effective tillers/plant | I     | 1.08±1.06     | -0.89±0.16**  | 23.39±2.48**  | 8.45±1.04**   | —            | -14.19±1.74** | 76.58**                        | D                 |
|                         | II    | 0.49±1.03     | 0.88±0.14**   | 30.56±2.33**  | 10.73±1.101** | —            | -16.17±1.36** | 142.22**                       | D                 |
| Flag leaf area          | I     | 28.08±1.12**  | -8.45±0.38**  | 27.25±2.62**  | 10.70±1.05**  | 13.80±0.89** | -5.20±1.60**  | 335.50**                       | D                 |
|                         | II    | 1.64±0.88     | -1.49±0.19**  | 95.52±1.94**  | 27.65±0.86**  | 1.52±0.47**  | -60.38±1.16** | 3216.9**                       | D                 |
| Spike length (cm)       | I     | 7.35±0.59     | 0.33±0.6**    | 9.38±1.43**   | 3.30±0.59**   | -0.95±0.37   | -3.95±0.87**  | 41.01*8                        | D                 |
|                         | II    | 0.15±0.72     | 0.51±0.06**   | 26.90±1.83**  | 10.50±0.72**  | —            | -13.80±1.17** | 220.27**                       | D                 |
| Spikelets/spike         | I     | 13.84±1.27**  | 1.75±0.21**   | 13.53±3.64**  | 5.31±1.25*8   | -2.69±1.22*  | -6.52±2.41*   | 53.49**                        | D                 |
|                         | II    | 18.00±0.43**  | 1.02±0.10*8   | 4.66±1.14**   | 1.78±0.41*    | —            | -1.91±0.75*   | 27.01**                        | D                 |
| 1000-grain weight (g)   | I     | 33.90±2.14**  | -2.10±0.69**  | 9.91±2.38**   | 5.33±2.29*    | 16.00±4.23*8 | —             | 20.80**                        |                   |
|                         | II    | 43.49±0.23**  | -2.90±0.23**  | 11.92±1.55**  | —             | 11.61±1.82** | 14.41±1.53**  | 122.14**                       | D                 |
| Harvest Index           | I     | 31.26±1.12**  | -521±0.20**   | 33.64±2.37**  | 14.15±1.10**  | 2.38±0.48**  | -18.53±1.38*8 | 207.23**                       | D                 |
|                         | II    | 49.33±0.13**  | 3.30±0.13**   | -25.69±1.62** | —             | -4.78±1.75*  | 29.57±1.87**  | 251.84**                       | D                 |
| Grain yield/plant       | I     | -11.55±1.94** | -3.33±0.45**  | -95.75±5.11** | 33.70±1.89**  | 10.25±1.58** | -56.40±3.98** | 325.08**                       | D                 |
|                         | II    | -1105±2.50**  | 3.00±0.39*8   | 94.20±5.81**  | 34.10±2.47**  | 7.50±1.47*8  | -42.20±3.49** | 202.11*8                       | D                 |

\*,\*\* Significant at 5% and 1% levels, respectively D=Duplicate

Katheria KB and RK Sharma (1996) Genetic analysis for earliness, plant height and kernel weight in two bread wheat. *Indian J. Genet.* **56**: 548-552.

Mather K (1949) *Biometrical Genetics*. Mathuen and Co., London.

Singh G, GS Nanda and KS Gill (1984) Inheritance of yield and its components in five crosses of spring wheat. *Indian J. Agric. Sci.* **54**: 943-49.

Srivastava RB, OP Luthra D Singh and KC Goyal (1981) Genetic Architecture of yield, harvest index and related traits in wheat. *Cereal Res. Commu.* **9**: 31-37.

## Performance of Different Citrus Rootstocks in the Citrus Germplasm Repository

**Awtar Singh, IP Singh and Shyam Singh**

National Research Centre for Citrus, Post Bag No. 464, Shankar Nagar PO, Nagpur-440010, Maharashtra

**Key Words:** Citrus Rootstocks, Evaluation

Most of the commercial *Citrus* species are propagated on a rootstock, which imparts resistance/tolerance to many biotic and abiotic stresses and also determines the fruit quality of the scion variety. Rough lemon (*Citrus jambhiri* Lush.) is the most commonly used rootstock for citrus, but it is susceptible to phytophthora diseases

and citrus nematode (Fouque *et al.* 1977, Whiteside and Knorr, 1979, Passos and Cunhasobrinho, 1981, Agarwal, 1982). Development of a new rootstock is a difficult and time consuming process (Barrett, 1977). Therefore, collection of rootstocks from different indigenous and foreign sources and their evaluation under the target

environment will be desirable. Keeping these objectives in view, the citrus rootstocks were collected from different foreign sources and they were evaluated along with the common rootstocks collected from indigenous sources.

Nineteen citrus rootstocks collected from foreign (Nos. 1-14) and indigenous sources (Nos. 15-19) were planted in the germplasm repository of National Research Centre for Citrus, Nagpur in 1991. These rootstocks were observed for vegetative and reproductive characters every year during the month of February-March and for fruit characters during October-November. The vegetative characters observed were plant height, stem girth, canopy spread and volume, whereas the reproductive characters included initiation of flowering and fruit characters. The plant height was recorded from ground level to the upper most leaf tip of the seedlings. Stem girth was recorded 4" above the ground level. The canopy volume was calculated following the formula of Castle (1983). Flower initiation was recorded when the first flower bud appeared on the plant. The fruit characters were recorded when the fruits were fully mature. Each observation was repeated six times and there were six replications for each rootstock. The data were analysed in randomized block design using standard software.

The search for new rootstocks is a continuous process for the improvement of citrus industry. The use of rough lemon has been abandoned in many advanced countries due to the inferior fruit quality and susceptibility to viruses and soil borne diseases, particularly *Phytophthora* and citrus nematode (Vonstaden and Oberholzer, 1977) and has been replaced by trifoliate oranges and their hybrids. In the present studies, highly significant differences have been observed for different vegetative and reproductive characters in all the rootstocks. However, the performance of these rootstocks varied at different places in the world (Castle *et al.* 1993).

The perusal of data for vegetative and reproductive performance of seedling rootstocks indicated that the plant height was maximum in Trifeola (5.65 m) followed by C-35 citrange (5.37 m) and Schaub rough lemon (5.12 m), whereas minimum height was recorded in Sun Chu Sha mandarin (3.13 m) followed by Flying Dragon trifoliate orange (3.25 m). Stem girth was highest in sour orange (69.00 cm), but it was at par with Schaub rough lemon (66.67 cm) and Swingle citrumelo (63.67 cm), whereas minimum girth was recorded in Flying Dragon (28.33 cm). Canopy volume was recorded maximum in Schaub rough lemon (69.24 m<sup>3</sup>) followed

by rough lemon (53.64 m<sup>3</sup>) and X-639 (42.58 m<sup>3</sup>), while the lowest canopy volume was recorded in Flying Dragon (3.24 m<sup>3</sup>) followed by trifoliate orange (11.32 m<sup>3</sup>), though they were not different statistically. Hence, Schaub rough lemon, X-639, Rangpur lime and rough lemon were vigorously growing rootstocks, whereas trifoliate oranges, sour orange, Cleopatra mandarin and Sun Chu Sha were slow growing rootstocks. Other rootstocks exhibited intermediate growth.

Earliest flowering (December) was recorded in Benton citrange, Trifeola and trifoliate orange and the flowering was latest (February-March) in Flying Dragon, Rich 16-6 and sour orange. It was observed that trifoliate orange hybrids were the earliest in flowering, trifoliate oranges were the latest and other monofoliate type rootstocks, except sour orange were intermediate in initiation of flowering.

The perusal of data indicated that the heaviest fruits were produced in Alemow (420.67 g) followed by Rangpur lime X Troyer citrange (228.33 g), whereas smallest fruits were produced in trifoliate orange (15.6 g), Rich 16-6 (18.67 g) and Flying Dragon (21.17 g). Elongated fruit shape was recorded in Rangpur lime X Troyer citrange, Rangpur lime, rough lemon and Alemow, while flat fruits were observed in Sun Chu Sha, X-639 and Cleopatra mandarin. All other rootstocks produced more or less round fruits. Skin thickness was recorded maximum in Swingle citrumelo (6.90 mm) followed by Schaub rough lemon (5.10 mm), while minimum skin thickness was recorded in Sun Chu Sha (1.85 mm) and Rich 16-6 (1.87 mm). Number of segments/fruit was highest in Alemow (14.50) and lowest in trifoliate orange and Rich 16-6 (6.50). Seed content/fruit was maximum in Alemow (31.50) followed by Swingle citrumelo (26.17) and it was minimum in Sun Chu Sha (4.50) and X-639 (5.00). As seeds/fruit is an important character for the propagation of rootstocks, many rootstocks used in this study may not be commercialized owing to this problem.

In general, TSS and acidity were maintained in fruits on the higher side in trifoliate orange hybrids and the strains of trifoliate orange. As the rootstock affects the scion fruit physico-chemical characteristics, there may be many rootstocks from this list that can be used to improve the quality of the scion in this area and particularly the Nagpur mandarin. These include Flying Dragon and Rich 16-6 trifoliate oranges.

On the basis of field performance of these rootstocks,

it was observed that Rangpur lime, Schaub rough lemon, Alemow and rough lemon were vigorously growing, while Flying Dragon, Rich 16-6, C-32 citrange, Benton citrange and Sun Chu Sha were slow growing rootstocks. Trifoliate hybrids like X-639 and Trifeola were comparable to rough lemon in vegetative growth, but Swingle citrumelo, Willits and C-35 citranges exhibited intermediate growth. Rough lemon was reported as vigorous, Swingle citrumelo and C-35 citrange as intermediate and Rich 16-6 and Cleopatra as slow growing, but Rangpur lime, X-639 and Trifeola were reported as intermediate in South Africa (Rabe *et al.* 1993). Similarly, rough lemon, Rangpur lime and Alemow were reported high in their performance, while Swingle and C-35 as intermediate and Rich 16-6 and Flying Dragon as low in performance (Castle *et al.* 1993). Differences in growth parameters in different rootstocks and especially in strains of trifoliate orange were also reported (Agarwal, 1986). X-639 and Trifeola were as vigorous as rough lemon and they also have tolerance to *Phytophthora* and hence can be tried as potential rootstocks, whereas X-639 was also a regular bearer (Awtar Singh *et al.* unpublished). For a rootstock to be successful, it should be vigorous and should have many seeds/fruit. From this point of view, Alemow, Swingle citrumelo, C-35 citrange, Flying Dragon, Rich 16-6 and Shekwasha X rough lemon can be considered worth trying. As the fruits produced on rough lemon rootstock are generally poor in quality and are with rough skins, these rootstocks collected from foreign sources can be tried to improve the quality. Two rootstock hybrids viz.- X-639 and Trifeola were vigorously growing and also closely related to mandarins, may be potential rootstocks for mandarins in India. Flying Dragon and

Rich 16-6 are resistant to *Phytophthora* and citrus nematode and also slow growing, may be useful in high density plantings of citrus or as one of parents in breeding programmes aimed at evolving rootstock hybrids suitable for high density plantings. However, the late flowering in trifoliate oranges may pose a problem in the breeding programmes.

### References

- Agarwal PK (1982) Performance of different citrus rootstocks in India - A review. *Agric. Rev.* 3: 17-34.
- Agarwal PK (1986) Pre-bearing performance of nine strains of trifoliate orange (*Poncirus trifoliata* Raf.) *Indian J. Hortic.* 43: 66-68.
- Barrett HC (1977) Intergeneric hybridization of citrus and other genera in citrus cultivar improvement. *Proc. Int. Soc. Citric.* 2: 585-589.
- Castle WS (1983) Growth, yield and cold hardiness of seven years Bear's lemon on twenty rootstocks. *Proc. Fla. St. Hortic. Soc.* 96: 23-25.
- Castle WS, DPH Tucker, AH Krezdon and CO Youtsey (1993) Rootstocks for Florida citrus, rootstock selection: the first step to success. *Extension Bull.* (2<sup>nd</sup> edition). University of Florida, 92p.
- Fouque A, P Frossard, J Bourdent, Z Bambara, O Bambara and S Barpentier (1977) Preliminary results of trials on citrus rootstocks in Ivory Coast. *Fruits* 32: 335-349.
- Passos OS and AP da Cunhasobrinho (1981) Citrus rootstocks in Brazil. *Proc. Int. Soc. Citric.* 1: 102-105.
- Rabe E, JGK Coetzee and ATC Lee (1993) Rootstocks for Southern Africa-An overview. *Proc. 4<sup>th</sup> World Cong. Citrus Nurserymen*, pp 267-268.
- Vonstaden DFA and PCJ Oberholzer (1977) The performance of nucellar citrus lines on several rootstocks in South Africa. *Proc. Int. Soc. Citric.* 2: 532-534.
- Whiteside JD and LC Knorr (1979) Susceptibility of different rough lemon collections to foot, blight and *Alternaria* leaf spot. *Proc. Fla. St. Hortic. Soc.* 91: 75-77.

## Evaluation of Promising Germplasm of Brinjal (*Solanum melongena* L.)

**AK Singh, RS Pan, Mathura Rai and VSR Krishna Prasad**

*Horticulture and Agro-Forestry Research Programme, Plandu, Ranchi-834010, Jharkhand*

**Key Words :** Brinjal, Germplasm, Evaluation

Brinjal (*Solanum melongena* L.) also called eggplant, being native of India is one of the most common and principal vegetable crop grown throughout the year in the country. Genetic improvement of yield is a basic requirement of any crop breeding programme. The success of breeding programme depends on the magnitude and type of genetic variation in respect of yield, its component and other traits of economic importance. Therefore, to assess the extent of genetic variation and to identify most promising genetic stock for improvement the present investigation was carried out.

Brinjal germplasm comprising 54 lines was grown in randomised block design with two replications. The plot size was 2.4 m<sup>2</sup> with inter-and intra-row spacing of 60 x 50 cm. Recommended package practices were adopted to raise healthy crop. The observations were recorded on five competitive plants for yield/plant (q/ha), fruit weight (g), fruit length (cm), fruit breadth

(cm), days to first flowering, plant spread (cm) and plant height (cm) and data were analysed statistically following Panse and Sukhatme (1984).

The general mean SEM, CV for different traits is presented in Table 1. The days to first flowering range from 48.20 to 68.30 with an average of 55.87. The lines CH-494 and CH-684 were found earliest in flowering. The average plant height was recorded 69.25 cm. Among top performing lines maximum and minimum value was observed in genotype CH-684 (81.6 cm) and CH-554 (52.95 cm), respectively. Plant spread varied from 64.99 - 93.66 cm. Minimum and maximum plant spread was recorded in line CH-494 and CH-684, respectively. Maximum fruit weight 268.50 g was recorded in genotype CH-586. However, minimum fruit weight 43.75 g was noticed in IC-144083. The average value for this economic trait was 163.14 g. Average value for fruit length (cm) and breadth (cm) were 11.12 cm and 6.42 cm, respectively.

**Table 1. Mean performance of top fifteen high yield promising germplasm**

|     | Acc.No.      | Days to first flower | Plant height (cm) | Plant spread (cm) | Fruit weight (g) | Fruit length (cm) | Fruit breadth (cm) | Yield (q/ha) |
|-----|--------------|----------------------|-------------------|-------------------|------------------|-------------------|--------------------|--------------|
| 1.  | CH-450       | 64.00                | 67.45             | 74.83             | 218.75           | 09.27             | 6.95               | 659.10       |
| 2.  | CH-575       | 52.40                | 73.80             | 87.91             | 206.25           | 09.52             | 8.47               | 643.55       |
| 3.  | CH-586       | 49.70                | 68.65             | 78.91             | 268.50           | 12.20             | 8.50               | 633.35       |
| 4.  | IC-144083    | 61.70                | 72.30             | 76.49             | 043.75           | 14.80             | 2.52               | 628.16       |
| 5.  | CH-769       | 54.70                | 61.30             | 74.05             | 212.50           | 09.27             | 8.32               | 594.75       |
| 6.  | CH-214       | 57.30                | 69.80             | 72.66             | 156.25           | 08.37             | 7.15               | 583.36       |
| 7.  | CH-721       | 64.60                | 56.60             | 77.40             | 168.75           | 10.90             | 6.80               | 582.25       |
| 8.  | CH-168       | 48.70                | 58.16             | 69.40             | 187.50           | 09.95             | 7.12               | 565.07       |
| 9.  | CH-554       | 55.00                | 52.95             | 80.21             | 150.00           | 06.22             | 6.22               | 563.95       |
| 10. | CH-784       | 60.10                | 68.60             | 68.16             | 168.75           | 20.30             | 4.22               | 541.55       |
| 11. | CH-494       | 48.20                | 57.45             | 64.99             | 118.75           | 10.25             | 5.40               | 522.90       |
| 12. | CH-712       | 66.50                | 79.45             | 83.10             | 237.50           | 10.62             | 7.90               | 519.80       |
| 13. | CH-684       | 68.30                | 81.65             | 93.66             | 125.00           | 13.80             | 5.27               | 517.90       |
| 14. | CH-463       | 55.00                | 69.80             | 78.74             | 181.25           | 17.05             | 5.22               | 513.56       |
| 15. | CH-828       | 51.70                | 72.10             | 83.32             | 162.50           | 10.52             | 6.27               | 511.45       |
|     | General mean | 55.87                | 69.25             | 72.59             | 163.14           | 11.12             | 6.42               | 438.97       |
|     | F test       | **                   | **                | **                | **               | **                | **                 | **           |
|     | Sem ±        | 04.87                | 05.97             | 06.78             | 19.18            | 0.75              | 00.48              | 076.28       |
|     | CV%          | 12.33                | 12.20             | 13.21             | 16.63            | 9.62              | 10.62              | 024.57       |
|     | CD at 5%     | 13.74                | 16.85             | 19.12             | 54.11            | 2.13              | 01.36              | 215.12       |
|     | CD at 1%     | 18.28                | 22.41             | 25.43             | 71.96            | 2.84              | 01.81              | 286.12       |

Fruit length ranged from 6.22 cm to 17.05 cm. Contrary to this fruit breadth ranged from 4.22 - 8.50 cm, exhibiting good scope for improvement in both the traits. Average yield of 438.97 q/ha among the genotypes were observed. It ranged from 511.45-659.10 q/ha among the top 15 promising lines. Highest yield was recorded in genotype CH-450 (659.10 q/ha) followed by CH-575 (643.55 q/ha), CH-586 (633.35 q/ha) and IC-144083 (628.16 q/ha). Therefore, it is evident that a considerable range of variability has been observed for all the traits under evaluation. The low estimates SEM and CV also suggested the presence of genetic variability with low

interference on non-genetic factors. Mishra and Mishra (1990), Nandi (1992) and Dutta (1988) also reported variation in germplasm of brinjal.

### References

- Dutta OP (1988) Performance of brinjal lines resistant to bacterial wilt. *Ann. Rep. IIHR*, Bangalore.
- Mishra SN and RS Mishra (1990) Variability, heritability and genetic advance in F1 generation of a diallele cross in brinjal. *Indian J. Hortic.* **47**: 93-96.
- Nandi A (1992) A note on the evaluation of brinjal lines. *Haryana J. Hortic. Sci.* **21** : 117-118.
- Panse VG and PV Sukhatme (1984) *Statistical Methods for Agricultural Workers*. ICAR, New Delhi.

## Characterization of Toria (*Brassica rapa* ssp. *toria*) Germplasm

**AK Misra, PR Kumar and Shiv Ratan**

National Research Centre on Rapeseed-Mustard, Sewar, Bharatpur-321303 Rajasthan

**Key Words:** Agro-morphological traits, Toria germplasm, Characterization

Oilseed brassica species are cultivated most widely throughout the globe. In India, oilseed brassicas are the second most important oilseed crop after groundnut. These crops are mainly grown in winter season except for early forms of *Brassica rapa* ssp. *toria*. Toria is cultivated largely in Assam, Orissa, West Bengal, Meghalaya and Tripura, under *rabi* season. It is also cultivated as catch crop or as mixed crop with gram and lentil in northern parts of the country, while in eastern parts it is grown as winter crop. It is most suited to the multiple cropping systems. It escapes from major pests and disease due to early maturing nature, which is an added advantage over mustard cultivation.

Ninety-four lines of toria germplasm, obtained from different centres were grown in augmented design during *rabi* 1999-2000 at NRCRM, Bharatpur, in a two row plot of 3 m length with the row to row and plant to plant spacing of 30 and 10 cm, respectively. PT 303 and T-9 were used as checks. The observations were recorded on 5 randomly selected plants for plant height, primary branches/plant, secondary branches/plant, main shoot length, number of siliquae on main shoot, seeds/siliqua, siliqua length, siliqua beak length, biological

yield/per plant, harvest index, 1000-seed weight, oil and protein content. All the characters except for oil and protein content exhibited substantial variability. Highest variability was observed for seed yield/plant (cv 71.6%) followed by secondary branches/plant (cv 57.0%). Oil content showed least variability *i.e.* CV 3.3% (Table 1).

**Table 1. Range, mean and coefficient of variation (CV) for different agro-morphological traits in *B. rapa* ssp. *toria* germplasm**

| Characters               | Range      | Mean $\pm$ S. Em | CV (%) |
|--------------------------|------------|------------------|--------|
| Plant height (cm)        | 38.4-127.8 | 89.4 $\pm$ 2.5   | 22.1   |
| Primary branches/plant   | 2.8-9.2    | 5.14 $\pm$ 0.2   | 27.3   |
| Secondary branches/plant | 2.0-20.8   | 8.7 $\pm$ 0.6    | 57.0   |
| Main shoot length (cm)   | 32.0-65.6  | 46.4 $\pm$ 1.1   | 18.8   |
| Siliquae on main shoot   | 24.2-77.8  | 49.5 $\pm$ 1.9   | 30.3   |
| Siliqua length (cm)      | 3.1-5.2    | 4.1 $\pm$ 0.05   | 10.8   |
| Siliqua beak length (cm) | 0.9-1.7    | 1.4 $\pm$ 0.02   | 14.2   |
| Seeds/siliqua            | 8.2-20.8   | 15.1 $\pm$ 0.3   | 14.5   |
| 1000-seed weight (g)     | 1.04-4.0   | 2.6 $\pm$ 0.1    | 26.6   |
| Oil content (%)          | 37.8-43.9  | 40.9 $\pm$ 0.2   | 3.3    |
| Protein content (%)      | 18.8-22.9  | 21.0 $\pm$ 0.1   | 4.6    |
| Seed yield/plant (g)     | 2.1-25.5   | 8.7 $\pm$ 0.8    | 71.6   |
| Harvest index (%)        | 13.7-39.4  | 28.3 $\pm$ 0.7   | 18.9   |

Fruit length ranged from 6.22 cm to 17.05 cm. Contrary to this fruit breadth ranged from 4.22 - 8.50 cm, exhibiting good scope for improvement in both the traits. Average yield of 438.97 q/ha among the genotypes were observed. It ranged from 511.45-659.10 q/ha among the top 15 promising lines. Highest yield was recorded in genotype CH-450 (659.10 q/ha) followed by CH-575 (643.55 q/ha), CH-586 (633.35 q/ha) and IC-144083 (628.16 q/ha). Therefore, it is evident that a considerable range of variability has been observed for all the traits under evaluation. The low estimates SEM and CV also suggested the presence of genetic variability with low

interference on non-genetic factors. Mishra and Mishra (1990), Nandi (1992) and Dutta (1988) also reported variation in germplasm of brinjal.

### References

- Dutta OP (1988) Performance of brinjal lines resistant to bacterial wilt. *Ann. Rep. IIHR*, Bangalore.
- Mishra SN and RS Mishra (1990) Variability, heritability and genetic advance in F1 generation of a diallele cross in brinjal. *Indian J. Hortic.* **47**: 93-96.
- Nandi A (1992) A note on the evaluation of brinjal lines. *Haryana J. Hortic. Sci.* **21** : 117-118.
- Panse VG and PV Sukhatme (1984) *Statistical Methods for Agricultural Workers*. ICAR, New Delhi.

## Characterization of Toria (*Brassica rapa* ssp. *toria*) Germplasm

**AK Misra, PR Kumar and Shiv Ratan**

National Research Centre on Rapeseed-Mustard, Sewar, Bharatpur-321303 Rajasthan

**Key Words:** Agro-morphological traits, Toria germplasm, Characterization

Oilseed brassica species are cultivated most widely throughout the globe. In India, oilseed brassicas are the second most important oilseed crop after groundnut. These crops are mainly grown in winter season except for early forms of *Brassica rapa* ssp. *toria*. Toria is cultivated largely in Assam, Orissa, West Bengal, Meghalaya and Tripura, under *rabi* season. It is also cultivated as catch crop or as mixed crop with gram and lentil in northern parts of the country, while in eastern parts it is grown as winter crop. It is most suited to the multiple cropping systems. It escapes from major pests and disease due to early maturing nature, which is an added advantage over mustard cultivation.

Ninety-four lines of toria germplasm, obtained from different centres were grown in augmented design during *rabi* 1999-2000 at NRCRM, Bharatpur, in a two row plot of 3 m length with the row to row and plant to plant spacing of 30 and 10 cm, respectively. PT 303 and T-9 were used as checks. The observations were recorded on 5 randomly selected plants for plant height, primary branches/plant, secondary branches/plant, main shoot length, number of siliquae on main shoot, seeds/silique, silique length, silique beak length, biological

yield/per plant, harvest index, 1000-seed weight, oil and protein content. All the characters except for oil and protein content exhibited substantial variability. Highest variability was observed for seed yield/plant (cv 71.6%) followed by secondary branches/plant (cv 57.0%). Oil content showed least variability *i.e.* CV 3.3% (Table 1).

**Table 1. Range, mean and coefficient of variation (CV) for different agro-morphological traits in *B. rapa* ssp. *toria* germplasm**

| Characters               | Range      | Mean $\pm$ S. Em | CV (%) |
|--------------------------|------------|------------------|--------|
| Plant height (cm)        | 38.4-127.8 | 89.4 $\pm$ 2.5   | 22.1   |
| Primary branches/plant   | 2.8-9.2    | 5.14 $\pm$ 0.2   | 27.3   |
| Secondary branches/plant | 2.0-20.8   | 8.7 $\pm$ 0.6    | 57.0   |
| Main shoot length (cm)   | 32.0-65.6  | 46.4 $\pm$ 1.1   | 18.8   |
| Siliquae on main shoot   | 24.2-77.8  | 49.5 $\pm$ 1.9   | 30.3   |
| Silique length (cm)      | 3.1-5.2    | 4.1 $\pm$ 0.05   | 10.8   |
| Silique beak length (cm) | 0.9-1.7    | 1.4 $\pm$ 0.02   | 14.2   |
| Seeds/silique            | 8.2-20.8   | 15.1 $\pm$ 0.3   | 14.5   |
| 1000-seed weight (g)     | 1.04-4.0   | 2.6 $\pm$ 0.1    | 26.6   |
| Oil content (%)          | 37.8-43.9  | 40.9 $\pm$ 0.2   | 3.3    |
| Protein content (%)      | 18.8-22.9  | 21.0 $\pm$ 0.1   | 4.6    |
| Seed yield/plant (g)     | 2.1-25.5   | 8.7 $\pm$ 0.8    | 71.6   |
| Harvest index (%)        | 13.7-39.4  | 28.3 $\pm$ 0.7   | 18.9   |

Many promising lines were identified for different characters as revealed in Table 2. Among the genotype evaluated, genotype NIC-7187 found superior for yield contributing traits *i.e.* primary branches/plant, main shoot length, harvest index and seed yield/plant and genotype IC-94030 was observed superior for secondary branches/plant, number of siliqua on main shoot, seed/siliqua length, seed yield/plant, 1000-seed weight and oil content. Desirable traits such as lower plant height and small siliqua beak length is observed in genotype EC 305374.

The data reveals the vast potential of existing germplasm in developing genotypes, with desirable traits. However, efforts should be made to broaden genetic base of oilseed brassicae by collecting landraces having desired economic attributes.

**Table 2. Promising accessions of toria for different economic traits**

| Attributes                             | Germplasm accessions                                |
|----------------------------------------|-----------------------------------------------------|
| Plant height (<60 cm)                  | EC-305374, EC-333595, EC-305594, IC-147592, TS-50   |
| Primary branches/plant (>7.0)          | YS-36-4, NDT-9902, NIC-7187, IC-289660, IC-94030    |
| Secondary branches/plant (>15.0)       | YS-36-4, MCT-96, IC-94030, NDT-9902, EC-333597      |
| Main shoot length (> 76.0 cm)          | NIC-7187, EC-333597, IC-94030, IC-94030, NDT-9902   |
| No. of siliquae on main shoot (> 74.0) | NDT-9902, PBT-221, IC-94030                         |
| Seeds/Siliqua (> 17.0)                 | NDT-9902, JMT-9341, MCT-96, IC-94030                |
| Siliqua length (> 4.0 cm)              | IC-94030, NDT-9902, IC-76707, IC-94306, IC-289660   |
| Seed yield/plant (>18.0 g)             | IC-289660, NIC-7187, EC-333597, IC-94030, EC-333597 |
| Harvest index (> 35%)                  | NRCT-98-120, TH-9802, NIC-7187, EC-305574           |
| Siliqua beak length (< 1.0 cm)         | IC-94030, TS-50, PBT-221, EC-305374, EC-333597      |
| 1000-seed weight (> 3.5 g)             | PT-303, IC-94030, TH-9802, NRCT-98-120, NDT-9902    |
| Protein content                        | TK-9902, TS-51, PBT-126-6, PBT-221                  |
| Oil content (> 40%)                    | YS-36-4, IC-94030, IC-94030, IC-76707, IC-289660    |

## Variability and Character Association Among Floral Traits and Yield in Bread Wheat (*Triticum aestivum* (L.) em. Thell)

**SK Singh\* and RM Singh**

Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, Uttar Pradesh

**Key Words:** Wheat (*Triticum aestivum*), Variability Character Association, Floral Traits, Field Traits

Development of hybrids in wheat is being considered as an alternative approach to achieve a quantum jump in grain yield. Thus, selection for floral traits which enhance magnitude of out-crossing such as duration of floral opening, greater anther extrusion in the male parent; openness of florets and stigma receptivity in the female parent is crucial for successful development of hybrids. An experiment was conducted to investigate the extent of variability among wheat genotypes for floral traits and yield along with nature of association among these traits.

The experimental material consisted of 491 diverse genotypes of bread wheat including land races, released varieties and advanced lines introduced from CIMMYT, Mexico. These were grown in randomized block design in three replications during *rabi* 1996-97. Crop was sown in the last week of November in a double row plot of 3 m length with inter-and intra-row spacings of 25 cm and 10 cm, respectively. The data were recorded for 7 floral traits, *viz.*- days to 50% flowering, anther length, stigma length, anther extrusion, openness of floret, duration of flower opening, pollen viability and yield/plant in 10 randomly selected plants. Coefficients of variability, broad sense heritability (%), genetic advance

\*Present Address: Scientist (Plant Breeding), Directorate of Wheat Research, PO Box 158, Karnal-132001, Haryana

observed at genotypic level. Floral traits (anther length, stigma length, anther extrusion, duration of floral opening and openness of florets) had positive association among one another. However, days to 50% flowering showed significant negative associations with pollen viability and yield/plant (Chhabra and Sethi, 1991; Hucl, 1996). As these traits promote natural out crossing, the association of these traits with higher yield indirectly suggests the possibility of exploiting these traits for successful development of hybrids in wheat.

## References

- Atashi-Rang Gand KA Lucken (1978) Variability, combining ability and inter-relationships of anther length, anther extrusion, glume tenacity and shattering in spring wheat. *Crop Sci.* **18**: 267-272.
- Chhabra AK and SK Sethi (1991) Inheritance of cleistogamic flowering in durum wheat (*Triticum durum*). *Euphytica* **55**: 147-150.
- Choudhary MA, N Mahmood and I Khaliq (1994) Pollen production studies in common bread wheat. *Rachis*. **11**: 68-72.
- Hucl P (1996) Outcrossing rates for 10 Canadian spring wheat cultivars. *Canadian J. Plant Sci.* **76**: 423-427.
- Joppa LR, IH McNeal and MA Berg (1968) Pollen production and pollen shedding of hard red spring (*Triticum aestivum* L. em. Thell.) and durum (*T. durum* Desf) wheats. *Crop Sci.* **8**: 487-490.

## Comparison of Direct and Indirect Effects of Yield Traits on Yield in Tall and Dwarf Genotypes of Pea (*Pisum sativum* L.)

**SK Singh and SBL Srivastava**

Department of Genetics and Plant Breeding, CSA University of Agriculture and Technology, Kanpur-208002, Uttar Pradesh

**Key Words: Evaluation, Correlation, Pea, Yield Traits**

Most of the present cultivars belong to tall group and significantly contribute to the production of peas. Tall types have disadvantages of lodging, bird damage and low harvest index. Dwarf genotypes are the recent developments having tendrils to escape bird damage, lodging resistant and more seed: foliage ratio. In general, dwarf types are low yielder but more plant population per unit area results in yield advantage over tall types. Thus, there is need to compare the effect of various traits on yield in both the groups which may be useful in improvement programme.

Two separate experiments for 20 tall and 12 dwarf genotypes were conducted in randomized block design with three replications in experimental field at Oilseeds Research Farm of the University. The row and plant spacing was 40 x 20 cm in tall types and 30 x 15 cm in dwarf types in 6-row plot. The observations were recorded on 10 randomly selected plants in each treatment for days to flower, plant height (cm), number of primary branches, number of nodes, inter node length (cm), number of pods/plant, number of seeds/pod, 100-seed weight (g) and yield/plant (g). The genotypic association

was calculated and partitioned into direct and indirect effects by path coefficient analysis (Wright, 1921) using SPAR programme.

Highly significant differences were observed between treatment means for all the traits in both the groups. Yield showed the high and positive genotypic association with number of pods/plant and number of primary branches in tall types and with number of pods/plant, inter node length and plant height in dwarf types (Pratap *et al.* 1995; Kumar *et al.* 1999). The path analysis of yield components on yield/plant (Table I) in tall genotypes showed the maximum positive direct effect by plant height followed by number of pods/plant, number of seeds/pod, 100-seed weight and number of primary branches while in dwarf types, highest direct contribution was shown by days to flower, number of pods/plant and 100-seed weight in positive direction (Pratap *et al.* 1995; Bharadwaj and Kohli, 1999).

The strong and positive correlation of yield with number of pods/plant in both the population was also a result of positive indirect effects *via* number of nodes

**Table 1. Direct and indirect effects of yield traits on yield/plant in tall (T) and dwarf (D) genotypes of pea**

| Character                  |   | Effect via     |                |                            |                 |                   |                      |                      |                 | Genotypic correlation with yield/plant |
|----------------------------|---|----------------|----------------|----------------------------|-----------------|-------------------|----------------------|----------------------|-----------------|----------------------------------------|
|                            |   | Days to flower | Plant height   | Number of primary branches | Number of nodes | Inter-node length | Number of pods/plant | Number of seeds/pods | 100-seed weight |                                        |
| Days to flower             | T | <b>00.195</b>  | -00.240        | -00.093                    | -00.964         | 00.275            | -00.239              | 00.027               | 00.126          | -0.012                                 |
|                            | D | <b>211.568</b> | 14.887         | 21.251                     | -67.785         | 25.286            | -86.201              | -115.849             | -03.301         | -0.145                                 |
| Plant height               | T | -00.054        | <b>00.866</b>  | -00.136                    | -00.097         | 00.632            | -00.144              | 00.033               | 00.072          | -0.094                                 |
|                            | D | -68.434        | <b>-46.025</b> | 12.865                     | 26.762          | -41.992           | 119.646              | 00.269               | -02.609         | 0.509                                  |
| Number of primary branches | T | -00.052        | -00.343        | <b>00.344</b>              | 00.108          | 00.154            | 00.702               | -00.077              | -00.156         | 0.678                                  |
|                            | D | -92.113        | 12.131         | <b>-48.809</b>             | 33.789          | -01.084           | -03.965              | 95.290               | 04.611          | -0.150                                 |
| Number of nodes            | T | 00.062         | 00.419         | -00.184                    | <b>-00.202</b>  | -00.177           | -00.278              | 00.167               | 00.014          | -0.178                                 |
|                            | D | 127.982        | 10.992         | 14.718                     | <b>-112.057</b> | 25.817            | -29.678              | -39.210              | 01.327          | -0.109                                 |
| Internode length           | T | -00.076        | 00.779         | -00.75                     | -00.050         | <b>-00.703</b>    | 00.004               | -00.005              | 00.013          | -0.115                                 |
|                            | D | -118.952       | -42.973        | -01.177                    | 64.325          | <b>-44.974</b>    | 141.101              | 06.037               | -02.697         | 0.689                                  |
| Number of pods/plant       | T | -00.065        | -00.178        | 00.340                     | 00.079          | -00.004           | <b>00.710</b>        | -00.060              | -00.125         | 0.698                                  |
|                            | D | -110.415       | -33.339        | 01.171                     | 20.134          | -38.419           | <b>165.172</b>       | -01.611              | -01.876         | 0.814                                  |
| Number of seeds/pod        | T | 00.014         | 00.078         | -00.072                    | -00.091         | 00.011            | -00.115              | <b>00.370</b>        | 00.027          | 0.222                                  |
|                            | D | 157.419        | 00.087         | 29.872                     | -28.219         | 01.744            | 01.709               | <b>-155.700</b>      | -06.539         | 0.373                                  |
| 100-Seed weight            | T | 00.070         | 00.177         | -00.154                    | -00.008         | -00.027           | -00.254              | 00.029               | <b>00.350</b>   | 0.182                                  |
|                            | D | -63.442        | 10.907         | -20.445                    | -13.516         | 11.021            | -28.177              | 92.489               | <b>11.009</b>   | -0.155                                 |

Residual effect square : Tall= 0.091 : Dwarf = -8.188

Antiqued values are direct effects

and number of primary branches. Yield had strong correlation with number of primary branches in tall types due to positive indirect effects through number of pods/plant, inter node length and number of nodes which nullified the negative effects of other traits. In dwarf genotypes, the positive indirect effects *via* number of pods/plant, number of nodes and number of seeds/pod resulted in positive strong association with inter node length. Although plant height had negative direct effect, the positive indirect effects *via* number of pods/plant, number of nodes and number of primary branches resulted in positive correlation in dwarf types. Plant height in tall types and days to flower in dwarf types, having high and positive direct effect could not contribute towards positive correlation with yield due to preponderance of negative indirect effects.

The path coefficient analysis, thus, showed that number of pods/plant in both the groups and number of primary branches in tall types exert a high direct and positive influence on yield /plant. Therefore, these traits could be taken as an index to improve the seed yield through selection.

### References

- Bharadwaj RK and UK Kohli (1999) Association and path analysis in garden pea (*Pisum sativum* L.). *Hortic. J.* **12**: 61-62.
- Kumar D, R kumar and S Kumar (1999) Correlation studies for quantitative traits in dwarf and tall types of pea. *Ann. Agric. Biol. Res.* **4**: 79-81.
- Pratap PS, GL Bhatia and SK Malik (1995) Character association and path analysis studies in garden pea. *Haryana J. Hortic. Sci.* **24**:119-126.
- Wright S (1921) Correlation and causation. *J. Agric. Res.* **20**: 257-287.

## Screening of Sesame Germplasm for Resistance against Leaf Roller and Capsule Borer (*Antigastra catalaunalis* Dup.)

**Nikhil Shrivastava, SS Duhoon, HK Jharia and BR Singh**

All India Coordinated Research Project on Sesame and Niger, Jawaharlal Nehru Krishi Vishwa Vidyalaya Campus, Jabalpur-482004, Madhya Pradesh

**Key Words:** *Sesamum* Germplasm, Resistance, Leaf Roller, Capsule Borer

Sesame (*Sesamum indicum* L.) is commercially cultivated in regions of warm climate and well distributed rainfall. Sesame crop is attacked by a large number of pests of which the leaf roller and capsule borer (*Antigastra catalaunalis* Dup.) is the most serious pest in India. It occurs regularly and infests the crop during seedling, flowering and maturity stages of crop growth and causes up to 90% yield losses (Cheema and Singh, 1987). Growing a resistant variety is an ideal component of integrated pest management strategy. The present study conducted at project coordinating unit (Sesame and Niger) JNKVV, Jabalpur, deals with evaluation of 1492 sesame germplasm for their reaction to *Antigastra catalaunalis*.

One thousand four hundred and ninety two germplasm of sesame were sown in the first fortnight of July during Kharif 1992–1993. The experiment was laid-out in rod-row design with single row of 3 m with row to row spacing 40 cm. Recommended doses of fertilizers were applied. Observation on flower infestation and capsules damaged by capsule borer were recorded on 5 plants/row at 45 days after sowing (DAS) and at harvest. The healthy and damaged flowers/twig and healthy and damaged capsules/plant were counted and finally per cent flower and capsule damage was worked out. The germplasm was grouped and classified in respect of flowers and capsules damaged by leaf roller and capsule borer (*Antigastra catalaunalis*) following the screening procedure of AICORPO.

Four lines viz.- SI-1995, S-0505, IS-16 and ES-25-1-84 were free from flower damage. Minimum 1.9% flower damage was recorded with SI-261 where as it was maximum (74%) with AT-1. In checks viz.- RT-46, RT 54, Uma and CO-1, the average flower damage was 11.3, 10.4, 12.1 and 11.7%, respectively.

Minimum 3.3 % capsules damaged by capsule borer were recorded in IC-44095 while it was maximum (51.4%) with RJS-59. Seven lines viz.- SI-107, SI-319-2, SI-987, SI-1169, DT-11.8, KRR-1 and IC-44095 recorded less than 5% damage and were found promising to capsule borer. In checks i.e. RT-46, RT-54, Uma and CO-1, the average capsule damage was 9.9, 11.0, 10.8 and 1.7% respectively. Four lines viz.- SI-3, SI-1209, OTS-2 and T-44 recorded less than 10% flower infestation and also capsule damage by capsule borer. Thus, these lines were promising for both flower and capsule damage. Murali Bhaskaran and Thangavelu (1990) also reported resistance in terms of capsule damage with different germplasm and reported more or less similar damage. These lines can be used as donor for resistant breeding programme.

### References

- Cheema JS and G Singh (1987) Biology of Sesame leaf webber and capsule borer, *Antigastra catalaunalis* (Dup: Pyralidae. Lepidoptera) in Punjab. *J. Res. Agric. Univ.* **24**: 65-74.
- Murli Bhaskaran RK and S Thangavelu (1990) Germplasm screening against sesame leaf roller and pod borer. *Sesame-Safflower Newslett.* **5**: 40-45.

## Evaluation of Germplasm for Some Quantitative Characters in Opium Poppy (*Papaver somniferum* L.)

**OP Singh**

Department of Horticulture, Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad-224229, Uttar Pradesh

**Key Words:** Opium poppy, Characterization, Alkaloids, Seed oil yield, Genetic variability

Opium poppy (*Papaver somniferum* L.) is one of the most important medicinal plant. This plant is well known for its medicinal value and is frequently used in different systems of medicine for the treatment of various diseases. It is cultivated in U.P., M.P. and Rajasthan in India. The latex of opium poppy contains about 40 alkaloids. These alkaloids are used by pharmaceutical industries for preparing various medicines. The seed of opium poppy is equally important. The seed contains about 60-65% oil. In European countries it is cultivated as oil seed crop. In India, seeds are used as a spice.

Now-a-days due to very narrow genetic base its latex yield potential is almost at plateau stage. There

is need to introduce new genetic variability to break down the yield barrier. The present investigation was undertaken with the objective to know the genetic variability for different characters in 58 genotypes of poppy.

The 58 germplasm lines were sown in randomized block design with two replications in a plot size of 4.0 x 0.3 m at a spacing of 30 cm row to row and 10 cm plant to plant in November 1999. Normal cultural practices were followed. The observations were recorded for plant height (cm), stem diameter (cm), peduncle length (cm), days to first flowering, capsule length (cm), capsule breadth, seed yield (g/plot), husk yield (g/plot) and latex yield (g/plot) (Table 1).

**Table 1. Evaluation of germplasm of opium poppy for various quantitative and qualitative characters in opium poppy**

| S.No | Genotype | Plant height (cm) | Stem dia (cm) | Peduncle length (cm) | Day to 1 <sup>st</sup> flowering | Capsule length (cm) | Capsule breadth (cm) | No. of Stigmatic rays | Seed yield/plot (gms) | Husk yield/plot (gms) | Latex yield/plot (g) |
|------|----------|-------------------|---------------|----------------------|----------------------------------|---------------------|----------------------|-----------------------|-----------------------|-----------------------|----------------------|
| 1.   | ND-4     | 110.7             | 1.12          | 21.70                | 102.0                            | 3.18                | 3.65                 | 13.3                  | 240.0                 | 167.5                 | 8.51                 |
| 2.   | ND-6     | 109.7             | 1.11          | 22.50                | 101.0                            | 3.15                | 3.84                 | 13.0                  | 195.0                 | 155.0                 | 10.66                |
| 3.   | ND-7     | 103.4             | 1.07          | 19.70                | 101.5                            | 3.02                | 3.71                 | 13.5                  | 240.0                 | 272.5                 | 10.75                |
| 4.   | ND-8     | 101.9             | 1.06          | 24.50                | 103.0                            | 3.11                | 3.65                 | 13.0                  | 210.0                 | 190.0                 | 11.73                |
| 5.   | ND-9     | 109.9             | 1.24          | 21.40                | 105.0                            | 2.47                | 3.81                 | 13.3                  | 122.5                 | 127.5                 | 11.69                |
| 6.   | ND-10    | 106.3             | 0.91          | 23.90                | 102.0                            | 2.52                | 3.53                 | 12.4                  | 197.5                 | 127.5                 | 6.84                 |
| 7.   | ND-11    | 118.2             | 1.08          | 26.00                | 97.5                             | 2.97                | 3.88                 | 13.2                  | 265.0                 | 247.5                 | 12.10                |
| 8.   | ND-12    | 107.2             | 1.09          | 23.00                | 98.5                             | 3.08                | 3.90                 | 13.3                  | 247.5                 | 265.0                 | 12.63                |
| 9.   | ND-16    | 116.0             | 1.07          | 24.00                | 101.0                            | 3.15                | 3.83                 | 13.9                  | 177.5                 | 260.0                 | 10.05                |
| 10.  | ND-17    | 102.6             | 0.90          | 22.50                | 101.5                            | 3.07                | 3.76                 | 13.6                  | 232.5                 | 217.5                 | 7.06                 |
| 11.  | ND-20    | 111.3             | 1.10          | 23.40                | 105.5                            | 3.16                | 4.01                 | 13.9                  | 217.5                 | 195.0                 | 6.03                 |
| 12.  | ND-21    | 114.1             | 1.06          | 24.00                | 102.5                            | 3.09                | 3.81                 | 14.3                  | 185.0                 | 215.0                 | 7.60                 |
| 13.  | ND-22    | 123.6             | 1.19          | 27.00                | 103.0                            | 2.49                | 4.03                 | 14.0                  | 227.5                 | 272.5                 | 9.6                  |
| 14.  | ND-23    | 109.2             | 1.04          | 26.00                | 102.5                            | 2.70                | 4.12                 | 15.8                  | 220.0                 | 257.5                 | 9.7                  |
| 15.  | ND-24    | 121.3             | 1.21          | 28.00                | 100.5                            | 3.40                | 4.25                 | 13.5                  | 170.0                 | 223.0                 | 9.2                  |
| 16.  | ND-25    | 118.4             | 1.37          | 22.80                | 99.5                             | 3.32                | 3.81                 | 13.5                  | 167.5                 | 245.0                 | 6.96                 |
| 17.  | ND-26    | 107.8             | 1.22          | 22.10                | 99.5                             | 3.24                | 4.16                 | 14.0                  | 220.0                 | 255.0                 | 12.55                |
| 18.  | ND-28    | 114.8             | 1.12          | 24.00                | 100.0                            | 3.39                | 3.90                 | 14.3                  | 182.5                 | 242.5                 | 7.19                 |
| 19.  | ND-29    | 105.7             | 1.05          | 23.30                | 101.5                            | 3.32                | 4.21                 | 14.5                  | 265.0                 | 192.5                 | 6.55                 |
| 20.  | ND-31    | 110.5             | 1.03          | 23.70                | 103.0                            | 3.23                | 4.04                 | 13.5                  | 287.5                 | 252.5                 | 11.21                |
| 21.  | ND-35    | 105.2             | 1.16          | 23.60                | 102.0                            | 3.65                | 3.95                 | 13.2                  | 287.5                 | 237.5                 | 11.83                |
| 22.  | ND-36    | 107.0             | 1.05          | 23.50                | 98.5                             | 3.86                | 3.70                 | 12.4                  | 100.0                 | 187.5                 | 8.09                 |
| 23.  | ND-37    | 119.0             | 1.17          | 25.10                | 99.5                             | 3.73                | 4.13                 | 13.4                  | 222.5                 | 165.0                 | 7.75                 |
| 24.  | ND-38    | 120.2             | 1.22          | 24.90                | 101.5                            | 3.64                | 3.71                 | 13.8                  | 197.5                 | 190.0                 | 8.30                 |
| 25.  | ND-40    | 107.6             | 0.99          | 23.70                | 99.0                             | 2.92                | 3.64                 | 12.9                  | 260.0                 | 255.0                 | 10.44                |
| 26.  | ND-41    | 121.4             | 1.04          | 24.30                | 99.5                             | 2.51                | 3.36                 | 13.5                  | 205.0                 | 242.5                 | 18.90                |

Contd.

Table 1. Contd.

| S.No | Genotype | Plant height (cm) | Stem dia (cm) | Peduncle length (cm) | Day to 1 <sup>st</sup> flowering | Capsule length (cm) | Capsule breadth (cm) | No. of Stigmatic rays | Seed yield/plot (gms) | Husk yield/plot (gms) | Latex yield/plot (g) |
|------|----------|-------------------|---------------|----------------------|----------------------------------|---------------------|----------------------|-----------------------|-----------------------|-----------------------|----------------------|
| 27.  | ND-42    | 117.0             | 1.00          | 23.00                | 103.0                            | 2.66                | 4.40                 | 13.7                  | 287.5                 | 187.5                 | 8.14                 |
| 28.  | ND-43    | 106.7             | 1.06          | 23.70                | 102.5                            | 2.66                | 3.82                 | 13.5                  | 282.5                 | 242.5                 | 8.35                 |
| 29.  | ND-44    | 105.6             | 0.99          | 24.40                | 102.0                            | 2.79                | 3.31                 | 13.1                  | 180.0                 | 220.0                 | 7.86                 |
| 30.  | ND-45    | 103.0             | 1.02          | 25.00                | 100.5                            | 2.98                | 3.74                 | 13.3                  | 175.0                 | 212.5                 | 8.93                 |
| 31.  | ND-47    | 104.4             | 0.97          | 21.60                | 99.5                             | 2.76                | 3.80                 | 13.1                  | 212.5                 | 225.0                 | 10.49                |
| 32.  | ND-48    | 114.8             | 1.07          | 24.90                | 99.5                             | 2.71                | 3.98                 | 13.4                  | 223.0                 | 242.5                 | 11.32                |
| 33.  | ND-89    | 108.0             | 0.98          | 24.10                | 99.5                             | 2.90                | 3.58                 | 13.0                  | 167.5                 | 220.0                 | 7.58                 |
| 34.  | ND208    | 112.3             | 0.92          | 24.80                | 100.5                            | 3.00                | 4.02                 | 14.0                  | 187.5                 | 275.0                 | 10.61                |
| 35.  | NC-57915 | 102.7             | 0.96          | 23.90                | 101.5                            | 2.70                | 3.80                 | 12.5                  | 020.50                | 207.5                 | 9.51                 |
| 36.  | NC-57923 | 98.4              | 0.94          | 21.00                | 102.0                            | 3.76                | 3.78                 | 13.8                  | 160.0                 | 215.0                 | 9.42                 |
| 37.  | NC-57928 | 109.5             | 1.11          | 22.80                | 100.5                            | 3.08                | 4.26                 | 13.4                  | 182.5                 | 230.0                 | 9.54                 |
| 38.  | NC-57936 | 117.7             | 0.92          | 24.80                | 100.5                            | 3.79                | 3.66                 | 14.3                  | 190.0                 | 155.0                 | 7.54                 |
| 39.  | NC-57948 | 104.9             | 0.99          | 20.90                | 102.0                            | 3.06                | 3.94                 | 13.3                  | 230.0                 | 257.5                 | 7.84                 |
| 40.  | NC-57950 | 120.2             | 1.21          | 24.60                | 103.5                            | 2.83                | 3.69                 | 13.9                  | 242.5                 | 272.5                 | 8.55                 |
| 41.  | NC-57951 | 97.7              | 1.05          | 21.90                | 102.0                            | 2.66                | 3.70                 | 14.2                  | 225.0                 | 187.5                 | 8.89                 |
| 42.  | NC-57955 | 103.9             | 0.99          | 26.10                | 58.5                             | 2.03                | 3.51                 | 13.3                  | 150.0                 | 192.5                 | 7.34                 |
| 43.  | U.O-390  | 114.5             | 0.95          | 22.20                | 99.5                             | 3.58                | 3.47                 | 13.1                  | 232.5                 | 205.0                 | 9.67                 |
| 44.  | U.O-285  | 109.3             | 1.14          | 23.10                | 101.5                            | 3.80                | 4.04                 | 13.9                  | 235.0                 | 215.0                 | 8.75                 |
| 45.  | U.O-790  | 113.4             | 1.03          | 21.90                | 101.5                            | 2.98                | 3.57                 | 13.4                  | 222.5                 | 215.0                 | 9.7                  |
| 46.  | U.O-1185 | 112.6             | 1.06          | 26.60                | 99.5                             | 3.57                | 3.91                 | 14.5                  | 180.0                 | 135.0                 | 8.46                 |
| 47.  | U.O-1285 | 104.1             | 0.93          | 21.80                | 100.5                            | 3.35                | 3.56                 | 13.8                  | 135.0                 | 165.0                 | 7.89                 |
| 48.  | U.O-1385 | 109.8             | 1.16          | 21.10                | 102.0                            | 3.10                | 4.06                 | 14.0                  | 237.5                 | 250.0                 | 13.53                |
| 49.  | U.O-1495 | 106.2             | 1.05          | 23.80                | 101.0                            | 3.26                | 3.75                 | 14.2                  | 140.0                 | 185.0                 | 6.52                 |
| 50.  | U.O-1585 | 109.0             | 0.71          | 23.30                | 102.0                            | 3.34                | 3.46                 | 13.4                  | 170.0                 | 155.0                 | 9.55                 |
| 51.  | U.O-1985 | 115.3             | 1.28          | 24.00                | 102.5                            | 3.97                | 3.70                 | 14.2                  | 240.0                 | 260.0                 | 6.83                 |
| 52.  | MOP-217  | 109.5             | 1.09          | 21.70                | 100.5                            | 3.52                | 3.96                 | 13.9                  | 160.0                 | 190.0                 | 10.31                |
| 53.  | MOP-539  | 107.0             | 0.99          | 24.10                | 98.0                             | 3.03                | 3.71                 | 11.8                  | 225.0                 | 300.0                 | 7.69                 |
| 54.  | NBPGR-2  | 107.4             | 0.94          | 25.80                | 100.5                            | 2.86                | 3.70                 | 14.4                  | 132.5                 | 155.0                 | 7.38                 |
| 55.  | NBPGR-3  | 103.7             | 0.99          | 22.70                | 104.0                            | 3.30                | 3.48                 | 13.1                  | 117.5                 | 162.5                 | 6.53                 |
| 56.  | NBRI-1   | 109.5             | 1.06          | 22.30                | 102.0                            | 2.37                | 3.69                 | 13.8                  | 272.5                 | 190.0                 | 17.50                |
| 57.  | Telia    | 106.7             | 0.98          | 22.60                | 100.5                            | 3.64                | 3.91                 | 13.9                  | 190.0                 | 172.5                 | 7.45                 |
| 58.  | IC-15-2  | 106.1             | 0.99          | 24.60                | 101.5                            | 3.19                | 4.08                 | 14.0                  | 140.0                 | 172.5                 | 6.22                 |

Plant height varied from 97.7 cm to 123.6 cm. The maximum plant height was recorded for the genotype ND-22 and minimum for NC-57951. The variation in plant height indicates that there is enough scope for selection. The ideal plant height for cultivation is 100-110 cm. The maximum stem diameter was recorded for the genotype ND-37 (1.37 cm) and minimum for the genotype UO-1585 (0.71 cm). Peduncle length ranged from 19.7 cm to 28.0 cm. However, the longest peduncle was observed in genotype ND-24 and shortest in genotype ND-7. Earliest flowering took place in genotype ND-11 (97.5 days) and latest in genotype ND-9 (105.0 days). The capsule length ranged from 2.03 cm to 3.97 cm for the genotype NC-57935 and UO 1985 respectively.

The capsule width varied from 3.31 cm (ND-44) to 4.40 cm (ND-42). The maximum number of stigmatic rays was recorded for the genotype ND-23 (15.8/capsule) and minimum for MOP-539 (11.8/capsule).

The seed yield varied from 100.00 g/plot to 287.5 g/plot for the genotype ND-36 and ND-31, respectively. The variation for seed yield indicates that there is enough scope for selection. The latex yield, which is the most important character ranged from 6.22 g/plot to 18.9 g/plot. The maximum latex yield was recorded for the genotype ND-41 and the minimum in genotype ND-20. The variation for latex yield in present set of germplasm indicates that the chance of selection is quite fair.

## Genetic Variability for Yield Components in Aromatic and Quality Rice Germplasm

**N Shobha Rani, AS Rama Prasad, GSV Prasad, P Bhaskar Reddy and B Krishna Veni**

*Directorate of Rice Research, Rajendranagar, Hyderabad-500030, Andhra Pradesh*

**Key Words:** Aromatic rice, Variability, Characterization, Correlation analysis

India is a home for rich diversity of aromatic and other quality rice. Collection and characterization of this germplasm is not only important for utilizing the appropriate attribute based donors in breeding programmes but is also essential in the present era for protecting the unique rice, which are particularly endemic to our country, under the UN Convention on Biological Diversity (CBD). At the Directorate of Rice Research under the two ICAR network programmes on quality rice, a collection of long and short grain aromatic and other quality types were evaluated and characterized to identify donors for utilization and also get information on character associations which would contribute towards planning sound breeding methods. Earlier attempts to characterize the vast rice genetic resources both within the country (CRRI, 1971, DRR, 2000) and abroad (IRRI, 1970) were made but this is an effort devoted only to quality rice and its variability.

Four hundred and eighty one scented/quality germplasm accessions predominantly indigenous (366) with a few exotic (115) were grown in an augmented design (Federer, 1956) with 6 checks (Kasturi, Pusa Basmati 1, Basmati 370, Karnal Local, Jaya, IR 64). The plot size was 2.61 m<sup>2</sup> for each entry and standard management practices were followed. Eleven yield and yield components were recorded from 5 randomly selected plants from the middle row excluding border plants from each accession as per Standard Evaluation System for Rice, (INGER), IRRI (1996). Estimates of variability

parameters (mean, minimum, maximum, range, standard deviation, skewness, kurtosis) and correlation analysis of the data for quantitative traits were done (Panse and Sukhatme 1989).

The germplasm accessions showed a wide range of variability for all the agronomic and yield components. The plant height ranged from 62 cm to 177 cm with maximum number (100 accessions) being tall (150 cm) (Table 1; Fig 1). The number of productive tillers plant<sup>-1</sup> ranged from 3 to 24 with 250 accessions possessing tillering capacity of 15 productive tillers/plant. Longest flowering duration recorded was 140 days (Khao Jao Hawn), while the shortest was 84 days (RR 501) with nearly 200 entries flowering in 110 days. Flowering duration was the least variable character (cv: 29%) while the sterile grains/panicle and sterility percentage were the most variable characters (cv: 96% and 92%) The panicle length varied from 5 cm to 35 cm with a good number of cultivars (250) recording 30 cm panicle length. 150 entries showed a maximum of 150 total spikelets/panicle, while maximum number of entries as high as 400 showed at least 50 sterile spikelets/panicle indicating that sterility could be one of the major limiting factors for yield in this group of rice. Chauhan and Tandon (1984) in hill rice; Mani *et al.* (1977) in aromatic genotypes also reported wide range of variability for yield components. Some of the promising entries for yield components include: Maniki Madhuri was tallest (177 cm); Badshabhog (23) followed by HBC 85 (22)

**Table 1. Variability parameters in aromatic and quality rice germplasm with respect to agronomic and yield components**

|          | PHT   | TNO   | FD    | MAT   | PL    | TSNO  | FSNO  | SSNO  | STP   | GY    | TW    |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| MEAN     | 130.3 | 12.1  | 105.2 | 135.1 | 26.2  | 145.1 | 121.6 | 23.6  | 17.2  | 3.3   | 19.8  |
| MIN      | 62.0  | 3.0   | 84.0  | 114.0 | 5.0   | 28.0  | 4.0   | 0.0   | 0.0   | 0.5   | 7.4   |
| MAX      | 177.0 | 24.0  | 140.0 | 167.0 | 35.0  | 405.0 | 321.0 | 200.0 | 94.6  | 10.0  | 34.7  |
| SD       | 24.4  | 3.6   | 8.8   | 8.6   | 4.1   | 59.0  | 53.1  | 21.6  | 14.7  | 1.5   | 4.2   |
| CV%      | 43.30 | 54.60 | 28.93 | 25.22 | 39.66 | 63.74 | 66.12 | 95.74 | 92.30 | 68.30 | 46.16 |
| Skewness | -0.42 | 0.36  | 0.75  | 0.66  | -1.02 | 0.96  | 0.60  | 2.57  | 2.10  | 1.25  | 0.02  |
| Kurtosis | -0.77 | 0.26  | 0.77  | 0.48  | 2.35  | 2.08  | 0.74  | 11.67 | 5.73  | 2.23  | 0.67  |

Please see abbreviations of column heads below Table 2

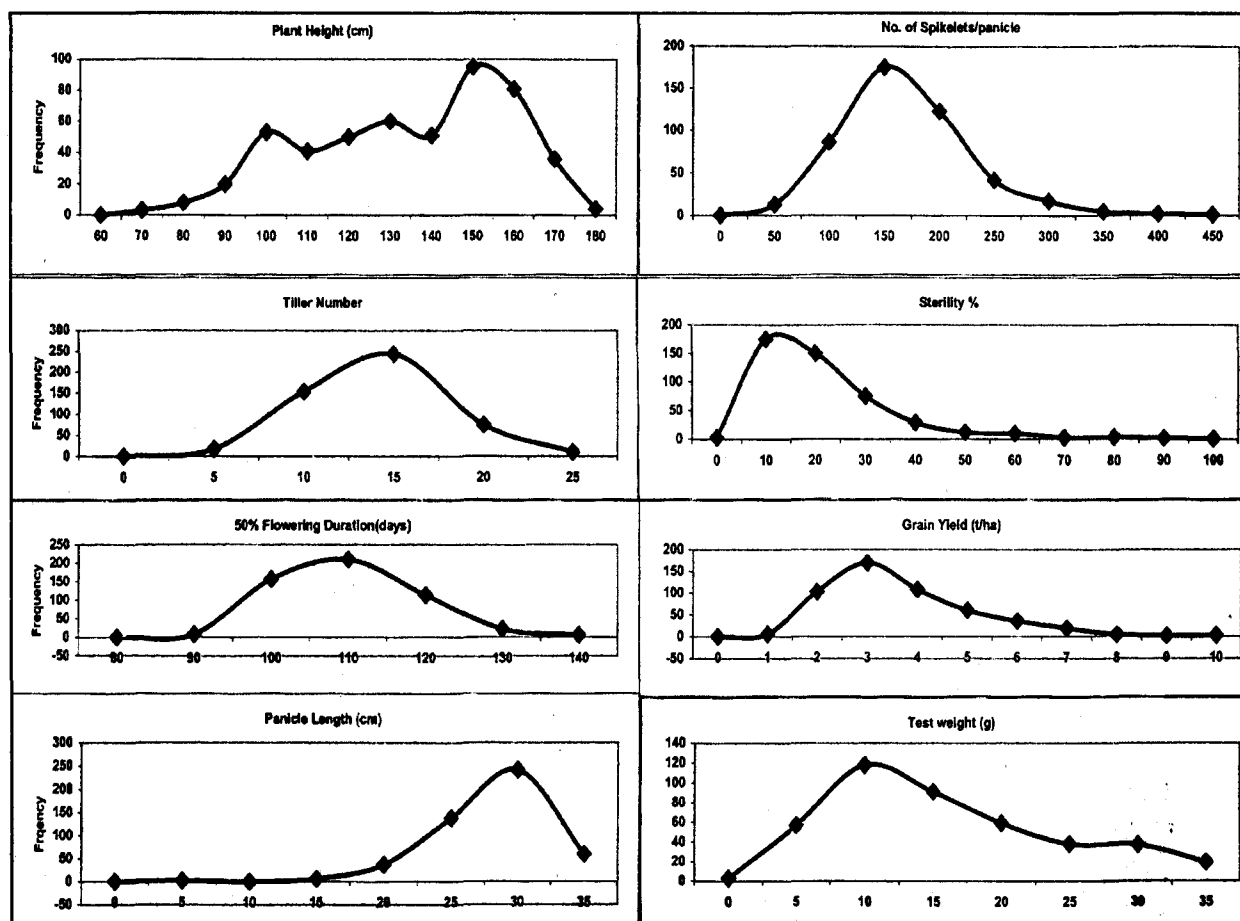


Fig. 1. Frequency distribution of aromatic and quality rice germplasm accessions with respect to agronomic and yield components

for highest productive tiller/plant; Basmati 1 and Badshahbhog for maximum panicle length of 34 cm. Bongcay exhibited no sterility while among the basmati types, Basmati 370B recorded least sterility (1.8%). MTU 22 recorded highest total spikelets/panicle (405) while maximum test weight was recorded in Naipon No. 1 (34.7 g) followed by RP 3120-15 (31.7 g) and highest yield in ARC 7229 and C-4-63-G (9.99t/ha) (Table 2).

Highly significant correlations among some of the important agronomic and yield components were observed (Table 3) especially in case of plant height and flowering duration which have influence on grain yield and its components. Plant height had high significant correlation with panicle length (0.496\*\*) followed by total grains/panicle with grain yield (0.391\*\*). While increase in flowering duration entailed in increase of total spikelet number/panicle, followed by fertile spikelets/panicle and

grain yield; increase in total spikelets/panicle was positively associated with fertile spikelets/panicle which had an impact in enhancing the grain yield. Studying varietal variation and association among panicle traits in rice Sharma and Dubey (1997) also found that grain yield/panicle had significant positive association with total spikelets/panicle. Similar correlations were also reported by Talukdar and Talukdar (1997), Prasad *et al.* (1988) and Gupta *et al.* (1999). Highly significant correlations were also obtained between panicle length and flowering duration and height of the tiller by earlier workers (Palaniswamy and Kumaran 1990; Raja Gopalan 1967; Richharia *et al.* 1963). The investigation has thus identified many useful donors for yield contributing traits in both dwarf and tall plant stature and the character association established would help in planning effective breeding methods.

**Table 2. Top aromatic and quality rice germplasm accessions based on agronomic and yield components**

| Short            | PHT  | Tall            | TNO  |                             | FD   | Early                  |     |
|------------------|------|-----------------|------|-----------------------------|------|------------------------|-----|
| BPT 5204         | 65   | Randhuni pagal  | 170  | RP 3238-33                  | 21   | RR 501                 | 84  |
| TD 52            | 65   | Basmati Mehtrah | 173  | Gopal Bhog                  | 21   | UPR 1071-21            | 85  |
| Calrose 76       | 72   | Basmati Bahar   | 174  | ARC 14760                   | 21   | Hinohikari             | 87  |
| Koshihikari      | 76   | BR-9            | 174  | Du thom thai binh hai phong | 22   | BK 865-1               | 87  |
| IR 841-85-1-1-2  | 78   | Maniki Madhuri  | 177  | IR 62873-417-4-3            | 22   | Hassany                | 87  |
|                  |      |                 |      | HBC 85                      | 22   |                        |     |
|                  |      |                 |      | Badshahbhog                 | 23   |                        |     |
| FD               |      | PL              | TSNO |                             | STP  |                        |     |
| Long             |      |                 |      |                             |      |                        |     |
| Pusa Basmati 1   | 131  | Hansraj         | 34   | Katarni                     | 344  | Bong Cay               | 0.0 |
| Basmati 5875     | 131  | Basmati 43 A    | 34   | Kon Joha 2                  | 347  | HKR 120                | 1.2 |
| Bong Cay         | 137  | ARC 14372       | 34   | MTU 4407 (Vijaya Mahsuri)   | 383  | Hung-mi-hsiang-ma-tsan | 1.4 |
| Bong Cay         | 137  | Basmati 1       | 35   | IR 62873-405-1-1            | 391  | Ayepyaung              | 1.8 |
| Bong Cay         | 137  | Badshahbhog     | 35   | MTU-22 (Kusuma)             | 405  | Basmati 370 B          | 1.8 |
| Khao Jao Hawm    | 140  |                 |      |                             |      |                        |     |
| GY               |      | TW              | TW   |                             |      |                        |     |
|                  |      | Low             |      | High                        |      |                        |     |
| AKP 1            | 7.99 | Badshahbhog     | 7.4  | SPRLR 841-84-9-5-2-1-3      | 30.8 |                        |     |
| MTU-23 (Akkullu) | 8.33 | Kon Joha 2      | 9.1  | Basmati T 370               | 31.2 |                        |     |
| Basmati 376      | 9.99 | Randhuni pagal  | 9.1  | RP 3120-15                  | 31.7 |                        |     |
| ARC 7229         | 9.99 | Jeraga Samba    | 9.9  | Pusa 743                    | 31.7 |                        |     |
| C-463-G          | 9.99 | Govind Bhog     | 10.1 | Naipon No 1                 | 34.7 |                        |     |

PHT – Plant height (cm); TNO – Tiller No.; FD – 50% flowering duration (days);

PL – Panicle length (cm); TSNO – Total spikelets no/panicle;

STP – Sterility%; GY – Grain yield (t/ha); TW – Test weight (g)

**Table 3. Correlations among agronomic and yield components in aromatic and quality rice germplasm**

|      | PHT | TNO   | FD      | MAT     | PL      | TSNO     | FSNO    | SSNO     | STP      | GY       | TW       |
|------|-----|-------|---------|---------|---------|----------|---------|----------|----------|----------|----------|
| PHT  | –   | 0.055 | 0.138** | 0.142** | 0.496** | 0.019    | 0.031   | -0.022   | -0.069   | -0.155** | -0.153** |
| TNO  |     | –     | -0.088  | -0.098  | 0.272** | 0.002    | 0.042   | -0.100*  | -0.143** | 0.117*   | -0.038   |
| FD   |     |       | –       | 0.980** | -0.021  | 0.0193** | 0.195** | 0.044    | 0.024    | 0.110*   | -0.169** |
| MAT  |     |       |         | –       | -0.034  | 0.191**  | 0.187** | 0.055    | 0.033    | 0.114*   | -0.192** |
| PL   |     |       |         |         | –       | 0.127*   | 0.221** | -0.189** | -0.348   | 0.028    | -0.089   |
| TSNO |     |       |         |         |         | –        | 0.926** | 0.434**  | -0.114*  | 0.351**  | -0.107*  |
| FSNO |     |       |         |         |         |          | –       | 0.065    | -0.432** | 0.391**  | -0.079   |
| SSNO |     |       |         |         |         |          |         | –        | 0.742**  | -0.002   | -0.101*  |
| STP  |     |       |         |         |         |          |         |          | –        | -0.218** | -0.126*  |
| GY   |     |       |         |         |         |          |         |          |          | –        | 0.083    |
| TW   |     |       |         |         |         |          |         |          |          |          | –        |

PHT – Plant height (cm); TNO – Tiller No.; FD – 50% flowering duration (days); MAT – days to maturity;

PL – Panicle length (cm); TSNO – Total spikelets no/panicle; FSNO – Fertile spikelets no/panicle;

SSNO – Sterile spikelets no/panicle; STP – Sterility%; GY – Grain yield (t/ha); TW – Test weight (g)

\* Significant at 5% level; \*\* Significant at 1% level

**References**

- Chauhan VS and JP Tandon (1984) Genetic variability and character association in hill rices. *Oryza* 21: 138-142.
- CRRI (1971) *National Germplasm Collection of Rice*. CRRI, Cuttack 235 p.

Directorate of Rice Research (2000) *Evaluation of Rice Germplasm for Biotic Stress*. ICAR ad-hoc Research network programme 1993-98. DRR, Hyderabad.

Federer TW (1956) Augmented or Hoonuiaku designs. *The Hawaiian Planters Record* 4: 191-208.

- Gupta KR, DVS Panwar and Rakesh Kumar (1999) Character association in segregating population in basmati rice. *Oryza* **36**: 16-19.
- IRRI (1970) Catalogue of rice cultivars and breeding lines (*Oryza sativa* L) in the world collection of the International Rice Research Institute, IRRI, Los Baños, Philippines, 281p.
- IRRI (1996) *Standard Evaluation System for Rice*. INGER Genetic Resources Centre, IRRI, Los Baños, Philippines, 52p.
- Mani SC, SK Verma and RK Sharma (1977) Genetic variability and character association for panicle traits in basmati rice. *Agric. Sci. Digest* **17**: 155-157.
- Prasad GSV, ASR Prasad, MVS Shastry and TE Srinivasan (1988) Genetic relationship among yield components in rice (*Oryza sativa* L) *Indian J. Agric. Sci.* **58**: 470-472.
- Panse VG and PV Sukhatme (1989) *Statistical Methods for Agricultural Workers*. ICAR, New Delhi 359p.
- Palaniswamy KM and K Kutty (1990) Effect of tiller height and flowering duration on panicle length in three rice varieties. *Oryza* **27**: 433-435.
- Raja Gopalan K (1967) Correlation studies and application of discriminant function for selection under soil drought in rice. *Oryza* **4**: 1-11.
- Richharia RH, B Misra and R Seetharaman (1963) Studies on world genetic stock of rice III. Duration to flower, height of plants and number of ear bearing tillers. *Oryza* **1**: 20-30.
- Sharma RK and SD Dubey (1997) Variation and association among panicle traits in rice. *Oryza* **34**: 8-12.
- Talukdar A and P Talukdar (1997) Inheritance of scent and genetic relationship of grain yield with some other attributes in rice. *Oryza* **34**: 171-173.

## Evaluation of Sub-tropical Pear Germplasm

**AS Sandhu, Tajinder Singh, Raghbir Singh, WS Dhillon and KK Sharma**

*Department of Horticulture, Punjab Agricultural University, Ludhiana-141004, Punjab*

**Key Words: Pear, Evaluation, Flowering characters, Morphological variation**

Pear is one of the most important temperate fruits of the world next to apple. Most of the cultivars belonging to *Pyrus communis* are suitable for cultivation in temperate climate. However, the Oriental pear [*Pyrus pyrifolia* (Burm.) Nakai] cultivars are well adapted to sub-tropical climate of North-Western states of India. The Patharnakh is the leading cultivar in the region although some scattered plantations of soft pear cultivars such as LeConte and Baggugosha also exist. To broaden genetic base of pear, a survey of Punjab and adjoining states was made to harness the genetic variability both in sand and soft pears. As a result 19 superior strains of soft pear were collected. In addition, Asian pear cultivars and their hybrids were also introduced from France and USA. This paper deals with studies wherein evaluation of sub-tropical pear germplasm has been done with respect to morphological and flowering characteristics.

Thirty different strains/cultivars of Asian and European pears and their hybrids were collected from indigenous and exotic sources during 1989-1992 and planted in the test block of New Orchard of the Department of Horticulture, Punjab Agricultural University, Ludhiana, for evaluation of their performance under Punjab conditions. The observations on morphological and

flowering characteristics were recorded. The tree height and mean tree spread from North-South and East-West and plant girth were measured when the plants were dormant. The volume of the tree was calculated and expressed in m<sup>3</sup>. The data was also recorded on the date of leaf fall, leaf emergence, full-bloom and duration of flowering. The percentage of fruit set was recorded by bagging the unopened flowers on the spurs to assess the self-compatibility in different genotypes.

The data given in Table 1 indicate that the AR-89-2 was the most vigorous which recorded maximum tree height (7.27 m), spread (3.560 m) and volume (49.51 m<sup>3</sup>). This was followed by AR-89-1 and ARP-90-17. The least vigorous strain was found to be ARNBD-92-28 which had minimum height (4.08 m) and tree volume (4.63 m<sup>3</sup>). However, the stem girth was maximum (63.50 cm) in AR-89-8 followed by AR-89-2 (61.12 cm) and it was minimum (34.37 cm) in ARG-90-18. In earlier studies, Gupta and Chauhan (1976) reported that average tree height of Patharnakh was 5.8 m, whereas that of LeConte and Smith cultivars was 4.4 m. The coefficient of variance of volume was recorded to be 58.52 which indicates that the great variability in terms of tree volume does exist in the

- Gupta KR, DVS Panwar and Rakesh Kumar (1999) Character association in segregating population in basmati rice. *Oryza* **36**: 16-19.
- IRRI (1970) Catalogue of rice cultivars and breeding lines (*Oryza sativa* L) in the world collection of the International Rice Research Institute, IRRI, Los Baños, Philippines, 281p.
- IRRI (1996) *Standard Evaluation System for Rice*. INGER Genetic Resources Centre, IRRI, Los Baños, Philippines, 52p.
- Mani SC, SK Verma and RK Sharma (1977) Genetic variability and character association for panicle traits in basmati rice. *Agric. Sci. Digest* **17**: 155-157.
- Prasad GSV, ASR Prasad, MVS Shastry and TE Srinivasan (1988) Genetic relationship among yield components in rice (*Oryza sativa* L) *Indian J. Agric. Sci.* **58**: 470-472.
- Panse VG and PV Sukhatme (1989) *Statistical Methods for Agricultural Workers*. ICAR, New Delhi 359p.
- Palaniswamy KM and K Kutty (1990) Effect of tiller height and flowering duration on panicle length in three rice varieties. *Oryza* **27**: 433-435.
- Raja Gopalan K (1967) Correlation studies and application of discriminant function for selection under soil drought in rice. *Oryza* **4**: 1-11.
- Richharia RH, B Misra and R Seetharaman (1963) Studies on world genetic stock of rice III. Duration to flower, height of plants and number of ear bearing tillers. *Oryza* **1**: 20-30.
- Sharma RK and SD Dubey (1997) Variation and association among panicle traits in rice. *Oryza* **34**: 8-12.
- Talukdar A and P Talukdar (1997) Inheritance of scent and genetic relationship of grain yield with some other attributes in rice. *Oryza* **34**: 171-173.

## Evaluation of Sub-tropical Pear Germplasm

**AS Sandhu, Tajinder Singh, Raghbir Singh, WS Dhillon and KK Sharma**

*Department of Horticulture, Punjab Agricultural University, Ludhiana-141004, Punjab*

**Key Words: Pear, Evaluation, Flowering characters, Morphological variation**

Pear is one of the most important temperate fruits of the world next to apple. Most of the cultivars belonging to *Pyrus communis* are suitable for cultivation in temperate climate. However, the Oriental pear [*Pyrus pyrifolia* (Burm.) Nakai] cultivars are well adapted to sub-tropical climate of North-Western states of India. The Patharnakh is the leading cultivar in the region although some scattered plantations of soft pear cultivars such as LeConte and Baggugosha also exist. To broaden genetic base of pear, a survey of Punjab and adjoining states was made to harness the genetic variability both in sand and soft pears. As a result 19 superior strains of soft pear were collected. In addition, Asian pear cultivars and their hybrids were also introduced from France and USA. This paper deals with studies wherein evaluation of sub-tropical pear germplasm has been done with respect to morphological and flowering characteristics.

Thirty different strains/cultivars of Asian and European pears and their hybrids were collected from indigenous and exotic sources during 1989-1992 and planted in the test block of New Orchard of the Department of Horticulture, Punjab Agricultural University, Ludhiana, for evaluation of their performance under Punjab conditions. The observations on morphological and

flowering characteristics were recorded. The tree height and mean tree spread from North-South and East-West and plant girth were measured when the plants were dormant. The volume of the tree was calculated and expressed in m<sup>3</sup>. The data was also recorded on the date of leaf fall, leaf emergence, full-bloom and duration of flowering. The percentage of fruit set was recorded by bagging the unopened flowers on the spurs to assess the self-compatibility in different genotypes.

The data given in Table 1 indicate that the AR-89-2 was the most vigorous which recorded maximum tree height (7.27 m), spread (3.560 m) and volume (49.51 m<sup>3</sup>). This was followed by AR-89-1 and ARP-90-17. The least vigorous strain was found to be ARNBD-92-28 which had minimum height (4.08 m) and tree volume (4.63 m<sup>3</sup>). However, the stem girth was maximum (63.50 cm) in AR-89-8 followed by AR-89-2 (61.12 cm) and it was minimum (34.37 cm) in ARG-90-18. In earlier studies, Gupta and Chauhan (1976) reported that average tree height of Patharnakh was 5.8 m, whereas that of LeConte and Smith cultivars was 4.4 m. The coefficient of variance of volume was recorded to be 58.52 which indicates that the great variability in terms of tree volume does exist in the

Table 1. Morphological and flowering characteristics of pear germplasm

| Strain                  | Height (m) | Spread (m) | Girth (cm) | Volume (m <sup>3</sup> ) | Date of leaf fall* | Date of leaf emergence | Date of full bloom | Duration of flowering (days) | Percentage Fruit-set (self-pollination) |
|-------------------------|------------|------------|------------|--------------------------|--------------------|------------------------|--------------------|------------------------------|-----------------------------------------|
| AR-89-1                 | 6.63       | 3.46       | 56.00      | 43.68                    | 17/2 Dec/Jan, 2000 | 4/5 Mar                | 18 Mar             | 17                           | 1.46                                    |
| AR-89-2                 | 7.27       | 3.56       | 61.12      | 49.51                    | 18/3 Dec/Jan       | 3/4 Mar                | 15 Mar             | 19                           | 1.32                                    |
| AR-89-3                 | 6.43       | 2.90       | 53.62      | 31.62                    | 20/1 Dec/Jan       | 5/6 Mar                | 16 Mar             | 17                           | 0.64                                    |
| AR-89-4                 | 6.58       | 2.81       | 57.50      | 28.42                    | 18/3 Dec/Jan       | 1/5 Mar                | 18 Mar             | 16                           | 0.98                                    |
| AR-89-5                 | 6.39       | 2.19       | 49.75      | 16.69                    | 4/7 Jan            | 29 Feb/1 Mar           | 13 Mar             | 10                           | 0.52                                    |
| AR-89-6                 | 4.78       | 1.57       | 37.16      | 14.05                    | 3/5 Jan            | 2/11 Mar               | 17 Mar             | 14                           | 0.83                                    |
| AR-89-7                 | 6.52       | 3.16       | 60.12      | 33.43                    | 22/8 Dec/Jan       | 1/5 Mar                | 16 Mar             | 17                           | 0.57                                    |
| AR-89-8                 | 6.95       | 2.60       | 63.50      | 25.96                    | 28/4 Dec/Jan       | 1/2 Mar                | 14 Mar             | 16                           | 0.42                                    |
| AR-89-9                 | 6.57       | 2.59       | 55.87      | 23.40                    | 28/3 Dec/Jan       | 4/7 Mar                | 17 Mar             | 16                           | 1.19                                    |
| AR-89-10                | 6.89       | 2.81       | 59.49      | 29.64                    | 28/4 Dec/Jan       | 4/5 Mar                | 15 Mar             | 15                           | 0.39                                    |
| AR-90-11                | 6.54       | 2.71       | 56.00      | 23.62                    | 4/6 Jan            | 4/6 Mar                | 16 Mar             | 17                           | 0.45                                    |
| AR-90-12                | 5.85       | 1.66       | 44.50      | 20.44                    | 2/6 Jan            | 5 Mar                  | 16 Mar             | 17                           | 1.06                                    |
| AR-90-13                | 5.93       | 2.46       | 49.25      | 25.55                    | 28/10 Dec/Jan      | 6/9 Mar                | 22 Mar             | 14                           | 0.00                                    |
| AR-90-14                | 7.16       | 2.13       | 54.00      | 16.87                    | 3/8 Jan            | 3/4 Mar                | 17 Mar             | 18                           | 0.84                                    |
| AR-90-15                | 6.77       | 2.00       | 56.62      | 14.30                    | 30/5 Dec/Jan       | 1/5 Mar                | 15 Mar             | 16                           | 0.00                                    |
| AR-90-16                | 6.45       | 2.07       | 54.75      | 16.82                    | 2/5 Jan            | 3/5 Mar                | 17 Mar             | 16                           | 0.55                                    |
| ARP-90-17               | 7.18       | 3.01       | 55.25      | 36.90                    | 22/25 Oct, 1999    | 12/15 Feb.             | 25 Feb.            | 15                           | 0.00                                    |
| ARG-90-18               | 5.18       | 1.37       | 34.37      | 7.51                     | 30/2 Dec/Jan, 2000 | 1/8 Mar                | 13 Mar             | 13                           | 0.00                                    |
| ARG-90-19               | 6.34       | 2.05       | 54.37      | 11.51                    | 3/10 Jan           | 1/2 Mar                | 13 Mar             | 13                           | 0.00                                    |
| AR-90-20                | 4.93       | 1.77       | 44.12      | 8.27                     | 6/11 Jan           | 19/23 Mar              | 28 Mar             | 09                           | 12.81                                   |
| AR-90-21                | 4.73       | 1.13       | 39.00      | 4.40                     | 1/10 Jan           | 18/28 Mar              | 29 Mar             | 11                           | 24.13                                   |
| ARA-90-22               | 5.20       | 2.28       | 51.37      | 14.93                    | 11/15 Jan          | 6/10 Mar               | 19 Mar             | 13                           | 2.19                                    |
| ARA-90-23               | 5.96       | 1.96       | 46.87      | 10.55                    | 6/16 Jan           | 18/20 Mar              | 26 Mar             | 13                           | 26.44                                   |
| ARA-90-24               | 5.92       | 2.72       | 53.50      | 31.24                    | 5/10 Jan           | 15/18 Mar              | 23 Mar             | 14                           | 38.57                                   |
| ARA-90-25               | 6.24       | 2.59       | 56.75      | 22.18                    | 28/3 Dec/Jan       | 16/21 Mar              | 25 Mar             | 15                           | 10.76                                   |
| ARA-90-26               | 5.37       | 1.39       | 46.87      | 8.11                     | 26/3 Dec/Jan       | 22/26 Mar              | 01 Apr.            | 14                           | 41.61                                   |
| ARNBD-92-27             | 5.75       | 1.50       | 45.00      | 9.71                     | 29/5 Dec/Jan       | 16/20 Feb.             | 06 Mar             | 16                           | 0.00                                    |
| ARNBD-92-28             | 4.08       | 1.22       | 36.49      | 4.63                     | 2/5 Jan            | 10/12 Mar              | 20 Mar             | 12                           | 0.00                                    |
| ARNBD-92-29             | 6.07       | 1.36       | 46.25      | 8.43                     | 4/6 Jan            | 6/8 Mar.               | 17 Mar             | 07                           | 19.13                                   |
| ARNBD-92-30             | 4.81       | 1.45       | 35.10      | 9.04                     | 2/5 Jan            | 19/24 Mar.             | 03 Apr.            | 19                           | 0.00                                    |
| Coefficient of Variance | 13.75      | 30.78      | 16.61      | 58.53                    | —                  | —                      | —                  | —                            | 193.86                                  |

\* Data recorded in December-January, 2000 except for APR-90-17 (year 1999)

germplasm which can be exploited to identify low canopy genotypes. The date of leaf fall in all the strains ranged between December 17 to January 16 except in ARP-90-17 in which leaf fall took place on 22<sup>nd</sup> to 25<sup>th</sup> October. The leaf fall started as earlier as on 17<sup>th</sup> December in AR-89-1 and as late as 11<sup>th</sup> January in ARA-90-22. The last date of leaf fall was recorded to be 16<sup>th</sup> January in ARA-90-23. The variation in leaf fall in different strains indicates that all the strains/cultivars do not enter into induction phase of dormancy at one time.

The date of leaf emergence in different strains ranged between 12<sup>th</sup> February to 28<sup>th</sup> March. The earliest (12<sup>th</sup>

February) leaf emergence was recorded in the ARP-90-17. The wide variation in the leaf emergence also indicated their varied chilling requirement. In most of the strains full bloom occurred around mid of March, except a few in which full bloom occurred in February and April. The full-bloom was earliest (25<sup>th</sup> February) in AR-90-17 and it was delayed to 3<sup>rd</sup> April in Strain No. 30. Earlier studies also indicated that the flowering in domesticated varieties of the region started between February to March (Aulakh *et al.* 1981). Similarly, the duration of flowering ranged between 7 to 19 days in different strains. Salwan (1985) also revealed that duration

of flowering was 4-15 days in some of the pear varieties.

The percentage of fruit-set through self-pollination ranged between 0.00 to 38.54 being highest in AR-90-24. The AR-90-13, 15, 17, 18, 19 and 30 did not set any fruit. This indicates that these strains/cultivars may be self-incompatible and need pollinizer for satisfactory fruit set. However, this needs further investigation. The coefficient of variation for fruit set was as high as 193.86 which shows that some of the strains/cultivars which have high fruit set on selfing could be the potential genotypes for obtaining higher

yield. Earlier, Mukherjee and Rana (1966) reported 18.6, 13.8 and 5.9% natural fruit set in LeConte, Kieffer and Smith cultivars, respectively under sub-tropical conditions.

#### References

- Aulakh PS, GS Dhaliwal and JS Jawanda (1981) Investigations on floral biology in sub-tropical pear. *Punjab Hortic. J.* **21**: 175-181.
- Gupta MR and GS Chohan (1976) Performance of pear cultivars at Bahadurgarh. *Punjab Hortic. J.* **16**: 115-120
- Mukherjee SK and DS Rana (1966) Studies on floral biology, fruit set and fruit development in pear grown under sub-tropical conditions. *Punjab Hortic. J.* **6**: 149-168.

## Screening Soybean (*Glycine max* (L) Merr.) Germplasm for Spring Summer Cultivation

**SK Lal, VKS Rana and RL Sapra**

*Genetics Division, Indian Agricultural Research Institute, New Delhi-110012*

**Key Words:** Soybean. Early maturity, Spring-summer cultivation

Soybean as a spring-summer crop has a great potential in India. It can serve two vital purposes. It can provide sustainability to rice-wheat cropping system, which is followed in an area of around 9 million ha and is facing problem of declining factor productivity due to its high energy demand, nutrient deficiencies, build-up of pests and deterioration in physical conditions of soil. Secondly, it can bring additional area under soybean cultivation to narrow down the current gap of 8 million tonnes that exists between the production of soybean in the country and the installed processing capacity of the soybean oil processing industry (Lal, 2001). As soybean is a short-day plant (Meyer *et al.* 1973), a different plant type is required for spring-summer crop. The present varieties under cultivation are too late in maturity and may not be suited for long day and short-duration of spring-summer crop. Genotypes less sensitive to photoperiod and early in maturity are required for this purpose. Therefore, an experiment was undertaken to screen lines from the working germplasm collections available with the project.

Early maturing lines are generally less sensitive to photoperiod (Shanmugasundaram, 1981). Therefore, out of 600 lines working collections, 20 lines of *G. Max*

(L) Merr. maturing in less than 100 days during *Kharif* season and one line of *G. sojae* were selected for planting during spring-summer 2000. The genotype were planted in a RBD with three replications, with a plot size of 2 rows of 5m length.

Days to 50% flowering of these lines were observed during *Kharif* 1999 and spring-summer 2000 (Table 1). Delay in days to 50% flowering ranging from 6 to 23 days was observed during spring-summer season as compared to *Kharif* season. Flowers were not developed on *G. sojae*. Out of 21 lines studied, pod formation was observed only in four lines. But seed filling was very poor in all the four lines.

Floral induction in early maturing varieties are less influenced by photoperiod than in the late maturing varieties (Yoshida, 1952). Since early maturing lines are less sensitive to photoperiod, out of working collection of six-hundred germplasm lines, 21 lines maturing in less than 100 days during *Kharif* season were selected for this study. The delay in flowering during spring-summer season was due to sensitivity of the genotypes to the long day conditions. The cumulative photoperiod observed during *Kharif* 99 and spring summer 2001 is shown in Fig. 1. This finding is consistent with the

of flowering was 4-15 days in some of the pear varieties.

The percentage of fruit-set through self-pollination ranged between 0.00 to 38.54 being highest in AR-90-24. The AR-90-13, 15, 17, 18, 19 and 30 did not set any fruit. This indicates that these strains/cultivars may be self-incompatible and need pollinizer for satisfactory fruit set. However, this needs further investigation. The coefficient of variation for fruit set was as high as 193.86 which shows that some of the strains/cultivars which have high fruit set on selfing could be the potential genotypes for obtaining higher

yield. Earlier, Mukherjee and Rana (1966) reported 18.6, 13.8 and 5.9% natural fruit set in LeConte, Kieffer and Smith cultivars, respectively under sub-tropical conditions.

#### References

- Aulakh PS, GS Dhaliwal and JS Jawanda (1981) Investigations on floral biology in sub-tropical pear. *Punjab Hortic. J.* **21**: 175-181.
- Gupta MR and GS Chohan (1976) Performance of pear cultivars at Bahadurgarh. *Punjab Hortic. J.* **16**: 115-120
- Mukherjee SK and DS Rana (1966) Studies on floral biology, fruit set and fruit development in pear grown under sub-tropical conditions. *Punjab Hortic. J.* **6**: 149-168.

## Screening Soybean (*Glycine max* (L) Merr.) Germplasm for Spring Summer Cultivation

**SK Lal, VKS Rana and RL Sapra**

*Genetics Division, Indian Agricultural Research Institute, New Delhi-110012*

**Key Words:** Soybean. Early maturity, Spring-summer cultivation

Soybean as a spring-summer crop has a great potential in India. It can serve two vital purposes. It can provide sustainability to rice-wheat cropping system, which is followed in an area of around 9 million ha and is facing problem of declining factor productivity due to its high energy demand, nutrient deficiencies, build-up of pests and deterioration in physical conditions of soil. Secondly, it can bring additional area under soybean cultivation to narrow down the current gap of 8 million tonnes that exists between the production of soybean in the country and the installed processing capacity of the soybean oil processing industry (Lal, 2001). As soybean is a short-day plant (Meyer *et al.* 1973), a different plant type is required for spring-summer crop. The present varieties under cultivation are too late in maturity and may not be suited for long day and short-duration of spring-summer crop. Genotypes less sensitive to photoperiod and early in maturity are required for this purpose. Therefore, an experiment was undertaken to screen lines from the working germplasm collections available with the project.

Early maturing lines are generally less sensitive to photoperiod (Shanmugasundaram, 1981). Therefore, out of 600 lines working collections, 20 lines of *G. Max*

(L) Merr. maturing in less than 100 days during *Kharif* season and one line of *G. sojae* were selected for planting during spring-summer 2000. The genotype were planted in a RBD with three replications, with a plot size of 2 rows of 5m length.

Days to 50% flowering of these lines were observed during *Kharif* 1999 and spring-summer 2000 (Table 1). Delay in days to 50% flowering ranging from 6 to 23 days was observed during spring-summer season as compared to *Kharif* season. Flowers were not developed on *G. sojae*. Out of 21 lines studied, pod formation was observed only in four lines. But seed filling was very poor in all the four lines.

Floral induction in early maturing varieties are less influenced by photoperiod than in the late maturing varieties (Yoshida, 1952). Since early maturing lines are less sensitive to photoperiod, out of working collection of six-hundred germplasm lines, 21 lines maturing in less than 100 days during *Kharif* season were selected for this study. The delay in flowering during spring-summer season was due to sensitivity of the genotypes to the long day conditions. The cumulative photoperiod observed during *Kharif* 99 and spring summer 2001 is shown in Fig. 1. This finding is consistent with the

Table 1. Days to 50% flowering in *Glycine max* and *G. sojae*

| Acc. No. | Kharif 1999<br>Photo-period | Kharif 1999<br>Days to 50%<br>flowering | Summer 2000<br>Photo-period | Summer 2000<br>Days to 50%<br>flowering |
|----------|-----------------------------|-----------------------------------------|-----------------------------|-----------------------------------------|
| 1        | 192                         | 34                                      | 332                         | 40                                      |
| 2        | 187.4                       | 33                                      | 332                         | 40                                      |
| 3        | 201.3                       | 35                                      | 368.6                       | 45                                      |
| 4        | 187.4                       | 33                                      | 332                         | 40                                      |
| 5        | 201.3                       | 35                                      | 368.6                       | 45                                      |
| 6        | 216.1                       | 38                                      | 370.3                       | 46                                      |
| 7        | 231.6                       | 44                                      | 409.1                       | 53                                      |
| 8        | 228.4                       | 40                                      | 387.6                       | 48                                      |
| 9        | 229                         | 41                                      | 436.9                       | 57                                      |
| 10       | 216.1                       | 38                                      | 379                         | 47                                      |
| 11       | 192                         | 34                                      | 368.6                       | 45                                      |
| 12       | 216.1                       | 38                                      | 368.6                       | 45                                      |
| 13       | 231.6                       | 44                                      | 409.1                       | 53                                      |
| 14       | 207.7                       | 36                                      | 379                         | 47                                      |
| 15       | 207.7                       | 36                                      | 409.1                       | 53                                      |
| 16       | 222.7                       | 39                                      | 387.6                       | 48                                      |
| 17       | 229                         | 41                                      | 402.3                       | 51                                      |
| 18       | 216.1                       | 38                                      | 402.3                       | 50                                      |
| 19       | 211.2                       | 37                                      | 370.3                       | 46                                      |
| 20       | 229                         | 41                                      | 402.5                       | 52                                      |
| 21       | 229                         | 41                                      | 421.8                       | 55                                      |

earlier studies (Hadley *et al.* 1984; Summerfield *et al.* 1993). The variability in duration of delay in days to flowering can be explained on the basis of variation in the genes which control time to flowering. Five loci have been reported to control time to flowering and maturity in soybean (Cober *et al.* 1996). A delay in flowering ranging from 1 to 23 days depending upon the type of gene present has been reported (Bernard, 1971; Buzzell, 1971; Buzzell and Bernard, 1975; McBlain *et al.* 1987). Pod formation was observed in less sensitive lines. However, seed filling was delayed due to abnormally high temperature and dry soil conditions at the time of pod formation. Increase in day length results in slow seed growth rate. Prolonged drought stress during seed filling decreases nitrogen fixation resulting in poor seed filling.

None of the lines screened were found suitable for cultivation during spring-summer season. However, four lines in which pod formation was observed, which can be utilized in the crossing programme.

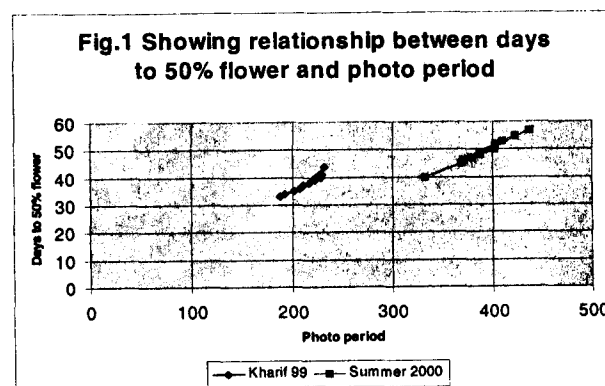


Fig. 1. Relationship between days to 50% flower and photoperiod

## References

- Bernard RL (1971) Two genes for time of flowering and maturity in soybean. *Crop Sci.* 11: 242-244.
- Buzzell RI (1971) Inheritance of soybean flowering response to fluorescent-day length condition. *Can. J. Genet. Cytol.* 13: 703-707.
- Buzzell RI and RL Bernard (1975) E2 and E3 maturity gene tests. *Soybean Genet. Newslett.* 2: 47-49.
- Cober ER, JW Tanner and HD Voldeng (1996) Genetic control of photoperiod response in early maturing near isogenic soybean lines. *Crop Sci.* 36: 601-606.
- Hadley P, EH Roberts, RJ Summerfield and FR Minchir (1984) Effect of temperature and photoperiod on flowering in soybean (*Glycine max* (L) Merrill) a quantitative model. *Ann. Bot.* 53: 669-681.
- Lal SK (2001) Soybean as a spring summer crop in rice-wheat cropping system. *SOPA Digest* Jan.-Mar. 12-14.
- McBlain BA, JO Hesketh and RL Bernard (1987) Genetic effects on reproductive phenology in soybean isolines differing in maturity genes. *Can. J. Plant Sci.* 67: 105-116.
- Meyer BS, DB Anderson, RH Bohning and DG Frattianne (1973) Introduction to plant physiology. D. van Nostrand Co. New York, 565.
- Shanmugasundaram S (1981) Varietal differences and genetic behaviour for the photoperiodic responses in soybean. *Bull. Instt. Trop. Agric. Kyushu Univ.* 4: 1-61.
- Summerfield RJ, RJ Lawn, A Qi, RH Ellis, EH Roberts, PM Chay, JB Brouwer, JL Rose, S Shanmugasundaram, SJ Yates and S Sandover (1993) Towards the reliable prediction of time to flowering in six annual crops. II. Soybean (*Glycine max*). *Exp. Agric.* 29: 253-289.
- Yoshida S (1952) Photoperiodic responses in soybean plants under long day conditions with supplemental illumination of different intensities at night. *Proc. Crop Sci. Soc. Japan* 21: 127-128.

## Characterization and Preliminary Evaluation of National Collections of Barnyard Millet (*Echinochloa* species) Germplasm

**BH Halaswamy, GV Srinivas, BM Ramakrishna, Vikram K Magar, M Krishnappa and Jayaram Gowda**

Project Co-ordination Cell, All India Coordinated Small Millets Improvement Project, University of Agricultural Sciences, GKVK, Bangalore-560065, Karnataka

**Key Words:** Barnyard millet, *Echinochloa*, Characterization, Fodder

Barnyard millet (*Echinochloa* species) which is known as *sawan* is cultivated as fodder and cereal in concentrated pockets in many states in India. The states growing barnyard millet are Uttaranchal, parts of western Uttar Pradesh, North Bihar, Maharashtra and Northeastern states. The grains are nutritious and cooked as rice after shelling. It is one of the quickest growing crops, some cultivars coming to harvest in 6-8 weeks.

Barnyard millet belongs to genus *Echinochloa* of the family Graminae. Several *Echinochloa* species, particularly *Echinochloa frumentacea* (Roxb.) Link, *Echinochloa colona* (L.) Link, *Echinochloa crusigalli* (L.) Beauv and *Echinochloa utilis* (Ohwi and Yabuno) are cultivated in Asia including China, Korea, Japan, USSR as well as India. They are also grown in USA and central African countries. Probably, different species of *Echinochloa* were domesticated in different parts of Asia. It is believed that *Echinochloa frumentacea* in China, *Echinochloa colona* in India and *Echinochloa crusigalli* in Japan, are domesticated.

Barnyard millet is one of the mandate crops of All India Coordinated Small Millets Improvement Project (AICSMIP) where research efforts are made in areas of crop improvement, crop production and crop protection. Many improved varieties have been released for cultivation in different states. As part of crop improvement activity, a modest collection of barnyard millet germplasm is maintained at the Active Collection Site (ACS), AICSMIP, Bangalore. These collections have been assembled partly through collection expeditions made within the country through NBPGR and also pooling of collections available elsewhere.

There was little information on the extent and kind of diversity present in the collections maintained at ACS. So, characterization and preliminary evaluation of the accessions maintained was considered essential.

Some 719 accessions collected from 7 Indian states and one exotic from Japan, were characterized and

primarily evaluated during *kharif* season 2000 at the main research station, UAS, GKVK, Bangalore which is situated at about 130° N latitude and 77° 37' E longitude at an altitude of 890 metres above mean sea level (Table 1).

**Table 1. Source of germplasm**

| State/country  | No. of accessions |
|----------------|-------------------|
| Bihar          | 261               |
| Japan          | 1                 |
| Karnataka      | 1                 |
| Madhya Pradesh | 147               |
| Orissa         | 5                 |
| Tamil Nadu     | 9                 |
| Uttaranchal    | 277               |
| Uttar Pradesh  | 18                |
| Total          | 719               |

Each accession was grown in space planted 3 metre long rows following a spacing of 25 cm between rows and 10 cm within row. The crop was raised adopting the recommended package. For characterization, 12 descriptors were considered, viz.- growth habit, degree of culm branching, degree of lodging at maturity, senescence, colour of inflorescence, inflorescence shape, compactness of inflorescence, shape of lower racemes, branching of lower racemes, spikelet arrangement, grain shape and grain colour. All these characters are having relatively high heritability and show stable expression with least environmental influence. The scoring for these characters was done as per the procedures given in *Echinochloa* descriptors of IBPGR (IBPGR, 1983). For preliminary evaluation, only four quantitative characters were included. They are plant height, number of basal tillers, length of inflorescence and days to flowering. The metric data collected from five plants for the quantitative characters were subjected to statistical analysis to work mean, range and coefficient of variability. Regarding characterization, grouping was done based on their segregation to different categories and frequencies were worked out.

The germplasm showed wide range of variability in plant height (73.8-169.2 cm), number of basal tillers (2-21), length of inflorescence (9.8-26.4) and days to flowering (34-52). High CV was observed for number

of basal tillers (42.9%) followed by days to flowering (32.3) (Table 2 and Fig. 1).

Morphological characters exhibited large variability. Growth habit was found to be erect (647) and decumbent type (72), where as colour of the inflorescence ranged from green (198) to light purple (318) and dark purple (203). Inflorescence shape was mostly pyramidal (638) followed by elliptic (54) and cylindrical (27), while a majority of the germplasm accessions had semi-compact type of inflorescence (441) and 192 were compact and 86 were of open type. Spikelets were arranged around the rachis (702) and also on one side of rachis in some

**Table 2. Variability for different quantitative characters of barnyard millet germplasm (Total number=719)**

| Character               | Range      | Mean  | SE  | CV % |
|-------------------------|------------|-------|-----|------|
| Plant Height            | 73.8-169.2 | 108.4 | 0.5 | 12.6 |
| No. of basal tillers    | 2-21       | 4.2   | 0.1 | 42.9 |
| Length of Inflorescence | 9.8-26.4   | 17.0  | 0.1 | 15.3 |
| Days to flowering       | 34-52      | 9.6   | 0.1 | 32.3 |

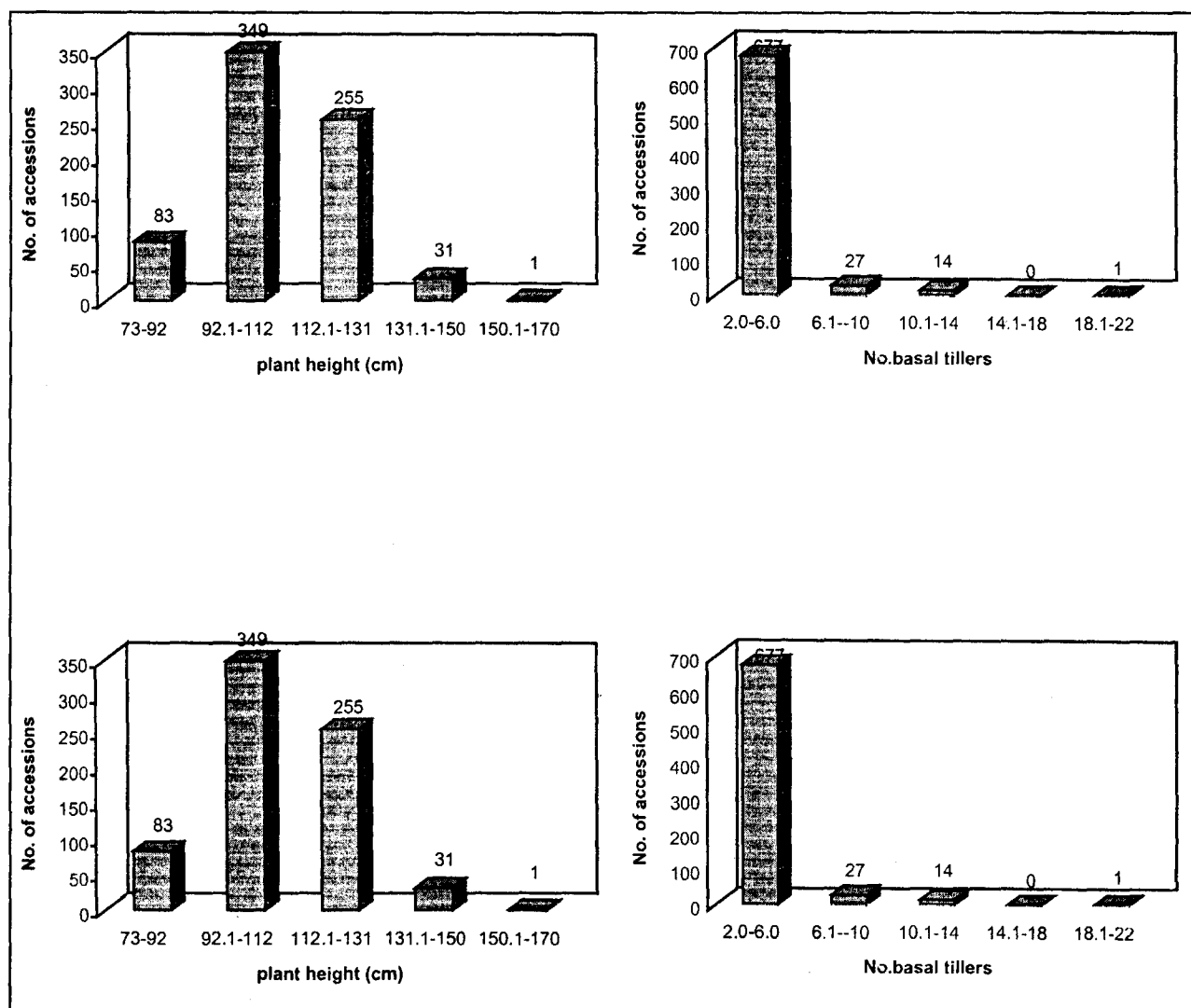


**Fig. 1. Frequency distribution for plant height, number of basal tillers, length of inflorescence and days to 50% flowering**  
Indian J. Plant Genet. Resour. 14: 213-216 (2001)

Table 3. Statewise grouping of barnyard millet accessions (719) for qualitative characters

| Descriptor/<br>descriptor state      | Bihar          | Karnataka   | Tamil<br>Nadu | Madhya<br>Pradesh | Orissa      | Uttar-<br>anchal | Uttar<br>Pradesh | Japan       | Total |
|--------------------------------------|----------------|-------------|---------------|-------------------|-------------|------------------|------------------|-------------|-------|
| <i>Growth habit</i>                  |                |             |               |                   |             |                  |                  |             |       |
| Erect                                | 236<br>(36.47) | 1<br>(0.15) | 9<br>(1.39)   | 113<br>(19.46)    | 3<br>(0.46) | 273<br>(42.19)   | 11<br>(1.7)      | 1<br>(0.15) | 647   |
| Decumbent                            | 25<br>(34.32)  | 0           | 0             | 34<br>(47.22)     | 2<br>(2.77) | 4<br>(5.55)      | 7<br>(9.72)      | 0           | 72    |
| <i>Degree of culm branching</i>      |                |             |               |                   |             |                  |                  |             |       |
| Low                                  | 218<br>(36.45) | 0           | 4<br>(0.67)   | 109<br>(18.22)    | 4<br>(0.67) | 243<br>(41.4)    | 14<br>(2.34)     | 1<br>(0.17) | 598   |
| Medium                               | 42<br>(35.89)  | 1<br>(0.85) | 5<br>(4.27)   | 35<br>(29.91)     | 1<br>(0.85) | 29<br>(24.78)    | 4<br>(3.42)      | 0           | 117   |
| High                                 | 1<br>(25.1)    | 1<br>(1.29) | 0             | 3<br>(75)         | 0           | 0                | 0                | 0           | 4     |
| <i>Degree of lodging at maturity</i> |                |             |               |                   |             |                  |                  |             |       |
| Low                                  | 30<br>(38.96)  | 0           | 0             | 11<br>(14.26)     | 0           | 36<br>(46.78)    | 0                | 0           | 77    |
| Intermediate                         | 42<br>(45.65)  | 0           | 0             | 0                 | 0           | 33<br>(35.86)    | 17<br>(18.47)    | 0           | 92    |
| High                                 | 189<br>(34.36) | 1<br>(0.18) | 9<br>(1.63)   | 119<br>(21.64)    | 5<br>(0.9)  | 208<br>(37.81)   | 18<br>(3.27)     | 1<br>(0.18) | 550   |
| <i>Senescence</i>                    |                |             |               |                   |             |                  |                  |             |       |
| Actively growing                     | 147<br>(37.4)  | 0           | 4<br>(1.01)   | 66<br>(16.79)     | 0           | 170<br>(43.25)   | 6<br>(1.52)      | 0           | 393   |
| Dead                                 | 114<br>(34.96) | 1<br>(0.3)  | 5<br>(1.53)   | 81<br>(24.85)     | 5<br>(1.53) | 107<br>(32.82)   | 12<br>(3.68)     | 1<br>(0.3)  | 326   |
| <i>Inflorescence colour</i>          |                |             |               |                   |             |                  |                  |             |       |
| Green                                | 44<br>(22.22)  | 1<br>(0.50) | 3<br>(1.51)   | 103<br>(52.02)    | 5<br>(2.52) | 23<br>(11.67)    | 18<br>(9.0)      | 1<br>(0.5)  | 198   |
| Light Purple                         | 127<br>(39.94) | 0           | 2<br>(0.62)   | 33<br>(10.37)     | 0           | 156<br>(49.06)   | 0                | 0           | 318   |
| Dark Purple                          | 90<br>(44.33)  | 0           | 4<br>(1.97)   | 11<br>(5.41)      | 0           | 98<br>(48.27)    | 0                | 0           | 203   |
| <i>Inflorescence shape</i>           |                |             |               |                   |             |                  |                  |             |       |
| Cylindrical                          | 1<br>(1.18)    | 0           | 0             | 42<br>(77.77)     | 5<br>(9.2)  | 4<br>(7.4)       | 2<br>(3.7)       | 0           | 54    |
| Pyramidal                            | 260<br>(40.75) | 1<br>(0.16) | 9<br>(1.4)    | 95<br>(14.94)     | 0           | 256<br>(40.25)   | 16<br>(2.51)     | 1<br>(0.16) | 638   |
| Globose                              | 0              | 0           | 0             | 10                | 0           | 17               | 0                | 0           | 27    |
| <i>Compactness of inflorescence</i>  |                |             |               |                   |             |                  |                  |             |       |
| Open                                 | 29<br>(33.72)  | 0           | 0             | 37<br>(43.02)     | 5<br>(5.8)  | 15<br>(17.44)    | 37<br>(43.02)    | 0           | 86    |
| Intermediate                         | 138<br>(31.29) | 1<br>(0.23) | 6<br>(1.36)   | 102<br>(23.13)    | 0           | 183<br>(41.49)   | 102<br>(23.13)   | 0           | 441   |
| Compact                              | 94<br>(48.95)  | 0           | 3<br>(1.56)   | 8<br>(4.16)       | 0           | 79<br>(41.14)    | 8<br>(4.16)      | 1<br>(0.52) | 192   |
| <i>Shape of lower racemes</i>        |                |             |               |                   |             |                  |                  |             |       |
| Straight                             | 49<br>(23.44)  | 1<br>(0.47) | 1<br>(0.47)   | 44<br>(21.05)     | 5<br>(2.39) | 105<br>(50.23)   | 4<br>(0.91)      | 0           | 209   |
| Curved                               | 212<br>(42.65) | 0           | 8<br>(1.6)    | 92<br>(18.5)      | 0           | 170<br>(34.2)    | 14<br>(2.8)      | 1<br>(0.20) | 497   |
| Slender                              | 0              | 0           | 0<br>(84.61)  | 11<br>(15.38)     | 0           | 2                | 0                | 0           | 13    |

Contd.

Table 3 Contd.

| Descriptor/<br>descriptor state   | Bihar          | Karnataka   | Tamil<br>Nadu | Madhya<br>Pradesh | Orissa       | Uttar-<br>anchal | Uttar<br>Pradesh | Japan       | Total |
|-----------------------------------|----------------|-------------|---------------|-------------------|--------------|------------------|------------------|-------------|-------|
| <i>Branching of lower racemes</i> |                |             |               |                   |              |                  |                  |             |       |
| Absent                            | 149<br>(30.84) | 1<br>(0.2)  | 4<br>(0.8)    | 102<br>(21.12)    | 5<br>(1.02)  | 218<br>(45.15)   | 4<br>(0.8)       | 0           | 483   |
| Present                           | 112<br>(47.45) | 0           | 5<br>(2.11)   | 45<br>(19.06)     | 0            | 59<br>(25.0)     | 14<br>(5.93)     | 1<br>(0.4)  | 236   |
| <i>Spikelet arrangement</i>       |                |             |               |                   |              |                  |                  |             |       |
| Outside the rachis                | 1<br>(5.8)     | 0           | 0             | 9<br>(52.95)      | 5<br>(29.41) | 1<br>(5.8)       | 1<br>(5.8)       | 0           | 17    |
| Around the rachis                 | 260<br>(37.03) | 1<br>(0.14) | 9<br>(1.28)   | 138<br>(19.66)    | 0            | 276<br>(39.32)   | 17<br>(2.42)     | 1<br>(0.14) | 702   |
| <i>Grain shape</i>                |                |             |               |                   |              |                  |                  |             |       |
| Plano concave                     | 195<br>(50.52) | 1<br>(0.26) | 4<br>(1.04)   | 110<br>(28.49)    | 3<br>(0.77)  | 65<br>(16.83)    | 8<br>(2.07)      | 0           | 386   |
| Hemispherical                     | 62<br>(19.56)  | 0           | 4<br>(1.26)   | 34<br>(10.72)     | 2<br>(0.63)  | 205<br>(64.67)   | 9<br>(2.84)      | 1<br>(0.32) | 317   |
| Elliptical                        | 4<br>(25.0)    | 0           | 1<br>(6.25)   | 4<br>(25.0)       | 0            | 7<br>(43.75)     | 1<br>(6.25)      | 0           | 16    |
| <i>Grain colour</i>               |                |             |               |                   |              |                  |                  |             |       |
| Straw white                       | 21<br>(36.84)  | 0           | 0             | 29<br>(50.88)     | 1<br>(1.75)  | 6<br>(10.52)     | 0                | 0           | 57    |
| Grey + straw white                | 204<br>(34.46) | 1<br>(0.17) | 9<br>(1.52)   | 101<br>(17.66)    | 3<br>(0.51)  | 258<br>(43.58)   | 15<br>(2.53)     | 1<br>(0.17) | 592   |
| Grey                              | 20<br>(45.45)  | 0           | 0             | 0                 | 0            | 3<br>(21.42)     | 3<br>(21.42)     | 0           | 44    |
| Brownish Grey                     | 8<br>(57.14)   | 0           | 0             | 14<br>(33.53)     | 0            | 10<br>(22.72)    | 0                | 0           | 14    |
| Light Grey                        | 8<br>(66.66)   | 0           | 0             | 3<br>(25.1)       | 1<br>(8.33)  | 0                | 0                | 0           | 12    |

accessions. For grain shape, accessions were either plano-concave (379) or hemispherical (317) with some showing elliptical nature. As regards grain colour, there are 4 shades extending from straw white to gray. Some accessions showed mixture of two seed colour groups viz.- gray + straw white (585).

State-wise grouping of morphological characters (Table 3) did not reveal concentration of any group to a specific state. Promising entries identified for different agronomic characters are provided in Table 4. These include accessions showing higher plant height, higher number of basal tillers, longer inflorescence and early flowering.

#### Reference

IBPGR (1983) *Echinochloa Millet Descriptors*. IBPGR Secretariat, Rome.

Table 4. Promising entries identified for different agronomic characters

| Character               | Range    | Accessions                                                                                                                            |
|-------------------------|----------|---------------------------------------------------------------------------------------------------------------------------------------|
| Plant height            | > 125 cm | GECH 153, 201, 202, 403, 409, 410, 413                                                                                                |
| No. of basal tillers    | > 11 cm  | GECH 720, 705, 707, 708, 712, 721, 723, 724, 725                                                                                      |
| Length of inflorescence | > 23 cm  | GECH 193, 146, 148, 155, 321, 383, 403, 406, 529, 639                                                                                 |
| Days to flowering       | 35 days  | GECH 8, 10, 11, 30, 106, 595, 626, 633, 690, 692, 698, 700, 702, 706, 707, 708, 710, 711, 714, 715, 717, 718, 730, 739, 744, 747, 752 |

## Genetic Variability in Cardamom (*Elettaria cardamomum* Maton.)

**D Prasath, MN Venugopal and VS Korikanthimath**

Indian Institute of Spices Research, Cardamom Research Centre, Appangala, Madikeri, Kodagu-571201, Karnataka

**Key Words:** Cardamom, Evaluation, Genetic Analysis, Heritability

Small cardamom (*Elettaria cardamomum* Maton.), popularly called "Queen of Spices", is an important export oriented spice crop. India has a rich wealth of genetic resources of cardamom as the crop originated in the tropical forests of Western Ghats. Cardamom being cross-pollinated crop, abundant diversity exists in the population which can be exploited both for commercial and scientific interest. Assessment of variability for the yield and its components becomes absolutely essential before planning for an appropriate breeding strategy for genetic improvement. Parameters such as genotypic and phenotypic coefficient of variability are useful in detecting the amount of variability present in the germplasm. Heritability and genetic advance help in determining the influence of environment on the expression of genotype and the reliability of characters. Hence, present investigation was undertaken to quantify the available variability in small cardamom (*Elettaria cardamomum* Maton.) based on nine quantitative characters, to identify desirable genotypes based on performance, and to select promising donors for various characters which may be used in hybridization programme to obtain useful recombinants and to create genetic variability.

The study was conducted at Indian Institute of Spices Research, Cardamom Research Centre, Appangala, Madikeri, Kodagu (Dt.), Karnataka, which is located in heavy rainfall region (2500-3500 mm/annum) at an elevation of 1000 MSL. The experimental material

comprised 119 Malabar (prostrate panicle types) accessions spaced at 2m x 2m between the rows and plants. The accessions, represented collections and distinct morphotypes from cardamom growing tracts such as Waynad, Anamalais, Manjoli Hills, Nelliampathy, Lower Pulneys, Meghamalai and Cardamom Hills. Uniform suckers were planted during 1997 and the observations were recorded during 1999-2000 crop season on plant height, total tillers, bearing tillers, panicle length, number of nodes/panicle, internodal length, number of capsules/plant and yield/plant as recommended in IPGRI descriptor 1994. The mean value obtained were used for determining phenotypic coefficient variation (PCV) and genotypic coefficient of variation (GCV) (Comstock and Robinson, 1952), heritability (Allard, 1960) and expected genetic advance (Johnson *et al.* 1955).

The analysis of variance (ANOVA) for nine characters indicated that there is a considerable variation in respect to all the characters studied. However, absolute variability in different characters cannot be the criteria for deciding, as to which character is showing the highest degree of variability. For this, computation of phenotypic variance ( $V_p$ ), genotypic variances ( $V_g$ ) and coefficient of variation was done. Table 1 shows that maximum variation in Malabar type was exhibited by number of capsules/plant followed by yield/plant and number of panicles both at genotypic and phenotypic levels. Similar observations were recorded by Gopal *et al.* 1995. The

**Table 1. Genotypic, phenotypic variances, coefficient of variation, heritability and genetic advance for various characters**

| Character             | $V_p$    | $V_g$    | PCV %  | GCV %  | Heritability %<br>(Broad sense) | Genetic<br>Advance | GA<br>(% of mean) |
|-----------------------|----------|----------|--------|--------|---------------------------------|--------------------|-------------------|
| Plant height          | 0.22     | 0.13     | 27.92  | 21.46  | 59.09                           | 0.57               | 0.01              |
| Total tillers         | 203.17   | 132.58   | 52.25  | 41.40  | 65.26                           | 19.16              | 5.32              |
| Bearing tillers       | 32.42    | 18.63    | 71.18  | 53.95  | 57.46                           | 6.69               | 0.53              |
| Number of panicles    | 1586.64  | 955.67   | 94.95  | 73.69  | 60.23                           | 49.23              | 20.65             |
| Panicle length        | 298.16   | 214.14   | 49.36  | 41.83  | 71.82                           | 25.55              | 8.93              |
| No. of nodes/panicle  | 49.96    | 35.00    | 43.05  | 36.03  | 70.06                           | 10.19              | 1.67              |
| Internodal length     | 3.52     | 0.99     | 62.30  | 33.06  | 28.13                           | 1.08               | 0.03              |
| No. of capsules/plant | 89526.79 | 66622.56 | 138.86 | 119.78 | 74.42                           | 458.57             | 222.10            |
| Yield/plant           | 68606.87 | 52297.75 | 148.77 | 129.89 | 76.23                           | 411.32             | 233.62            |

variance was very low for characters like plant height and internodal length.

In the present study (Table 1), GCV was less compared to that of PCV for all the characters indicating a considerable influence of the environment on their expression. The GCV, which exhibits the extent of genetic variability in the population, ranged from 21.46 (plant height) to 129.89 (yield/plant). The GCV values were considerably high for characters such as yield/plant, number of capsules/plant and number of panicles. The above mentioned characters having higher range of variation have a better scope for improvement through selection.

Characters such as plant height, panicle length and number of nodes/panicles had nearly equal PCV and GCV values indicating least influence of the environment on their expression. In such a situation, selection can be effective on the basis of the phenotype alone with equal probability of success.

On the basis of GCV alone, it is not possible to determine the amount of heritable variation. It can be found out with greater degree of accuracy when heritability in conjunction with genetic advance is studied (Dudley and Moll, 1969). Hence, both heritability and genetic advance were determined to study the scope of improvement in various characters through selection. The heritability estimates ranged from 28.13% for internodal length to 76.23% for yield/plant (Table 1). High heritability values were observed for yield/plant, number of capsules/plant, panicle length and number of nodes/panicle indicating less influence of environment on these traits. Moderate to low heritability for other characters indicating that environmental effects constitute a major portion of the total phenotypic variation

and hence, selection for these characters will be less effective.

Expected genetic advance and its estimated percentage mean for various characters (Table 1) revealed that yield/plant and number of capsules/plant exhibited the highest genetic advance. Though characters like panicle length, number of nodes/panicles and total tillers exhibited moderate to high heritability values, their GCV was comparatively less, resulting in less genetic advance. This confirms to findings of Burton (1952), that GCV together with heritability estimates would give a better picture of genetic advance to be expected from selection. The characters like yield/plant and number of capsules/plant possessing high GCV, heritability and genetic advance could be effectively used in selection, as it has been suggested that characters with high heritability coupled with high genetic advance would respond to selection better than those with high heritability and low genetic advance.

#### References

- Allard RW (1960) *Principles of Plant Breeding*. John Wiley and Sons, Inc. New York.
- Burton GW (1952) Quantitative Inheritance of Grasses. *Proc. 6<sup>th</sup> Intl. Grassland Congr.* 1: 277-283.
- Comstock RE and HF Robinson (1952) Genetic parameters, their estimation and significance. *Proc. Intl. Grassland Congr.* 1: 284-291
- Dudley JW and RH Moll (1969) Interpretation and uses of estimates of heritability and genetic variances in plant breeding. *Crop Sci.* 9: 257-262.
- Gopal R, D Chandramony and NK Nayar (1995) Genetic basis of yield components in cardamom. *J. Plantation Crops* 20 (supplement): 230-232.
- Johnson HW, HF Robinson and RE Comstock (1955) Estimates of genetic and environmental variability in soybean. *Agron J.* 47: 314-318.

## Genetic Variability of Aonla in Chhattisgarh

VK Gupta and BR Jana\*

NBPGR Regional Station, CHES Campus, Namkum, Ranchi-834010, Jharkhand

**Key Words:** Aonla, Germplasm, Variability, Cultivar

Aonla (Indian gooseberry) or myrobalan (*Emblica officinalis* Graertn. syn. *Phyllanthus emblica* L.), a minor popular fruit of commercial and medicinal importance belongs to the family Euphorbiaceae and is said to be indigenous to tropical South-East Asia, particularly central and southern India. The genus *Phyllanthus* comprises about 350 (Hooker, 1947) or even 500 species (Bailey, 1947), mostly shrubs, few herbs and trees. It has a vast scope of growing in wastelands like salt affected marginal forest soil. Aonla grown in North India have some limitation like, Banarasi is shy bearer, Chakaiya has small size fruits, Francis is affected by necrosis and more over all varieties of aonla are susceptible to shoot gall pest.

Ten fully ripe fruits were randomly collected from all over the tree, and then these fruits were analysed

for physico-chemical characteristics (Table 1). The total soluble solids were determined with the help of hand refractrometer. The acidity was found out by titrating the known quantity of juice against 0.1 N sodium hydroxide using phenolphthalein as indicator. Total sugar was estimated by Lane and Eynon method where Vitamin C was measured through 2, 6 dichlorophenol indophenol visual titration method.

An exploration was undertaken in the area of Chhattisgarh (Surguja District) hills to collect aonla germplasm. Some promising collections of aonla are listed in Table 2.

Among above collection, IC-259416 is deciduous in nature. Bajpai (1965) and Ram (1971) also cited that some aonla varieties of North India are deciduous. Cultivated varieties have very high acid content like

**Table 1. Horticultural and general characteristics of aonla germplasm**

| Accession No. | Tree Character                       | Fruit size (LxB) | Fruit size (cc) ( $\pi r^2$ ) | Fruit wt. (g) | Stripe | Skin   | Skin colour       | Pulp character   | Pulp thickness (mm) | Acidity (%) | TSS ( $^{\circ}$ B) | Total sugar | Firmness (lb/sq inch) | Ascorbic acid % mg in 100g pulp | Pulp stone ratio | Shape (L/B) ratio |
|---------------|--------------------------------------|------------------|-------------------------------|---------------|--------|--------|-------------------|------------------|---------------------|-------------|---------------------|-------------|-----------------------|---------------------------------|------------------|-------------------|
| IC-259416     | 1. Deciduous dwarf                   | 3.80             | 5.33                          | 4.681         | 6.00   | Smooth | Deep lemon green  | Transparent      | 0.615               | 2.56        | 8.00                | 4.230       | 22.50                 | 667.0                           | 12.30            | 0.92              |
| IC-259417     | 2. Evergreen standard                | 7.20             | 10.17                         | 8.486         | 6.00   | Rough  | Light lemon green | Semi Transparent | 0.880               | 1.47        | 13.00               | 3.906       | 21.20                 | 348.0                           | 15.71            | 0.93              |
| IC-259418     | 3. Evergreen standard                | 6.40             | 7.50                          | 7.2610        | 6.00   | Smooth | Yellow            | Transparent      | 0.625               | 2.11        | 14.50               | 8.460       | 23.25                 | 584.0                           | 11.80            | 0.92              |
| IC-259419     | 4. Evergreen standard                | 8.20             | 11.77                         | 9.619         | 5.00   | Rough  | Dark yellow       | Transparent      | 0.650               | 2.49        | 13.20               | 3.585       | 22.25                 | 715.0                           | 12.39            | 0.87              |
| IC-259420     | 5. Evergreen spreading               | 5.90             | 9.67                          | 6.280         | 6.00   | Rough  | Red blush         | Transparent      | 0.675               | 1.60        | 13.50               | 5.644       | 20.75                 | 374.0                           | 11.07            | 0.90              |
| IC-259421     | 6. Not known                         | 8.00             | 13.37                         | 9.550         | 6.00   | Smooth | Dark yellow       | Transparent      | 0.700               | 2.17        | 11.00               | 6.773       | 25.30                 | 617.0                           | 16.27            | 0.90              |
| IC-259422     | 7. Evergreen erect                   | 9.60             | 13.65                         | 10.310        | 6.00   | Smooth | Bright Yellow     | Transparent      | 1.100               | 2.36        | 7.50                | 5.644       | 23.12                 | 689.0                           | 13.80            | 0.89              |
| IC-259423     | 8. Evergreen standard                | 10.90            | 14.87                         | 12.050        | 6.00   | Smooth | Lemon green       | Transparent      | 0.933               | 2.43        | 9.00                | 5.644       | 26.00                 | 699.4                           | 13.50            | 0.84              |
| IC-259424     | 9. Evergreen spreading high yielding | 11.10            | 14.88                         | 12.150        | 7.00   | Smooth | Bright yellow     | Transparent      | 0.752               | 2.60        | 15.00               | 8.194       | 25.50                 | 604.0                           | 13.46            | 0.93              |
|               | 10. Kanchan evergreen spreading      | 27.80            | 29.03                         | 31.000        | 6.00   | Smooth | Yellow            | Transparent      | 0.400               | 2.10        | 11.53               | 11.300      | 23.31                 | 711.0                           | 17.50            | 0.93              |
|               | Sem                                  | 0.0532           | 0.0189                        | 0.0189        | 0.0506 | —      | —                 | —                | 0.0181              | 0.0179      | 0.0430              | 0.002       | 0.0192                | 0.5626                          | 0.0374           | 0.006             |
|               | CV%                                  | 0.9322           | 0.2512                        | 0.2939        | 1.4711 | —      | —                 | —                | 4.5311              | 1.4148      | 0.6413              | 0.0534      | 0.1588                | 0.1619                          | 0.4731           | 1.1446            |
|               | CD at 5%                             | 0.1576           | 0.0559                        | 0.0560        | 0.1498 | —      | —                 | —                | 0.0537              | 0.0529      | 0.1274              | 0.0058      | 0.0570                | 1.6659                          | 0.1109           | 0.0177            |

\* Central Horticultural Experimentation Station, IIHR, Namkum, Ranchi-834010, Jharkhand

**Table 2. Some promising collections of aonla germplasm**

| Accession No. | Collection from  | Characteristics                                                                                                                                                           |
|---------------|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IC-259416     | Sonhat Forest    | Tree is deciduous, fruit is very small with prominent ribs having transparent pulp but tolerant to shoot gall pest.                                                       |
| IC-259417     | Kalyanpur Forest | Fruit small with very low acid content (1.47%)                                                                                                                            |
| IC-259418     | Kharara Forest   | Fruit with high TSS (14.5°B).                                                                                                                                             |
| IC-259419     | Basantpur Forest | Fruit with very high ascorbic acid content (715.0 mg/100g pulp). Stripe is mostly 5(5.33).                                                                                |
| IC-259420     | Sonhat Forest    | Fruit with prominent red blush on skin. Rough skin with translucent pulp.                                                                                                 |
| IC-259421     | Wardraf Nagar    | Fruits are of medium size with high pulp stone ratio (16.27:1)                                                                                                            |
| IC-259422     | Sonhat Forest    | Fruit with acceptable pulp thickness (1.1 cm), bright yellow skin with transparent pulp.                                                                                  |
| IC-259423     | Sonhat Forest    | Fruit with very high flesh firmness (26.0 lb/sq inch). Transparent pulp with lemon green skin.                                                                            |
| IC-259424     | Basantpur Forest | Acceptable fruit weight (12.2 g). Skin yellow, attractive transparent pulp. Smooth skin with high TSS content of 15°B. Tree of prolific bearer. Stripe is mostly 7(7.22). |

Kanchan (2.2%) and Krishna (2%); (Singh *et al.* 1994). IC-259417 had 1.47% acidity, which is very high. In terms of ascorbic acid content. cultivar Kanchan had 711 mg/100 g pulp, while IC-259419 showed maximum Vitamin C content of 715 mg/100 g pulp. In case of cultivated aonlas, Krishna TSS is 14°B (Singh *et al.* 1994) whereas number IC 259424 had maximum TSS content of 15°B. Physiological properties of rest of the varieties are at par with cultivated varieties of aonla. Kanchan is 6 striped fruit, while IC-259419 and IC-259424 have (5.0) and (7.0) stripes, respectively. Ram (1971) also reported that number of perianth segments varied from 5-7.

### References

- WOI (1960) *The Wealth of India Raw Materials*. Publications and Information Directorate, CSIR, New Delhi.
- Baily LH (1947) *The Standard Encyclopedia of Horticulture*. Macmillan & CO, New York, pp 3547-48.
- Bajpai PN (1965) Studies on vegetative growth and development of male and female gametophyte in aonla (*Emblca officinalis* Gaertn). Agra University *J. Res. Sci.* 14: 1676-86.
- Hooker JD (1947) *The Flora of British India* Vol. II Periodical Experts, Delhi.
- Ram S (1971) Studies on Physiology of Fruit Growth in Aonla (*Emblca officinalis* Gaertn.) Ph.D. Thesis Kanpur University, Kanpur.
- Singh IS, Wahid Ali and RK Pathak (1994) New varieties of Indian Gooseberry. *Indian Hort.* 39: 3-5.

## Genetic Variability in Dolichos Bean

**RS Pan, AK Singh and Mathura Rai**

*Horticulture and Agro-forestry Research Programme, Plandu, Ranchi-834010, Jharkhand*

**Key Words: Dolichos Bean, Genetic Variability, Heritability, Genetic Advance**

Dolichos bean is commercially cultivated in Chhotanagpur region of Jharkhand for its proteinaceous tender pods used as fresh vegetable. To boost up the productivity of this crop, development and cultivation of new improved varieties are of urgent need. To achieve this target through genetic improvement, it is essential to assess the genetic variability for yield and its components. Parameters of genotypic and phenotypic coefficients of variation (GCV, PCV) are useful in detecting the amount of variability present in the available germplasm. Heritability and genetic advance help in determining the influence of environment in expression of the characters and the extent

to which improvement is possible after selection (Robinson *et al.* 1949). The present study was undertaken to quantify the variability in the indigenously collected dolichos bean germplasm for 14 yield-related characters and to select the promising parental lines based on performance for utilization in genetic enhancement programme.

The experimental material consisted of 25 indigenously collected germplasm of dolichos bean. These were evaluated at Horticulture and Agro-forestry Research programme (HEFRP, Ranchi) during autumn-winter season of 2000-01 in RBD with three replications. A spacing of 1 m x 75 cm was maintained. Six plants

**Table 2. Some promising collections of aonla germplasm**

| Accession No. | Collection from  | Characteristics                                                                                                                                                           |
|---------------|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IC-259416     | Sonhat Forest    | Tree is deciduous, fruit is very small with prominent ribs having transparent pulp but tolerant to shoot gall pest.                                                       |
| IC-259417     | Kalyanpur Forest | Fruit small with very low acid content (1.47%)                                                                                                                            |
| IC-259418     | Kharara Forest   | Fruit with high TSS (14.5°B).                                                                                                                                             |
| IC-259419     | Basantpur Forest | Fruit with very high ascorbic acid content (715.0 mg/100g pulp). Stripe is mostly 5(5.33).                                                                                |
| IC-259420     | Sonhat Forest    | Fruit with prominent red blush on skin. Rough skin with translucent pulp.                                                                                                 |
| IC-259421     | Wardraf Nagar    | Fruits are of medium size with high pulp stone ratio (16.27:1)                                                                                                            |
| IC-259422     | Sonhat Forest    | Fruit with acceptable pulp thickness (1.1 cm), bright yellow skin with transparent pulp.                                                                                  |
| IC-259423     | Sonhat Forest    | Fruit with very high flesh firmness (26.0 lb/sq inch). Transparent pulp with lemon green skin.                                                                            |
| IC-259424     | Basantpur Forest | Acceptable fruit weight (12.2 g). Skin yellow, attractive transparent pulp. Smooth skin with high TSS content of 15°B. Tree of prolific bearer. Stripe is mostly 7(7.22). |

Kanchan (2.2%) and Krishna (2%); (Singh *et al.* 1994). IC-259417 had 1.47% acidity, which is very high. In terms of ascorbic acid content. cultivar Kanchan had 711 mg/100 g pulp, while IC-259419 showed maximum Vitamin C content of 715 mg/100 g pulp. In case of cultivated aonlas, Krishna TSS is 14°B (Singh *et al.* 1994) whereas number IC 259424 had maximum TSS content of 15°B. Physiological properties of rest of the varieties are at par with cultivated varieties of aonla. Kanchan is 6 striped fruit, while IC-259419 and IC-259424 have (5.0) and (7.0) stripes, respectively. Ram (1971) also reported that number of perianth segments varied from 5-7.

### References

- WOI (1960) *The Wealth of India Raw Materials*. Publications and Information Directorate, CSIR, New Delhi.
- Baily LH (1947) *The Standard Encyclopedia of Horticulture*. Macmillan & CO, New York, pp 3547-48.
- Bajpai PN (1965) Studies on vegetative growth and development of male and female gametophyte in aonla (*Emblca officinalis* Gaertn). Agra University *J. Res. Sci.* 14: 1676-86.
- Hooker JD (1947) *The Flora of British India* Vol. II Periodical Experts, Delhi.
- Ram S (1971) Studies on Physiology of Fruit Growth in Aonla (*Emblca officinalis* Gaertn.) Ph.D. Thesis Kanpur University, Kanpur.
- Singh IS, Wahid Ali and RK Pathak (1994) New varieties of Indian Gooseberry. *Indian Hort.* 39: 3-5.

## Genetic Variability in Dolichos Bean

**RS Pan, AK Singh and Mathura Rai**

*Horticulture and Agro-forestry Research Programme, Plandu, Ranchi-834010, Jharkhand*

**Key Words: Dolichos Bean, Genetic Variability, Heritability, Genetic Advance**

Dolichos bean is commercially cultivated in Chhotanagpur region of Jharkhand for its proteinaceous tender pods used as fresh vegetable. To boost up the productivity of this crop, development and cultivation of new improved varieties are of urgent need. To achieve this target through genetic improvement, it is essential to assess the genetic variability for yield and its components. Parameters of genotypic and phenotypic coefficients of variation (GCV, PCV) are useful in detecting the amount of variability present in the available germplasm. Heritability and genetic advance help in determining the influence of environment in expression of the characters and the extent

to which improvement is possible after selection (Robinson *et al.* 1949). The present study was undertaken to quantify the variability in the indigenously collected dolichos bean germplasm for 14 yield-related characters and to select the promising parental lines based on performance for utilization in genetic enhancement programme.

The experimental material consisted of 25 indigenously collected germplasm of dolichos bean. These were evaluated at Horticulture and Agro-forestry Research programme (HEFRP, Ranchi) during autumn-winter season of 2000-01 in RBD with three replications. A spacing of 1 m x 75 cm was maintained. Six plants

were grown in each replication. Ten randomly selected pods were used for recording pod characters in each replication. Data were recorded on number of primary branches/plant, leaf length, leaf breadth, peduncle length, days to 50% flowering, pod length, pod breadth, pod girth, pod weight, number of seeds/pod and fresh pod yield/plant. Analysis of variance was calculated by the method suggested by Panse and Sukhatme (1985). The PCV were estimated as per Burton (1952). Heritability in a broad sense and genetic advance were computed according to Johnson *et al.* (1955).

The analysis of variance indicated highly significant differences among 25 genotypes for all the 14 quantitative characters (Table 1). All the characters exhibited considerable range in their expression. The maximum extent of genetic variability was exhibited by number of pods/plant followed by number of pods/peduncle, pod weight and pod breadth. Similar results were obtained by Baswana *et al.* (1980) in dolichos bean. The characters possessing high GCV values have a better scope of improvement through selection. The difference between GCV and PCV was not of high magnitude for all the characters which indicated the minimum influence of

environment in expression of these characters. This suggests that selection can be effective on the basis of phenotype alone with equal probability of success. With the help of GCV alone, it is not possible to determine the extent of variation that is heritable. So, the knowledge of heritability of a character helps the plant breeder in predicting the genetic advance for any quantitative character and aids in exercising necessary selection pressure. The broad sense heritability was very high for pod weight, pod breadth, peduncle length, pod length, number of seeds/pod, number of pods/peduncle and number of pods/plant indicating less influence of environment on these traits. The heritability estimate of yield was of moderate level which suggested that environment effects constituted a major portion of total phenotype variation and hence, direct selection for yield would be less effective.

Johnson *et al.* (1955) reported that the heritability estimate along with genetic advance is more useful than the heritability alone in predicting the resultant effect of selecting the best individual genotype as it suggests the presence of additive gene effects (Panse, 1957). High heritability along with high genetic advance was

**Table 1. Mean sum of squares (treatment), mean, range, parameters of variance, heritability and genetic advance for 14 characters in dolichos bean germplasm**

| Characters                       | Mean sum of squares | Mean   | Range        | Coefficient of variation |                | Heritability (%) | Genetic advance (K=2.06) | GA as %age of mean |
|----------------------------------|---------------------|--------|--------------|--------------------------|----------------|------------------|--------------------------|--------------------|
|                                  |                     |        |              | Genotypic (%)            | Phenotypic (%) |                  |                          |                    |
| Number of primary branches/plant | 0.69**              | 3.67   | 2.48-4.45    | 9.49                     | 18.23          | 27.10            | 0.37                     | 10.08              |
| Leaf length (cm)                 | 3.56**              | 7.60   | 5.08-9.48    | 12.96                    | 16.72          | 60.04            | 1.57                     | 20.65              |
| Leaf breadth (cm)                | 3.50**              | 7.15   | 4.89-9.05    | 13.24                    | 18.26          | 52.54            | 1.41                     | 19.72              |
| Peduncle length (cm)             | 138.61**            | 26.65  | 15.46-36.20  | 25.30                    | 25.91          | 95.33            | 13.56                    | 50.89              |
| Days to 50% flowering            | 831.52**            | 105.88 | 68.00-121.67 | 15.29                    | 16.55          | 85.43            | 30.83                    | 29.18              |
| Pod length (cm)                  | 12.61**             | 10.54  | 4.74-13.69   | 19.27                    | 19.81          | 94.62            | 04.07                    | 38.61              |
| Pod breadth (cm)                 | 4.82**              | 2.53   | 1.21-5.21    | 49.96                    | 50.25          | 98.83            | 02.59                    | 102.37             |
| Pod girth (cm)                   | 0.06**              | 1.08   | 0.87-1.52    | 12.84                    | 14.06          | 83.43            | 26.16                    | 2422.22            |
| Pod weight (g)                   | 62.40**             | 9.08   | 3.30-19.60   | 50.14                    | 50.30          | 99.38            | 09.36                    | 102.97             |
| Number of pods/peduncle          | 75.32**             | 7.19   | 2.34-19.50   | 68.53                    | 72.02          | 90.55            | 09.65                    | 134.21             |
| Number of pods/node              | 6.49**              | 4.22   | 2.67-8.43    | 30.18                    | 42.75          | 49.85            | 01.85                    | 43.84              |
| Number of pods/plant             | 130869.30**         | 273.10 | 96.99-933.19 | 75.08                    | 79.19          | 89.90            | 400.52                   | 146.71             |
| Number of seeds/pod              | 0.86**              | 5.08   | 2.93-5.87    | 10.38                    | 10.82          | 91.98            | 01.04                    | 20.47              |
| Fresh pod yield/plant (kg)       | 1.52**              | 1.88   | 0.88-3.95    | 34.05                    | 44.38          | 58.86            | 1.01                     | 56.11              |

\*\* Significant at 1% level

recorded in characters viz.- pod weight, pod breadth, number of pods/peduncle and number of pods/plant. These characters also recorded high values of GCV and PCV which indicated that these characters could be improved through individual plant selection. The above results are in agreement with the findings of Baswana *et al.* (1980) who reported high values of GCV, heritability and genetic advance for pod weight, pod width and number of pods per cluster and Rathnaiah (1985) who reported the same trend for number of pods/plant in dolichos bean.

The high genetic variability and heritability along with genetic advance expressed by the above mentioned four characters indicated that the genotypes could be evaluated in multilocal trials and selected as donors for these traits and used as parents in hybridisation programme.

## References

- Baswana KS, ML Pandita, BS Dhankar and PS Partap (1980) Genetic variability and heritability studies on Indian bean (*Dolichos lablab* var. *lignosus* L.). *Haryana J. Hortic. Sci.* 9: 52-55.
- Burton GW (1952) Quantitative inheritance in grasses. *Proc. 6<sup>th</sup> Intl. Grassland Congr.* 1: 277-288.
- Johnson HW, HF Robinsons and RE Comstock (1955) Estimates of genetic and environmental variability in soybean. *Agron. J.* 47:314-318.
- Panase VG (1957) Genetics of quantitative characters in relation to plant breeding. *Indian J. Genet.* 47: 318-328.
- Panase VG and PV Sukhatme (1985) *Statistical Methods for Agricultural Workers*. 4<sup>th</sup> ed. ICAR, New Delhi.
- Rathnaiah TR (1985) The study of variability and formulation of selection indices for vegetable yield in field bean (*Lablab purpureus* L. Sweet). *Mysore J. Agric. Sci.* 19: 216.
- Robinson HF, RE Comstock and PH Hervey (1949) Estimates of heritability and degree of dominance in corn. *Agron. J.* 41: 353-359.

## Collection, Characterization and Evaluation of Rice Germplasm from Bastar Region

**IV Subba Rao, GSV Prasad, U Prasada Rao, A Rama Prasad, TL Acharyulu and S Rama Krishna**  
*Directorate of Rice Research, Rajendranagar, Hyderabad-500030, Andhra Pradesh*

**Key words:** Rice, Collection, Characterization

Landraces have low yielding capacity but possess high yield stability which is important for subsistence farming. Genetic diversity probably serves as an insurance against crop failure. The landraces may be regarded as natural composite varieties that have an array of resistant genes and are well buffered so that no single race or biotype of plant pest can attack at an epidemic level. Systematic study and characterization of germplasm is of great importance for current and future agronomic and genetic improvement of the rice crop. There is a need to extensively collect, exploit and evaluate hitherto untapped genetic productivity of the germplasm. Under NATP project on Plant Biodiversity, an attempt was made to undertake survey and collection of paddy germplasm in Bastar area of Dandakaranya region (Chhattisgarh) and further to characterize and identify variability available in the collection. The collection involved 123 native cultivars and landraces some of which are under cultivation by tribal community of Bastar area. The collection was

made from two blocks involving 21 villages and 71 farmer's fields. The materials were grown during wet season, 2000 at DRR Experimental Farm in three rows of 1.5 m long and 30 cm apart. Standard agronomic practices were followed and the seed was harvested at 14% moisture content. Cultivars were characterized using morpho-agronomic descriptors (IRRI, 1996). Data were recorded on 11 morphological traits and 9 agronomic features. Statistical analyses were done to estimate the frequency distribution for agro-morphological characters, variability and correlation among agronomic traits of germplasm.

Frequency distribution for 11 morphological characters (discontinuous variables) are presented in Table 1. A majority of cultivars were found to possess green basal leaf sheath (65%), green leaf blade (38%), light green collar (60%), white ligule (85%), light green auricle (59%), straw coloured apiculus (57%), white stigma (57%). Plant habit included erect (54%), semi

recorded in characters viz.- pod weight, pod breadth, number of pods/peduncle and number of pods/plant. These characters also recorded high values of GCV and PCV which indicated that these characters could be improved through individual plant selection. The above results are in agreement with the findings of Baswana *et al.* (1980) who reported high values of GCV, heritability and genetic advance for pod weight, pod width and number of pods per cluster and Rathnaiah (1985) who reported the same trend for number of pods/plant in dolichos bean.

The high genetic variability and heritability along with genetic advance expressed by the above mentioned four characters indicated that the genotypes could be evaluated in multilocal trials and selected as donors for these traits and used as parents in hybridisation programme.

## References

- Baswana KS, ML Pandita, BS Dhankar and PS Partap (1980) Genetic variability and heritability studies on Indian bean (*Dolichos lablab* var. *lignosus* L.). *Haryana J. Hortic. Sci.* 9: 52-55.
- Burton GW (1952) Quantitative inheritance in grasses. *Proc. 6<sup>th</sup> Intl. Grassland Congr.* 1: 277-288.
- Johnson HW, HF Robinsons and RE Comstock (1955) Estimates of genetic and environmental variability in soybean. *Agron. J.* 47:314-318.
- Panase VG (1957) Genetics of quantitative characters in relation to plant breeding. *Indian J. Genet.* 47: 318-328.
- Panase VG and PV Sukhatme (1985) *Statistical Methods for Agricultural Workers*. 4<sup>th</sup> ed. ICAR, New Delhi.
- Rathnaiah TR (1985) The study of variability and formulation of selection indices for vegetable yield in field bean (*Lablab purpureus* L. Sweet). *Mysore J. Agric. Sci.* 19: 216.
- Robinson HF, RE Comstock and PH Hervey (1949) Estimates of heritability and degree of dominance in corn. *Agron. J.* 41: 353-359.

## Collection, Characterization and Evaluation of Rice Germplasm from Bastar Region

**IV Subba Rao, GSV Prasad, U Prasada Rao, A Rama Prasad, TL Acharyulu and S Rama Krishna**  
*Directorate of Rice Research, Rajendranagar, Hyderabad-500030, Andhra Pradesh*

**Key words:** Rice, Collection, Characterization

Landraces have low yielding capacity but possess high yield stability which is important for subsistence farming. Genetic diversity probably serves as an insurance against crop failure. The landraces may be regarded as natural composite varieties that have an array of resistant genes and are well buffered so that no single race or biotype of plant pest can attack at an epidemic level. Systematic study and characterization of germplasm is of great importance for current and future agronomic and genetic improvement of the rice crop. There is a need to extensively collect, exploit and evaluate hitherto untapped genetic productivity of the germplasm. Under NATP project on Plant Biodiversity, an attempt was made to undertake survey and collection of paddy germplasm in Bastar area of Dandakaranya region (Chhattisgarh) and further to characterize and identify variability available in the collection. The collection involved 123 native cultivars and landraces some of which are under cultivation by tribal community of Bastar area. The collection was

made from two blocks involving 21 villages and 71 farmer's fields. The materials were grown during wet season, 2000 at DRR Experimental Farm in three rows of 1.5 m long and 30 cm apart. Standard agronomic practices were followed and the seed was harvested at 14% moisture content. Cultivars were characterized using morpho-agronomic descriptors (IRRI, 1996). Data were recorded on 11 morphological traits and 9 agronomic features. Statistical analyses were done to estimate the frequency distribution for agro-morphological characters, variability and correlation among agronomic traits of germplasm.

Frequency distribution for 11 morphological characters (discontinuous variables) are presented in Table 1. A majority of cultivars were found to possess green basal leaf sheath (65%), green leaf blade (38%), light green collar (60%), white ligule (85%), light green auricle (59%), straw coloured apiculus (57%), white stigma (57%). Plant habit included erect (54%), semi

spreading (30%) and spreading (16%) types. Cultivars were classified into moderately exerted (79%), and well exerted (21%) on the basis of panicle exertion. Open type panicle and horizontal flag leaf are other traits that were encountered in large number of varieties. Frequency distribution for 9 continuous variable descriptors are presented in Table 2. Dominant group included varieties in mid early groups with 105-125 day maturity duration; semi dwarf plants; 30-40 cm leaf length, 0.05 leaf width, 25-30 cm panicle length, 10-20 tillers; 10-20 panicles; 100-150 filled grains/panicle and 2-3 grams of 100-grain weight. Variability parameters of 9 agronomic features are given in Table 3. Maturity data was variable with a difference of 103-150 days between the earliest and the latest maturing accessions. Plant height varied widely from 64 to 123 cm. HMT Super and Sonam were the shortest,

while Dadamali was the tallest cultivar. Variability was pronounced in leaf length (22-56 cm). Culm number ranged between 7-32 while the effective tillers were in the range of 3-26. A maximum of 325 fertile grains/panicle and 3.4 gms of 100-grain weight were recorded in the collection. Occurrence of such desirable features in this germplasm collection and variability encountered would help in exploitation and development of agronomically superior genotypes. Evaluation of these accessions against various bio-constraints is in progress at various hot spot centres across the country.

Phenotype correlation among the agronomic characters are given in Table 4. Positive and significant association were established between leaf length and maturity (0.304\*\*), plant height (0.424\*\*) or leaf width

**Table 1. Frequency distribution for morphological characters in rice germplasm**

| Character               | Code | Frequency |
|-------------------------|------|-----------|
| Basal leaf sheath color | 1    | 80        |
|                         | 2    | 43        |
|                         | 3    | 0         |
| Leaf blade color        | 1    | 43        |
|                         | 2    | 47        |
|                         | 3    | 31        |
|                         | 4    | 2         |
| Collar color            | 1    | 74        |
|                         |      | 14        |
|                         | 2    |           |
| Ligule color            | 3    | 35        |
|                         | 1    | 85        |
|                         | 2    | 13        |
| Auricle color           | 3    | 25        |
|                         | 1    | 73        |
|                         | 2    | 14        |
| Apiculus color          | 1    | 47        |
|                         | 2    | 70        |
|                         | 3    | 6         |
| Stigma color            | 1    | 70        |
|                         | 2    | 53        |
| Plant type              | 1    | 19        |
|                         | 2    | 37        |
|                         | 3    | 67        |
| Panicle type            | 1    | 3         |
|                         | 2    | 23        |
|                         | 3    | 97        |
| Panicle exertion        | 1    | 3         |
|                         | 2    | 23        |
|                         | 3    | 97        |
| Flag leaf               | 1    | 73        |
|                         | 2    | 48        |
|                         | 3    | 2         |
|                         | 3    | 2         |

**Table 2. Frequency distribution for agronomic characters in germplasm collection**

| Character        | Class         | Frequency |
|------------------|---------------|-----------|
| Days to Maturity | 0-105         | 7         |
|                  | 105-125       | 102       |
|                  | 125-140       | 10        |
|                  | 140 and above | 4         |
| Plant height     | 50-100        | 77        |
|                  | 100-150       | 46        |
| Leaf length      | 20-30         | 21        |
|                  | 30-40         | 83        |
|                  | 40-50         | 17        |
|                  | 50-60         | 2         |
| Leaf width       | 0-0.5         | 122       |
|                  | 0.5-1         | 1         |
| Panicle length   | 15-20         | 3         |
|                  | 20-25         | 16        |
|                  | 25-30         | 86        |
|                  | 30-35         | 17        |
| Culm number      | 0-10          | 20        |
|                  | 10-20         | 96        |
|                  | 20-30         | 6         |
|                  | 30-40         | 1         |
| Panicle number   | 10-20         | 98        |
|                  | 20-30         | 23        |
|                  | 30-40         | 2         |
| Grain/panicle    | 0-50          | 2         |
|                  | 50-100        | 35        |
|                  | 100-150       | 60        |
|                  | 150-200       | 18        |
|                  | 200-250       | 3         |
| 100-grain weight | 250-300       | 4         |
|                  | 300-350       | 1         |
|                  | 0-1           | 5         |
|                  | 1-2           | 51        |
|                  | 2-3           | 63        |
|                  | 3-4           | 2         |

**Table 3. Variability parameters for agronomic characters in germplasm collection**

|          | Mat   | Ht    | LL    | LW    | PnL   | CmN   | PnN   | G/P    | GW    |
|----------|-------|-------|-------|-------|-------|-------|-------|--------|-------|
| Minimum  | 73    | 64    | 22    | 0.5   | 13.5  | 7     | 3     | 48.33  | 0.9   |
| Maximum  | 120   | 123   | 56    | 1.1   | 35.5  | 32    | 26    | 325    | 3.4   |
| Mean     | 88.69 | 96.46 | 34.89 | 0.86  | 22.77 | 14.22 | 8.50  | 125.57 | 2.05  |
| STD      | 8.32  | 9.62  | 5.58  | 0.09  | 2.97  | 4.18  | 3.79  | 48.58  | 0.48  |
| Skewness | 1.27  | -1.16 | 0.51  | -0.12 | 0.07  | 1.49  | 1.58  | 1.45   | -0.32 |
| Kurtosis | 3.38  | 2.39  | 1.68  | 0.92  | 3.05  | 3.61  | 3.92  | 3.03   | 0.28  |
| CV%      | 9.38  | 9.97  | 15.98 | 10.79 | 13.06 | 29.41 | 44.66 | 38.69  | 23.26 |

Mat: Days to maturity; Ht: Plant Height (cm); LL: Leaf length; LW: Leaf width; PnL: Panicle length; CmN: Culm number; PnN: Panicle number; G/P: Grains/panicle; GW: 100-grain weight.

**Table 4. Phenotypic correlations among agronomic characters of germplasm collection**

|     | Mat      | Ht       | LL       | LW      |
|-----|----------|----------|----------|---------|
| PnL | CmN      | PnN      | G/P      | GW      |
| Mat | -        |          |          |         |
| Ht  | 0.146    | -        |          |         |
| LL  | 0.304**  | 0.424**  | -        |         |
| LW  | 0.114    | 0.246**  | 0.253**  | -       |
| PnL | 0.069    | 0.144    | 0.136    | -0.031  |
| CmN | -0.104   | -0.231   | -0.235** | -0.195* |
| PnN | -0.241** | -0.385** | -0.386** | -0.216* |
| G/P | -0.017   | 0.029    | -0.125   | 0.0004  |
| GW  | -0.054   | 0.129    | 0.142    | -0.037  |

Mat: days to maturity; Ht: Plant Height (cm); LL: Leaf length; LW: Leaf width; PnL: Panicle length; CmN: Culm number; PnN: Panicle number; G/P: Grains per panicle; GW: 100-grain weight.

(0.253\*\*) between leaf width and plant height (0.246\*\*). Conversely, negative and significant associations were found between culm number and leaf length (-0.235\*\*) or leaf width (-0.195\*), panicle number with leaf length (-0.386\*\*), plant height (-0.385\*\*), maturity (-0.241\*\*) or leaf width (-0.216\*\*). The study suggests that tall plants result in few panicles but higher leaf length, leaf width, late maturing cultivars manifest higher leaf length but fewer panicles. Shorter leaf length and smaller leaf width in the study is indicative of higher culm and panicle number which is a very important clue to derive productive selections for higher yields.

Identification and description of the genetic variability in germplasm collection would help in exploitation of useful traits in plant breeding and genetic improvement of rice.

#### Reference

IRRI (1996) Standard Evaluation System for Rice. International Rice Research Institute, Manila, Philippines.

## Pollination Management Perspectives of Berseem Crop – Chicory Weed Association

**D Sarveswara Rao, Sonika, Meenakshi Singhal and Priya Kansal**

Dayalbagh Educational Institute, Dayalbagh, Agra-282005, Uttar Pradesh

**Key Words:** *Trifolium alexandrinum*, Berseem, *Cichorium intybus*, Pollination

Aspects of current agricultural production have been under serious review with a philosophical shift to sustainable agriculture. Productivity of the crop plants is greatly reduced by failure to achieve full reproductive capacity (Punjab Singh, 1988). Seed yield

in sexually reproducing plants is linked to the success of pollination and fertilization processes, that in turn, depend on the adaptation of the crop to the area in which it is grown, the availability of effective pollen vectors and the molecular interaction of pollen-pistil

**Table 3. Variability parameters for agronomic characters in germplasm collection**

|          | Mat   | Ht    | LL    | LW    | PnL   | CmN   | PnN   | G/P    | GW    |
|----------|-------|-------|-------|-------|-------|-------|-------|--------|-------|
| Minimum  | 73    | 64    | 22    | 0.5   | 13.5  | 7     | 3     | 48.33  | 0.9   |
| Maximum  | 120   | 123   | 56    | 1.1   | 35.5  | 32    | 26    | 325    | 3.4   |
| Mean     | 88.69 | 96.46 | 34.89 | 0.86  | 22.77 | 14.22 | 8.50  | 125.57 | 2.05  |
| STD      | 8.32  | 9.62  | 5.58  | 0.09  | 2.97  | 4.18  | 3.79  | 48.58  | 0.48  |
| Skewness | 1.27  | -1.16 | 0.51  | -0.12 | 0.07  | 1.49  | 1.58  | 1.45   | -0.32 |
| Kurtosis | 3.38  | 2.39  | 1.68  | 0.92  | 3.05  | 3.61  | 3.92  | 3.03   | 0.28  |
| CV%      | 9.38  | 9.97  | 15.98 | 10.79 | 13.06 | 29.41 | 44.66 | 38.69  | 23.26 |

Mat: Days to maturity; Ht: Plant Height (cm); LL: Leaf length; LW: Leaf width; PnL: Panicle length; CmN: Culm number; PnN: Panicle number; G/P: Grains/panicle; GW: 100-grain weight.

**Table 4. Phenotypic correlations among agronomic characters of germplasm collection**

|     | Mat      | Ht       | LL       | LW      |
|-----|----------|----------|----------|---------|
| PnL | CmN      | PnN      | G/P      | GW      |
| Mat | -        |          |          |         |
| Ht  | 0.146    | -        |          |         |
| LL  | 0.304**  | 0.424**  | -        |         |
| LW  | 0.114    | 0.246**  | 0.253**  | -       |
| PnL | 0.069    | 0.144    | 0.136    | -0.031  |
| CmN | -0.104   | -0.231   | -0.235** | -0.195* |
| PnN | -0.241** | -0.385** | -0.386** | -0.216* |
| G/P | -0.017   | 0.029    | -0.125   | 0.0004  |
| GW  | -0.054   | 0.129    | 0.142    | -0.037  |

Mat: days to maturity; Ht: Plant Height (cm); LL: Leaf length; LW: Leaf width; PnL: Panicle length; CmN: Culm number; PnN: Panicle number; G/P: Grains per panicle; GW: 100-grain weight.

(0.253\*\*) between leaf width and plant height (0.246\*\*). Conversely, negative and significant associations were found between culm number and leaf length (-0.235\*\*) or leaf width (-0.195\*), panicle number with leaf length (-0.386\*\*), plant height (-0.385\*\*), maturity (-0.241\*\*) or leaf width (-0.216\*\*). The study suggests that tall plants result in few panicles but higher leaf length, leaf width, late maturing cultivars manifest higher leaf length but fewer panicles. Shorter leaf length and smaller leaf width in the study is indicative of higher culm and panicle number which is a very important clue to derive productive selections for higher yields.

Identification and description of the genetic variability in germplasm collection would help in exploitation of useful traits in plant breeding and genetic improvement of rice.

#### Reference

IRRI (1996) Standard Evaluation System for Rice. International Rice Research Institute, Manila, Philippines.

## Pollination Management Perspectives of Berseem Crop – Chicory Weed Association

**D Sarveswara Rao, Sonika, Meenakshi Singhal and Priya Kansal**

Dayalbagh Educational Institute, Dayalbagh, Agra-282005, Uttar Pradesh

**Key Words:** *Trifolium alexandrinum*, Berseem, *Cichorium intybus*, Pollination

Aspects of current agricultural production have been under serious review with a philosophical shift to sustainable agriculture. Productivity of the crop plants is greatly reduced by failure to achieve full reproductive capacity (Punjab Singh, 1988). Seed yield

in sexually reproducing plants is linked to the success of pollination and fertilization processes, that in turn, depend on the adaptation of the crop to the area in which it is grown, the availability of effective pollen vectors and the molecular interaction of pollen-pistil

recognition systems (Shivanna and Sawhney 1997; Torchio 1995).

*Trifolium alexandrinum* L. is a widely adapted Rabi season legume fodder crop and *Cichorium intybus* L. (Asteraceae; Chicory) is found as dominant weed of berseem fields with an equal capacity to regenerate its vegetative shoots along with berseem after subsequent cuts. As the sowing and flowering time of chicory also coincides with that of berseem, generally, the market seed samples of berseem contain chicory seed as an adulterant. Chicory is also a major weed in other Rabi seasonal grain legume crops like chickpea, summer green gram and French bean reducing the yields from 35-83.3 per cent (Jain *et al.* 1997).

This peculiar berseem crop-chicory weed association necessitated an agronomic survey of selected villages from all the six tehsils of Agra District. The survey brought to light the practices of various sowing proportions of population mixtures of crop and weed taxa, ranging from instances where chicory not only dominated in the berseem fields, but even it is becoming the exclusive choice of farmers for fodder production, reason being that berseem performed poorly in specific location (Satsangi and Gautam, 1983).

The co-flowering nature of the crop and weed demands a comprehensive understanding of the reproductive biology and the interrelationships of berseem crop-chicory weed-insect pollinator complex, to evolve an eco-friendly pollination management strategy towards enhancing seed yields (Daphni 1992; Arroyo, 1981).

On the basis of sampling studies with quadrats, it is estimated that in berseem (cv Wardan) on an average there are about 1.39 million inflorescences/hectare which amount to about 132.34 million flowers/ha. In the experimental farm, about 62.66 insect visitors/m<sup>2</sup>/5 min were observed. The honeybee took about 13.65 seconds/inflorescence and paid visits to about 21.125 inflorescences/5 min, whereas the butterfly visited 16.75 berseem inflorescences/5 min. The average pollen load on stigma and its immediate neighbourhoods was about 65.05, however, contamination with other pollen species was not observed as the insect species confined to the same species in the field. The vegetative shoots bear about 1.606 inflorescences, and about 112 shoots/m<sup>2</sup> were present. Even though the average number of flowers/inflorescence was about 95.211, the average number of seed set in open-pollinated fields is depressingly low at 33.19/inflorescence. Extremely low level of bee

population to offer tripping services to flowers in the field seems to be the major cause besides ovule/embryo abortions. In caged plants, where honeybee visits were excluded, it resulted in 3.612 seeds per inflorescence (Shukla and Patil, 1985). Chowdhary *et al.* (1966) stated that berseem is a self-pollinated crop but tripping by honey bee is essential for seed-setting.

In chicory, about 109.83 capitula/plant were recorded with each head inflorescence having 13.35 florets. It is highly self-incompatible and cross-pollinated. Kumar *et al.* (1993) recorded about 17 insect species from 13 genera and 9 families visiting the flowers and *Bombus* species were the most abundant and honeybees were not seen visiting chicory. Insect foraging activity was confined to the forenoon only, as the flowers changed color and closed the petals in the afternoon while the berseem bloom persisted throughout the day on the plant. Butterflies preferred to visit chicory in the morning session and the berseem flowers the rest of the day. The average seed setting in chicory is 9.1/capitulum, which holds about 13.35 florets/capitulum.

The results indicate that berseem and chicory do not compete for the insect pollinator. On the other hand, together they help in enhancing the pollinator biodiversity in the field. Chicory seed yield did not suffer from under-pollination, whereas for berseem, accommodating beehive boxes in the field is necessary for achieving higher and quality seed-yield and also generating supplementary income to the farmer through honey production. United States of America, Canada and New Zealand studies indicate that chicory can be a potential forage crop along with grasses/legumes. Optimization of agronomic practices for legume-chicory combinations and reorientation of breeding and improvement strategies towards it are the need of the hour in the Indian context (Kunelius and Mac Rae, 1999).

## References

- Arroyo HTK (1981) Breeding Systems and Pollination Biology in Leguminosae. In: RM Polhill and RH Raven (ed.), *Advances in Legume Systematics*. Kew: (Royal Botanic Garden), 723-769.
- Chowdhary JB, RK Mehra, and AB Joshi (1966) Pollination in Berseem. *Indian J. Genet.* 26: 118-120.
- Daghni A (1992) Pollination Ecology: A practical approach. Oxford IRL. Press.
- Jain KK, KK Agarwal and CL Nakhtore (1997) Weed dynamics of Kharif and Rabi season at research farm of JNKVV, Jabalpur. *MP. World Weeds* 4: 3-4, 137-141.

- Kumar J, RC Mishra and JK Gupta (1993) Foraging activity and abundance of insect visitors to chicory (*Cichorium intybus* L) in mid-hills of Himachal Pradesh, India. *Indian Bee J.* **55**: 3-4, 31-36.
- Kunelius HT and KB Mac Rae (1999) Forage chicory persists with cool season grasses and legumes. *Canadian J. Plant Sciences* **79**:197-200.
- Punjab Singh (1988) Pasture and Forage Crop Research. A state of knowledge report. Range Management Society of India, IGRI, Jhansi. India, 1-440.
- Satsangi PS and V Gautam (1983) *Management of Rural Energy Systems*. Galgotia Publications, New Delhi, 360p.
- Shivanna KR and VK Sawhney (1997) *Pollen Biotechnology for Crop Production and Improvement*. Cambridge Univ. Press.
- Shukla GP and BS Patil (1985) Breeding Egyptian clover – a review. *Forage Res.* **11**: 1-19.
- Torchio PF (1995) Pollination of cultivated crops in the tropics, Rome: *FAO Agriculture Services Bull. No. 118*, 85p.

## Oil and Erucic Acid Content in Oilseed Crucifers

**S Mandal, Sangita Yadav, Ranbir Singh, Gulnaz Begum, Poonam Suneja and M Singh**

Biochemistry Laboratory, Germplasm Evaluation Division, National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012

**Key Words:** *Brassica* species, Crucifer, Erucic acids, Oil percentage

The fatty acid composition of the crucifer oil is genetically more variable than probably the composition of any other major vegetable oil (Matti, 1993). Palmitic, stearic, oleic, linoleic, linolenic, eicosenoic and erucic acid are the major fatty acids present in the oil extracted from members of family Cruciferae. Fatty acids are formed by step-wise biosynthetic pathway in which oleic acid either undergoes decreasing saturation to form linoleic acid and then linolenic acid or there is further chain elongation to form eicosenoic acid and then to erucic acid. Crucifers, compared to other oilseed crops are quite unique for exhibiting very high proportion of erucic acid (anti-nutritional factor). Erucic acid constitutes about 50% of the total fatty acids. It is considered as anti-nutritional because heavy accumulation of triglycerides and cholesterol esters containing erucic acid is observed in the heart of the rats fed with rapeseed oil (Saur and Kramer, 1983). This is mainly because erucic acid is metabolically inert, as it does not enter into the  $\beta$ -oxidation pathway to produce ATP (Joyee, 1978). Ziemiński *et al.* (1995) also concluded some harmful effects of high erucic rapeseed oil on the body. Although major breakthrough has been achieved with the production of low erucic acid and also low linolenic acid rapeseed varieties (Prevot, 1990) but most of the accessions with lower erucic acid are not acceptable for commercial production partially because of late maturity and lower oil yield under normal cultivation practices (Rucker and Robblen, 1996).

In the present communication, 153 accessions of different *Brassica* and alien species were studied for their total oil percentage and erucic acid concentration. Erucic acid content of species as well as high and low erucic acid containing *B. napus* lines were compared on the basis of their mean values.

One hundred and fifty three collections of rapeseed-mustard were built up through introduction, exchange and exploration activities of NBPGR, New Delhi. Germplasm comprising of *Brassica juncea* (47), *B. napus* (17), *B. campestris* var. yellow sarson (30), *B. campestris* var. toria (17), *B. campestris* var. brown sarson (12), *B. carinata* (4), *B. nigra* (7), *B. rapa* (1), *Eruca sativa* (6), *Sinapis alba* (4), *Crambe abyssinica* (1), *B. juncea* ssp *rugosa* (1), *B. chinensis* (3), *Raphanus caudatus* (1) and *Raphanus sativus* (2), were grown during rabi season 1999-2000 at Issapur experimental farm, NBPGR, New Delhi. Three rows of each accessions were planted with recommended basal dose of fertilizer, following normal cultural practices and plant protection measures. Seeds were harvested when plants attained complete physiological maturity. The data on five plants in each genotype was recorded. The mature seed were used for oil and fatty acid analysis. The presented data are the mean of analysis performed in triplicate. Seeds were dried to 4-5% moisture level in oven at 108°C for 16-18 h. The oil content of the seed samples were determined by non-destructive method using Newport NMR analyzer

- Kumar J, RC Mishra and JK Gupta (1993) Foraging activity and abundance of insect visitors to chicory (*Cichorium intybus* L) in mid-hills of Himachal Pradesh, India. *Indian Bee J.* **55**: 3-4, 31-36.
- Kunelius HT and KB Mac Rae (1999) Forage chicory persists with cool season grasses and legumes. *Canadian J. Plant Sciences* **79**:197-200.
- Punjab Singh (1988) Pasture and Forage Crop Research. A state of knowledge report. Range Management Society of India, IGRI, Jhansi. India, 1-440.
- Satsangi PS and V Gautam (1983) *Management of Rural Energy Systems*. Galgotia Publications, New Delhi, 360p.
- Shivanna KR and VK Sawhney (1997) *Pollen Biotechnology for Crop Production and Improvement*. Cambridge Univ. Press.
- Shukla GP and BS Patil (1985) Breeding Egyptian clover – a review. *Forage Res.* **11**: 1-19.
- Torchio PF (1995) Pollination of cultivated crops in the tropics, Rome: *FAO Agriculture Services Bull. No. 118*, 85p.

## Oil and Erucic Acid Content in Oilseed Crucifers

**S Mandal, Sangita Yadav, Ranbir Singh, Gulnaz Begum, Poonam Suneja and M Singh**

Biochemistry Laboratory, Germplasm Evaluation Division, National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012

**Key Words:** *Brassica* species, Crucifer, Erucic acids, Oil percentage

The fatty acid composition of the crucifer oil is genetically more variable than probably the composition of any other major vegetable oil (Matti, 1993). Palmitic, stearic, oleic, linoleic, linolenic, eicosenoic and erucic acid are the major fatty acids present in the oil extracted from members of family Cruciferae. Fatty acids are formed by step-wise biosynthetic pathway in which oleic acid either undergoes decreasing saturation to form linoleic acid and then linolenic acid or there is further chain elongation to form eicosenoic acid and then to erucic acid. Crucifers, compared to other oilseed crops are quite unique for exhibiting very high proportion of erucic acid (anti-nutritional factor). Erucic acid constitutes about 50% of the total fatty acids. It is considered as anti-nutritional because heavy accumulation of triglycerides and cholesterol esters containing erucic acid is observed in the heart of the rats fed with rapeseed oil (Saur and Kramer, 1983). This is mainly because erucic acid is metabolically inert, as it does not enter into the  $\beta$ -oxidation pathway to produce ATP (Joyee, 1978). Ziemiński *et al.* (1995) also concluded some harmful effects of high erucic rapeseed oil on the body. Although major breakthrough has been achieved with the production of low erucic acid and also low linolenic acid rapeseed varieties (Prevot, 1990) but most of the accessions with lower erucic acid are not acceptable for commercial production partially because of late maturity and lower oil yield under normal cultivation practices (Rucker and Robblen, 1996).

In the present communication, 153 accessions of different *Brassica* and alien species were studied for their total oil percentage and erucic acid concentration. Erucic acid content of species as well as high and low erucic acid containing *B. napus* lines were compared on the basis of their mean values.

One hundred and fifty three collections of rapeseed-mustard were built up through introduction, exchange and exploration activities of NBPGR, New Delhi. Germplasm comprising of *Brassica juncea* (47), *B. napus* (17), *B. campestris* var. yellow sarson (30), *B. campestris* var. toria (17), *B. campestris* var. brown sarson (12), *B. carinata* (4), *B. nigra* (7), *B. rapa* (1), *Eruca sativa* (6), *Sinapis alba* (4), *Crambe abyssinica* (1), *B. juncea* ssp *rugosa* (1), *B. chinensis* (3), *Raphanus caudatus* (1) and *Raphanus sativus* (2), were grown during rabi season 1999-2000 at Issapur experimental farm, NBPGR, New Delhi. Three rows of each accessions were planted with recommended basal dose of fertilizer, following normal cultural practices and plant protection measures. Seeds were harvested when plants attained complete physiological maturity. The data on five plants in each genotype was recorded. The mature seed were used for oil and fatty acid analysis. The presented data are the mean of analysis performed in triplicate. Seeds were dried to 4-5% moisture level in oven at 108°C for 16-18 h. The oil content of the seed samples were determined by non-destructive method using Newport NMR analyzer

(model-4000) from Oxford Analytical Instruments Ltd. U.K. after calibrating with pure *Brassica* oil.

Samples of rapeseed-mustard were freshly ground (Remi homogenizer) and weighed so that 40 mg oil is obtained when extracted with 10 ml solvent mixture consisting of chloroform: hexane: methanol (8:5:2 v/v). The extracts obtained were dried at 60°C in nitrogen gas for 30 min. Methyl esters of oil samples were prepared according to the method of Neff *et al.* (1994) with slight modifications. Transmethylation was performed by heating the oil samples in 0.5 N KOH in methanol at 60°C for 30 min. The reaction mixture was neutralized to pH 7.0 with 0.5 N HCl. The neutralized mixture was extracted with 10 ml petroleum ether: diethyl ether (1:1 v/v) and washed 3 times with water. The extract was dissolved in 5 ml acetone and dried in nitrogen gas. The residue was dissolved in hexane.

One µl of the hexane extract was injected onto highly polar Innowax capillary column of 30 m length, inner diameter of 0.32 mm and film thickness of 0.5 µm, through a splitter (1/80) in a Hewlett Packard model 6890 gas chromatograph equipped with flame ionization detector (FID). The injector and detector temperature were 260°C and 275°C, respectively. Oven temperature was maintained between 150°C (1min) to 210°C at 15°C/min., followed by 210°C to 250°C (12min) at 5°C/min.

Fatty acid peaks were identified by comparing their retention time with that of the known standards, run

in similar instrument conditions. Peak integration was done with the help of HP 3398A software.

**Oil Content in the Cruciferae:** Species wise the range of oil and erucic acid content and the respective mean values of the collections of 153 accessions are shown in Table 1. Among the most commonly grown *Brassica* species in India, *campestris* with all its morphotypes, is the richest oil bearing species followed by *B. juncea*, *B. napus* and *B. carinata*. Similar results were reported in one of our earlier observation. (Mandal *et al.* 2000).

**Erucic Acids:** Out of the 17 *B. napus* collections, about 50% collections were found to have low erucic acid within the range of 1.56 to 4%. Fatty acid composition of high and low erucic acid containing lines under *B. napus* species and overall other species in the crucifers calculated on the basis of mean values of any given species are shown in Fig. 1 and Fig. 2, respectively. Only five lines were identified among the 47 *B. juncea* collections which had low erucic acid concentration (<40%). Other low erucic acid containing species among the crucifers were *Sinapsis alba*, *Raphanus caudatus* and *Raphanus sativus* where mean percentages were found within the range of 32.21 to 39.79%. Maximum erucic acid content of 59.55% was observed in one genotype under *Crambe abyssinica*. Wang-YouPing *et al.* 1995 and 1997 have reported as high as 62% erucic acid in *C. abyssinica*. Mean erucic acid level among other collections were found to vary from 43.17 to 51.69%. Low erucic acid level of the oil was found

**Table 1. Total oil and erucic acid content in crucifers**

| Cruciferas species                                  | Species code | Oil (%)     |       | Erucic Acid (%) |       |
|-----------------------------------------------------|--------------|-------------|-------|-----------------|-------|
|                                                     |              | Range       | Mean  | Range           | Mean  |
| <i>B. juncea</i> (47)*                              | BJN          | 27.91-41.3  | 37.24 | 8.25-53.4       | 48.17 |
| <i>B. napus</i> (5) High erucic acid >35%           | BNP          | 23.97-42.72 | 35.24 | 35.34-45.40     | 40.54 |
| <i>B. napus</i> (12) Low erucic acid <18%           | BNP          |             |       | 1.56-17.8       | 6.81  |
| <i>B. campestris</i> var. <i>Yellow sarson</i> (30) | BYS          | 34.71-46.72 | 43.20 | 45.38-57.05     | 51.69 |
| <i>B. campestris</i> var. <i>Toria</i> (17)         | BCT          | 38.45-44.83 | 41.98 | 42.53-51.55     | 47.99 |
| <i>B. campestris</i> var. <i>Brown sarson</i> (12)  | BCS          | 36.27-44.21 | 40.96 | 39.79-53.25     | 47.49 |
| <i>B. nigra</i> (7)                                 | BNR          | 23.63-38.69 | 30.91 | 35.93-53.46     | 43.29 |
| <i>B. carinata</i> (4)                              | BCN          | 27.81-31.76 | 29.81 | 42.29-55.69     | 50.00 |
| <i>Crambe abyssinica</i> (1)                        | CAS          |             | 33.69 |                 | 59.55 |
| <i>Eruca sativa</i> (6)                             | ESV          | 23.71-29.52 | 25.79 | 41.16-44.81     | 43.17 |
| <i>Sinapsis alba</i> (4)                            | SAB          | 21.5-33.96  | 25.59 | 39.16-47.26     | 39.79 |
| <i>B. chinensis</i> (3)                             | BCH          | 41.0-41.47  | 41.28 | 39.58-49.79     | 45.72 |
| <i>B. juncea</i> (ssp. <i>rugosa</i> ) (1)          | BJR          |             | 47.02 |                 | 47.02 |
| <i>B. rapa</i> (1)                                  | BRP          |             | 45.87 |                 | 45.87 |
| <i>Raphanus sativus</i> (2)                         | RSV          | 30.76-35.65 | 33.05 | 31.76-33.62     | 32.69 |
| <i>Raphanus caudatus</i> (1)                        | RCD          |             | 33.62 |                 | 32.21 |

\* No. of accessions are in parentheses.

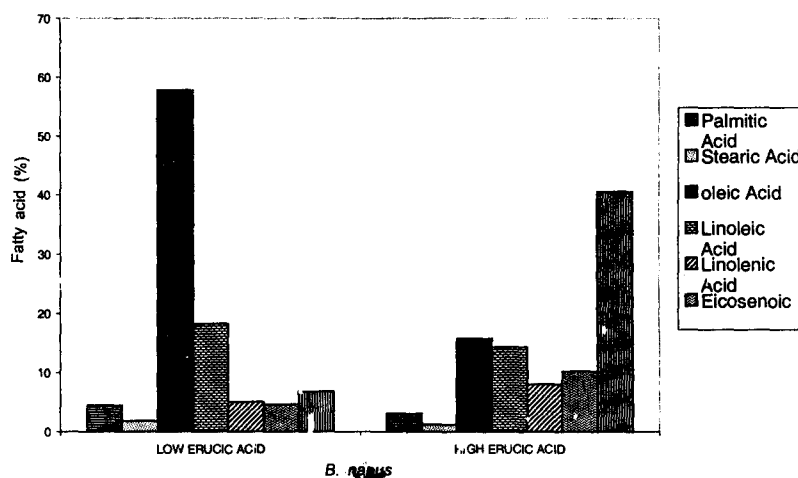


Fig. 1. Fatty acid profile of low and high erucic acid *B. napus* lines

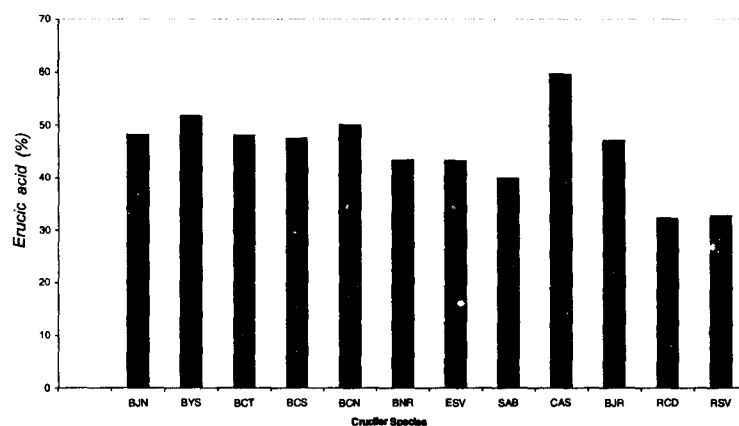


Fig. 2. Erucic acid content in different Brassica species

associated with high percentage of palmitic and oleic acid. Maximum oleic acid content of 66.68% was found in one low erucic acid containing line under *B. napus* germplasm. Oil content of present crucifer collections did not show any significant relationship with erucic acid concentration of the oil. But significant positive correlation was observed only in the collections of *B. juncea* and *B. nigra* species.

## References

- Joyee-Bease-rogers (1978) Nutritional evaluation of rapeseed oil and protein for food use. In: *Proceedings 5<sup>th</sup> International Rapeseed Conference* 2: 74.
- Mandal S, Ranbir Singh, Sangita Yadav, MA Kidwai and PL Gautam (2000) Oil content variations in seeds of *Brassica* species studied during one decade (1988-1998). *National Seminar on Oilseeds and Oil-Research and Development needs in the millennium*, Indian Society of Oilseed Research, 337-338.
- Matti Sovero (1993) Rapeseed, a new oilseed crop for the United State. In: J Janick and JE Simon (ed.) *New crops*, 302-307.
- Neff WE, RO Adlof, GR List, and MEL Agaimy (1994) Analyses of vegetable oil triglycerols by silver ion high performance liquid chromatography with flame ionization detector. *J. Liquid Chromatography* 17: 3951-3968.
- Prevot A (1990) A new variety of low-linolenic rapeseed oil; characteristics and room-odour tests. *J. Am. Oil Chem. Soc.* 67: 161-164.
- Rucker B and G Robblen (1996) Impact on low linolenic acid content on seed yield of winter oilseed rape (*Brassica napus* L.). *Plant Breed.* 115: 226-230.
- Saur FD and JKG Kramer (1983) The problems associated with the feeding of high erucic acid rapeseed oil and some fish oils to experimental animals. In: JKG Kramer, FD Saur and WS Pigden (ed.) *High and Low Erucic Acid Rapeseed Oils* Toronto, Canada Academic Press, pp 254-292.
- Wang-YouPing, Lan-LeFu, Luo-Peng, YP Wang, LF Lan, P Luo (1997) Selection of new strains of *Crambe abyssinica*. *Oil Crops China* 19: 6-9.
- Wang-YouPing, Luo-Peng, Li-XuFeng, YP Wang, P Luo, XF Li (1995) Preliminary study on *Crambe abyssinica*. *Acta Bot. Yunnanica* 17: 169-174.
- Ziemlanski S, TJ Budzynska and Krmiva (1995) Nutritive value of high-erucic acid and low erucic acid rapeseed oil. *J. Kermiva* 37: 221-238.

## Inheritance of RAPD Markers in Sorghum Hybrids

Lalit Arya, GS Sandhia, SS Malik and SK Singh

National Research Centre on DNA Fingerprinting, National Bureau of Plant Genetic Resources, Delhi-110012

**Key Words:** Molecular Characterization, RAPD markers, Sorghum

Sorghum (*Sorghum bicolor* L. Monech,  $2n=20$ ) comes fifth after wheat, maize, rice and barley both in area and production at world level. It is a predominantly self-pollinated crop with 2-20% out-crossing. RAPD detects nucleotide sequence polymorphism using a single primer of arbitrary sequence (Welsh and McClelland, 1990; Williams *et al.* 1990). In the present work RAPD analysis using selected decamer random primers was performed in three hybrids of sorghum along with their parents for understanding their usefulness in the identification of the hybrid.

**DNA extraction and amplification:** The seeds of the three hybrids and parents of sorghum *i.e.* CSH 6 (CS 3541 x 2219 A), CSH 16 (C 43 x 27 A) and CSH 13 R (RS 29 x 296 A), were procured from NRC Sorghum, Hyderabad. The DNA was extracted from the fresh leaves after 15 days of sowing by the modified CTAB procedure (Murray and Thompson, 1980). DNA amplification was conducted in Perkin Elmer DNA thermal cycler 480. Assays contained 20 ng genomic DNA, 200  $\mu$ M dNTPs each, 0.2  $\mu$ M primer (OperonTech.), 1.0 Unit Taq. Polymersae (Perkin Elmer), 3.0  $\mu$ M  $MgCl_2$  and 1X reaction buffer (10  $\mu$ M Tris-HCl pH 8.3, 50  $\mu$ M KCl). The reaction conditions were fixed at 40 cycles of 1

min. at 35°C, 2 min. at 72°C, 1 min. at 92°C with an initial melting at 94°C for 5 min. and a final extension at 72°C for 1 min. Amplified fragments were photographed by polaroid film #667.

RAPD markers are widely used for the identification of artificial and natural hybrids (Heun and Helentjaris, 1993; Wang *et al.* 1994; Parani *et al.* 1997). In the present study nine genotypes (six parental lines and three hybrids) were analyzed with selected decamer primers of arbitrary sequences. The RAPD profiles of parents and hybrids with different primers are given in Table 1, 2 and 3.

CSH 6 along with parents CS 3541 and 2219 A using five operon primers generated a total of 24 bands of which seven were polymorphic (Table 1). All the bands present in the hybrid, except three were shared by either of the parents thereby establishing the hybridity. The remaining four polymorphic bands present in the hybrid was from the male parent. These male specific bands could be exploited as potential markers for the identification of the hybrids.

RAPD analysis of hybrid sorghum CSH 16 with parents C 43 and 27 A generated a total of 35 bands of which three were polymorphic (Table 2). All the bands

**Table 1. Banding pattern of hybrid CSH 6 (H) along with the male parent CS3541 (M) and female parent 2219 A (F)**

| M     | H | F | M     | H | F | M      | H | F | M     | H | F | M     | H | F |
|-------|---|---|-------|---|---|--------|---|---|-------|---|---|-------|---|---|
| 1     | 1 | 1 | 0     | 1 | 0 | 1      | 1 | 1 | 1*    | 1 | 0 | 1*    | 1 | 0 |
| 0     | 1 | 0 | 1     | 1 | 1 | 1*     | 1 | 0 | 1     | 1 | 1 | 1     | 1 | 1 |
| 1     | 1 | 1 | 1*    | 1 | 0 | 1      | 1 | 1 | 1     | 1 | 1 | 1     | 1 | 1 |
| 1     | 1 | 1 | 1     | 1 | 1 |        |   |   | 0     | 1 | 0 | 1     | 1 | 1 |
| OPA 1 |   |   | OPE 3 |   |   | OPG 19 |   |   | OPH 5 |   |   | OPH 8 |   |   |

\*Male specific bands

**Table 2. Banding pattern of hybrid CSH 16 (H) along with the male parent C 43 (M) and female parent 27 A (F)**

| M    | H | F | M     | H | F | M      | H | F | M      | H | F | M     | H | F | M     | H | F | M     | H | F |
|------|---|---|-------|---|---|--------|---|---|--------|---|---|-------|---|---|-------|---|---|-------|---|---|
| 1    | 1 | 1 | 1     | 1 | 1 | 1      | 1 | 1 | 1      | 1 | 1 | 1     | 1 | 1 | 1     | 1 | 1 | 1     | 1 | 1 |
| 1    | 1 | 1 | 1     | 1 | 1 | 1      | 1 | 1 | 1      | 1 | 1 | 1     | 1 | 1 | 1     | 0 | 0 | 1*    | 1 | 0 |
| 1    | 1 | 1 | 1     | 1 | 1 | 1      | 1 | 1 | 0      | 1 | 0 | 1     | 1 | 1 | 1     | 1 | 1 | 1     | 1 | 1 |
| 1    | 1 | 1 | 1     | 1 | 1 | 1      | 1 | 1 | 1      | 1 | 1 | 1     | 1 | 1 | 1     | 1 | 1 | 1     | 1 | 1 |
|      |   |   | 1     | 1 | 1 | 1      | 1 | 1 | 1      | 1 | 1 |       |   |   | 1     | 1 | 1 |       |   |   |
|      |   |   |       |   |   |        |   |   |        |   |   |       |   |   |       |   |   | 1     | 1 | 1 |
|      |   |   |       |   |   |        |   |   |        |   |   |       |   |   |       |   |   | 1     | 1 | 1 |
| OPA1 |   |   | OPA 4 |   |   | OPA 17 |   |   | OPB 10 |   |   | OPC 4 |   |   | OPE 3 |   |   | OPH 8 |   |   |

\*Male specific band



## Collective Utilisation of Germplasm Resources for Rice Varietal Improvement

**U Prasada Rao, B Mishra, LV Subba Rao, GSV Prasad and N Shobha Rani**

*Directorate of Rice Research, Rajendranagar, Hyderabad-500030, Andhra Pradesh*

**Key Words:** Abiotic Stresses, Biotic Stresses, Rice Germplasm, Utilization

Germplasm collection, evaluation and utilization played a key role in rice varietal improvement which in turn brought in the green revolution to India. Rice germplasm collection was initiated by Parnell (Madras Presidency), Hector (Bengal) and Graham (Central province) during the years 1911-1920. Subsequently, rice research workers in different parts of the country undertook surveys during 1946-47 in their regions (Parthasarathy, 1972). Organized and systematic collection was initiated by the Central Rice Research Institute as "Jeypore Botanical Survey" during late fifties and early sixties which resulted in a collection of 1750 accessions from the Jeypore tract of Orissa (Govindaswamy and Krishna Murthy, 1959). The second survey in Manipur region, added another 900 accessions (Krishna Murthy and Sharma, 1970). The PL 480 supported scheme on rice collection in North-Eastern states of India which are supposed to be nearer to the centre of origin of rice, resulted in a collection of 6700 local cultivars and land races designated as ARC collections (Sharma *et al.*, 1971). Further collections in rainfed upland areas of Bihar, Karnataka, Maharashtra, Uttar Pradesh, Orissa and West Bengal added 1431 accessions in 1976 and 300 germplasm lines from 14 state agricultural departments and universities were added (Paroda and Malik, 1990). In the late seventies Dr RH Richharia and his associates collected around 20,000 accessions from Eastern Madhya Pradesh (Now Chhatisgarh). During 1976-85, NBPGR collected 6700 cultivated and 87 wild rice germplasm from different parts of the country. Subsequently 3697 germplasm lines of cultivated accessions were added which involve 167 lines of 4 wild species from Northern Orissa, Bihar, West Bengal, Sikkim and Mizoram during 1986-89 (Paroda and Malik, 1990). Thus, the total rice germplasm collection on hand of both cultivars and wild species exceeds 70,000 accessions in India. However, the collection contained a large number of duplicates being maintained at different centres. Primary sources of genetic diversity contributed to the identification of insect and disease resistant donors from Assam, Manipur, Orissa and Kerala. At global level the International Rice Genetic Resources Centre at International Rice Research Institute (IRRI),

Philippines has more than 80,000 accessions of cultivated rice and 3,000 wild species.

Evaluation of germplasm for tolerance to abiotic and biotic stress was mostly undertaken till sixties under field conditions and followed by more systematic tests under simulated or controlled greenhouse conditions at CRRI, Cuttack; IRRI, Philippines; Directorate of Rice Research (DRR); Hyderabad and other centres. Germplasm around 14,000 from Raipur and other centers were screened for resistance to biotic stresses at DRR and nine hot spot locations through ICAR adhoc research network programme 1993-1998. Donors for major pests were identified. Varietal improvement followed the identification of donor germplasm for different abiotic and biotic stress with free exchange of germplasm both within and outside the country which was facilitated through the National Bureau of Plant Genetic Resources (NBPGR) at New Delhi.

Donors for drought tolerance were identified from among the germplasm and cultivars at CRRI, IRRI (Chang *et al.* 1974) and through International Testing Programme (De Dutta and Seshu, 1975), DRR (Prasada Rao, 1984).

The donors identified were utilized in massive hybridization and 84 drought tolerant varieties for rainfed upland areas were identified (DRR 2001-1).

Major improvements in yield were realized in the shallow lowlands with the adoption of varieties like Mahsuri, IR 5, Intan and development of varieties like Pankaj, Jagannath, Swarnadhan, Savithri, CR 1014 in the earlier period (Gangadharan, 1985). By the dawn of new millennium around 123 varieties were released, utilizing the germplasm from Thailand, Bangladesh, IRRI and different states in India.

Varietal improvement for areas upto 50 cm water depth (semi-deep) and above 100 cms water depth (deep water) was pursued at CRRI Cuttack, IRRI Philippines, Chinsurah (West Bengal), Faizabad (Uttar Pradesh) and Patna (Bihar). The Lowland Consortium of IRRI and International Network on Genetic Evaluation of Rice (INGER) seed arranged through NBPGR, helped in the

development and release of 30 varieties for semi-deep and 14 for deep water areas in India.

In the pre-dwarf era introductions like Ch 977, Ch 1039, Ch 988 in Kashmir played a significant role. Later, utilizing the exotic germplasm from China, Japan, Korea and Russia together with native germplasm varieties for

hilly upland (6) and irrigated areas (27) were released (Table 1).

Germplasm from saline areas like Getu, Dasal, Nonabakra and Nonasail were utilised and 15 improved varieties with tolerance to salinity, alkalinity and sodicity were identified (DRR 2001-1).

**Table 1. Donors identified for abiotic stresses and the varieties evolved and released through collective utilisation in varietal improvement in India**

|            | Donors identified                                                                                                                                                                                                          | Popular varieties                                                                                                                            |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| <b>I</b>   | <b>Rainfed upland</b>                                                                                                                                                                                                      |                                                                                                                                              |
|            | Mettasanna, Lalnakanda 45, N22, MTU 17, CH 45, Basmati 76, Fine Gora                                                                                                                                                       | Aditya, Tulasi, Prasanna, MTU 9993, Ravi, Amrut, Govind, Birsadhan 201, Vandana Prabhat, Narendra 97, Avinash                                |
| <b>II</b>  | <b>Rainfed low lands</b>                                                                                                                                                                                                   |                                                                                                                                              |
| (a)        | <i>Shallow water area (up to 30 cm water depth)</i><br>GEB 24, Mehsuri, T 141, MTU 3, Prasadbhog, Latisail, Safri 17, NC 1281, T90 BAM 9, Peta, Intan                                                                      | Pankaj, Swarnadhan, Savithri, Radha, Laxmi, Ranjet, Bahadur, Rajashree, Utkal Prabha, Bipasa, Sashi, Gayatri                                 |
| (b)        | <i>Semi-deep water areas (up to 50 cm water depth)</i><br>Kalkersail, Baku, Velki, Gonda, Chenab                                                                                                                           | Amulya, nalini, Janaki, Vaidehi, Jalalahari, Baravarodhi, Suresh, Biraj, Jogen, Mahananda                                                    |
| (c)        | <i>Deep water area (above one meter water depth)</i><br>Badham, Boyan, NL 493, NC 490, Gomath                                                                                                                              | Jitendra, Jalprika, Jaladhi 1, Dinesh, Neeraja, Jalanidhi, Sabita                                                                            |
| <b>III</b> | <b>Saline alkaline areas</b>                                                                                                                                                                                               |                                                                                                                                              |
|            | Pokkali, Getu, Dasal, Nanabakra, Nonasail                                                                                                                                                                                  | CSR 10, CST 7, Linishree, CSR 13, CSR 27, Ushar 1, CSR 30                                                                                    |
| <b>IV</b>  | <b>Cold tolerant varieties for higher altitude, hilly areas</b>                                                                                                                                                            |                                                                                                                                              |
| (a)        | <i>Upland direct seeded areas</i><br>Mitak, UPRH 8, Sterjee 45, IRAT 102, Tapoochoz, Sukara, Zeera                                                                                                                         | VL dhan 221, VL dhan 206, VL dhan 16, PNR 519 Majhera 3                                                                                      |
| (b)        | <i>Irrigated areas</i><br>Khonorollo, CH 988, CH 1039, Abor Basmati, Giza 14, Ahomsali, Bijar, T 23 Basmati, Phul Patas 72, Jatto, Maboti                                                                                  | Veveka dhan 62, VL dhan 81, Jhelm, Chenab, RP 732, Nagardhan, RP 2421, Akutephou, Lima Phou, NEH Megha rice 1, NEH Megha rice 2, Pantdhan 11 |
| <b>V.</b>  | <b>Varieties resistant to biotic stress</b>                                                                                                                                                                                |                                                                                                                                              |
| (a)        | <i>Brown plant hopper</i><br>PTB 33, Manoharsali, Velluthcheera, ARC 6650, ARC 5984, PTB 21                                                                                                                                | Jyothi, Sonasali, Chaitanya, Krishnaveni, Vijetha                                                                                            |
| (b)        | <i>Gall midge - Biotype 1</i> Eswarakora<br><i>Gall midge - Biotype 1, 2-Siam</i> 29<br><i>Gall midge - Biotype 3, W</i> 1263<br><i>Gall midge - Biotype 1, 2, 4-PTB</i> 10<br><i>Gall midge - Biotype 1, 2, 5-Siam</i> 29 | Kakatiya<br>Vibhava, Phalguna<br>Rajendradhan 201<br>Suraksha<br>Triguna, Sneha, Bhuban                                                      |
| (c)        | <i>Stem borer</i><br>TKM 6                                                                                                                                                                                                 | Sasyasree, Vikas                                                                                                                             |
| (d)        | <i>Green leaf hopper and RTV</i><br>PTB 2, ARC 14529, Latisail, Kataribhog, Pankeri 203                                                                                                                                    | Vikramarya, Nidhi, Shaktiman                                                                                                                 |
| (e)        | <i>Blast</i><br>CO 29, Tetep, Tadukan                                                                                                                                                                                      | Rasi, Tulasi, Intan, Triveni, IR 64                                                                                                          |
| (f)        | <i>Bacterial leaf blight</i><br>Sigadis, LZN, IR 22, BJ1                                                                                                                                                                   | Ajaya, Pantdhan 10, PR 111                                                                                                                   |

The introduction of dwarf varieties and proliferation of biotic stresses was overcome through the identification of pest and disease resistant germplasm by screening both in endemic areas and under green house conditions.

Genetics of resistance to major pests like BPH, WBPH, GLH at IRRI suggested single monogenic dominant or recessive genes for resistance in most of the donors (Khush and Brar, 1991; Khush, 1995; Panda and Khush, 1995). Studies in India however revealed complex nature of inheritance involving 3-4 complementary dominant or recessive genes for brown plant hopper; 1-8 genes for rice gall midge against five known biotypes. White backed plant hopper, green hopper resistance was due to 1-3 genes (Prasada Rao *et al.* 2000). Varieties resistant to major pests and diseases as well as multiple resistant ones were developed (Prasada Rao, 1996).

Indigenous germplasm (210) was studied for all quality parameters and twenty HYVs were developed through hybridization (Krishnaiah and Shobha Rani, 1999, Singh *et al.* 2000).

Free flow of germplasm world over through INGER programme of IRRI organized through NBPGR facilitated the adoption and release of 30 IRRI lines as varieties in India. Similarly 40 Indian breed varieties were released in other countries; 23 in Sub-Saharan Africa, 7 in South Asia, 4 Latin America, 3 in South East Asia, 3 in West and North Africa for different ecological conditions.

In all, 632 rice varieties were developed in India till the year 2000 utilizing the vast germplasm resources in the country for all the agro-climatic situations, suiting to the needs of the farmers and the commercial organizations. The future production targets can be met by utilizing the vast genetic diversity in the germplasm, available in the gene bank at NBPGR, New Delhi and other repositories in the world.

## References

- Chang TT Loresto, GC Taguampay (1974) Screening Rice germplasm for drought resistance. *SABRAO J.* 6: 9-16.
- Choudhary D and MJ BK Rao (1982) Breeding rice varieties for dry land and drought prone areas in India In: *Drought resistance in crops with emphasis on rice* int. Rice Res. Institute.
- De Dutta and DV Seshu (1982) Evaluating ices for drought tolerance using field screening and multiplication testing In: *Drought Resistance in Crops with Emphasis on Rice*. International rice Research Institute Los Baños, Philippines. 245-263.
- Prasada Rao U, AS Rama Prasad and B Mishra (ed.) (2000) *High Yielding Rice Varieties of India-2000*, Published by DRR, Hyderabad.
- Gangadharan C (1985) *Breeding in Rice Research in India* PC Jaiswal (ed.) at Allied Publishers Pvt. Ltd, New Delhi, pp 73-100.
- Govindaswami S and A Krishna Murthy (1959) Genetic variability among cultivated rices of Jeypore tract and its utility in rice breeding. *Rice Newslett.* 7: 12-15.
- ICAR Adhoc Research network programme (1993-98) published by Directorate of Rice Research, Rajendranagar, Hyderabad-500030, pp1-341.
- Khush GS (1995) Breaking the yield frontier of rice. *Geo. J.* 35: 329-332.
- Khush GS and PS Brar (1991) Genetics of resistant to insect in crop plants. *Advn. Agro.* 45: 223-274.
- Krishna Murthy A and AC Sharma (1970) Manipur rice in rice germplasm. *Oryza* 7: 45-50.
- Krishnaiah K, N Shobha Rani (1999) New avenues for augmenting and sustaining rice exports from India. *Int. rice Commission Newsletter Vol 49.*
- Panda N and GS Khush (1995) Genetics of resistance to insect. In *Host plant resistant to insects*. IAB and IARI PO Box No. 933, Manila, Philippines pp 260-295.
- Paroda RS and SS Mallik (1990) Rice genetic resources its conservation and use in India. *Oryza* 27: 361-369.
- Parthasarathy N (1972) *Rice Breeder*. International Rice Research Institute, Los Baños (IRRI) Philippines, pp 5-9.
- Prasada Rao U (1984) Breeding varieties for rainfed upland situation Indirect effects. *J. Genet. Plant Breeding* 44: 42-48.
- Prasada Rao U (1996) Breeding varieties resistant to abiotic and biotic stresses. *2<sup>nd</sup> International Crop Science Congress*, New Delhi 17-24 November, pp 17-24.
- Prasada Rao U, K Krishnaiah, IC Pasalu and APK Reddy (2000) Breeding for high yield and multiple resistance to biotic stresses of rice in India, presented in the 3<sup>rd</sup> International Crop Science Congress, Hamburg Germany.
- Sharma SD, JMR Vellanki, KL Hakim and RK Singh (1971) Primitive and current cultivars of rice in Assam- a rich source of valuable genes. *Curr. Sci.* 40: 126-128.
- Singh RK, VS Singh and GS Khush (2000) In the Basmati rice of India in aromatic rices 2000 (ed.) published by Mohan Primiani for Oxford & IBH publishing Co Pvt. Ltd. 66 Janpath, New Delhi-110001. 135-153.

## Evaluation of Newly Acquired Cotton Germplasm Lines under Rainfed Condition

**VV Singh, Punit Mohan and SJ Baitule**

*Division of Crop Improvement, Central Institute for Cotton Research, Nagpur, Maharashtra*

**Key Words:** Characterization, Cotton, Rainfed condition, Variability

*Gossypium* is an economically important genus comprising of 49 species of which four are commercially cultivated for cotton lint and seed. Among the linted species, two are Old World Asiatic diploid cottons viz.- *G. arboreum* L. and *G. herbaceum* L. The other two are New World allotetraploid cottons namely, the American cotton or Upland cotton *G. hirsutum* L. and the Egyptian or Sea Island cotton *G. barbadense*. In most part of the world, only Upland or Egyptian cottons are grown, while India is the only country in the world where all the four cultivated species are grown commercially. Cotton is a major fibre crop of global importance with high commercial values. It constitutes 80% of raw material of our textile industry. Cotton has been an indispensable commodity in our social and economic life. Over quarter of the world cotton area is in India (8.8 mha) but productivity-wise India's position is very low (316 kg/ha lint) as compared to other countries like China (830 kg/ha), USA (783 kg/ha), Uzbekistan (762 kg/ha) and Pakistan (505 kg/ha).

Plant Genetic Resources are the foundation of any crop improvement programme. The success of research depends on the availability of diverse germplasm. The applied cotton improvement programmes that grow out of and derive materials from such research are also dependent on the diversity of germplasm. New varieties are developed rather invented and characters are discovered through evaluation of genetic resources. Assembly of large number of germplasm has no meaning if they are not properly and exhaustively evaluated and utilized in the development of new superior varieties/hybrids.

Evaluation of germplasm is one of the major step in the management of plant genetic resources (PGR). After the new germplasm material is received, passport data is prepared. Characterization of newly acquired germplasm lines is the next step and is done by growing them in ideal situation resulting in seed increase simultaneously. After achieving the above, detailed evaluation of genetic resources is done, documented, and seeds are made available to the users. Unless proper scientific and meaningful evaluation of the material is done, the actual and total worth of the germplasm cannot

be achieved/utilized. Keeping this in view, evaluation of recently acquired germplasm lines during last two years (1999-2000) was taken up. Evaluation was done as per the Germplasm Index Card developed on the basis of PGR's Descriptor list.

A total of 336 germplasm lines comprising of *G. hirsutum* 27 lines collected from Malwa Plateau and adjoining Banswara district of Rajasthan; eight exotic lines received from Turkey (6) and Iran (2) and 301 lines received from various private seed companies were evaluated under rainfed condition during 2000-2001 crop season at main research farm of Central Institute for Cotton Research, Nagpur. All the materials were grown in single row of 6.0 m length keeping row to row distance of 60 cm. Normal cultural practices were adopted to raise a good healthy crop. Three randomly selected plants in each line were tagged to record data. Observations were recorded for 34 characters as per the Germplasm Index Card. For the purpose of practical utility, seven (7) important economic characters are discussed here viz.- seed cotton yield/plant, boll weight, average boll number/plant, ginning out turn (GOT), mean halo length (MHL), seed index and plant height. Besides this, reaction against major pests was also recorded.

In general, wide range of variability for most of the characters was observed. Range of variability for major economic characters in comparison with local cultivar (LRA 5166) and superior genotypes identified are presented in Table 1.

Seed cotton yield, boll weight and number of bolls/plant are the most important characters contributing to yield in cotton. All the three are responsible for total cotton yield/unit area of a cultivar. Seed cotton yield/plant ranged from 14 to 18 g, boll weight from 1.6 to 5.8 g while average number of bolls/plant ranged from 11 to 52.

Quantity of lint obtained from the seed cotton and staple length determine the actual worth of a cultivar and the producer gets better price if the values for both (GOT and MHL) are on higher side. Ginning out turn ranged from 27.1 to 41.8%, while mean halo length had a range of 13.6 to 30.0 mm. High range of variability

**Table 1. Range of variability for important economic characters in newly acquired germplasm accessions under rainfed condition**

| Character                        | LRA 5166<br>Local<br>cultivar | Range<br>(Germplasm<br>accessions) | Elite Genotypes                                                                                                                                                                                |
|----------------------------------|-------------------------------|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Seed cotton yield/<br>plant (g)  | 126                           | 14-180                             | VSC, MC 127, SR 33, H4B (Pvt. Seed Co.)<br>Lashata, Sajar 314, Ashur ECSAN 92 (exotics)<br>Cotton 35, Cotton 30, Cotton 28, Cotton 3, Cotton 1 (Malwa)                                         |
| Average boll<br>weight (g)       | 3.8                           | 1.6-5.8                            | NA 1678, MPD, 5054, ES410, 99043 (Pvt. Seed Co.)<br>Lashata, Sajar 314, Nazilli 143, Carolina Queen, Nazilli 87 (exotics)<br>Cotton 17, 19, 39, 21 and 36 (Malwa)                              |
| Average number of<br>bolls/plant | 42                            | 11-52                              | NC AC1, KDGH 50, ACL 23, VCC 6, SR 403 (Pvt. Seed Co.)<br>Sajar 314, ECSAN 92, Lashata, Nazilli 143, Ashur (exotics)<br>Cotton 1, 3, 32, 33 and 29                                             |
| Ginning<br>out turn (%)          | 36                            | 27.1-41.8                          | VCA 5, Narsimha, USSR/Am. Big boll, AC 241,<br>AC 1588-3 (Pvt. Seed Co.)<br>Sajar 314, Nazilli 87, Ashur, Nazilli M 503, Carolina Queen (exotics)                                              |
| Mean halo length<br>(mm)         | 27                            | 13.6-30.0                          | ACC 111, Durg HS 271, Narsimha 1, H 5314,<br>Narsimha 4 (Pvt. Seed Co.),<br>Lashata, Nazilli M 503, Carolina Queen,<br>ECSAN 92, Nazilli 143 (exotics)<br>Cotton 36, 21, 35, 10 and 15 (Malwa) |
| Seed index (g)                   | 8.0                           | 6.2-11.5                           | SV 413, MC 67, HGP 9, NA 1678, ACC 103 (Pvt Seed. Co.)<br>Lashata, Nazilli 87, Carolina Queen, Sajar 314 (exotics)<br>Cotton 21, 9, 13, 35 and 17 (Malwa)                                      |
| Plant height (cm)                | 115                           | 44-141                             | MC 1271, GC 153, AC 1588-4, MCU 5-1, Narsimha-2 (Pvt. Seed Co.)<br>Sajar 314, Lashata, Carolina Queen, ECSAN 92, Ashur (exotics)<br>Cotton 27, 3, 13, 15 and 12 (Malwa)                        |

**Table 2. Resistant/tolerant genotypes in newly acquired collections of *G. hirsutum***

| S. No. | Pests               | Resistant/Tolerant Genotypes                                                                                                                                                                          |
|--------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.     | Sucking Pest-Jassid | ACC-128, AC 1588xSUMAN, AKG 2/41, SS-113, G. COT-18 (Pvt. Seed Co.)<br>Nazilli 84, Lashata, Sajar - 314, Ashur, Nazilli M-503 (exotics)<br>Cotton-1, Cotton-9, Cotton-23, Cotton-25 Cotton-27 (Malwa) |
| 2.     | Bollworm Complex    | SV504, ACT 738, BN-1, WSPL-1, AKG 2/48 (Pvt. Seed Co.)<br>Cotton-1, Cotton-8, Cotton-9, Cotton-10 Cotton-25 (Malwa)                                                                                   |

for these two characters is an indication that newly acquired germplasm material can be successfully utilized for the development of cultivar with high GOT and long fibre length. Seed size is also an important character and determines the vigour of the seedling. The seed index (100 seed weight) ranged from 6.2 to 11.5 g.

Plant height although a non-economic attribute, determines the number of fruiting branches (sympodia) in a cultivar. In general, under rainfed cultivation dwarf and compact plants are preferred while tall plants with short internodes are desirable in irrigated situations. For this character also a wide range of variability was observed and it ranged from 44 to 141 cm.

The newly acquired collections also showed various degree of resistance/susceptibility against important

sucking pests like jassid, aphids and bollworms. Resistant/tolerant germplasm lines identified are presented in Table 2.

The results show that desirable level of variability for most of the important economic attributes with moderate resistance against sucking pests and bollworms is available in the newly acquired germplasm collections of upland cotton which can be exploited by the plant breeders in the country for the development of variety/hybrid.

**Acknowledgements:** The authors wish to thank the Director, CICR, Nagpur for providing facilities. Thanks are also due to Shri BR Rode, Technical Officer for assisting in data recording and compilation.

## Performance of Alu Bokhara Amritsari – A New Variety of Plum for Subtropics

**JS Bal**

*Department of Horticulture, Faculty of Agriculture, Khalsa College, Amritsar-143002, Punjab*

**Key Words:** Alu bokhara, Genotype, Indigenous germplasm

In India, the Japanese plum (*Prunus salicina* Lindl.) is an important temperate fruit, primarily grown in the hills of Himachal Pradesh, Kashmir and UP. Santa Rosa is the chief cultivar prized for its bold sized fruits and attractive appearance but is confronted with the problem of sourness near the pit and poor shelf life (Karkara *et al.* 1993). Some low chilling types of plum are also successfully cultivated in the Northern plains of India, but could not gain the consumer acceptability because of some problem of sourness. For a viable breeding programme, evaluation of the indigenous germplasm is of paramount importance (Uppal and Kumar, 1992). Keeping the above facts in view, extensive explorations were made in plum growing districts of Punjab to identify an elite plum genotype (Bal *et al.* 1996). The *ex situ* conservation of the germplasm was taken up for multilocation trials. The present study deals with the evaluation of the accession of the identified genotype named as Alu Bokhara Amritsari to judge the performance in respect of tree vigour, bearing and quality in comparison to the commercial cv. Kala Amritsari.

The hard wood cuttings were planted in the well managed Government Orchards, Attari (Amritsar) to test its performance. The plantation was done at a spacing of 6 x 6m. The observations on tree growth, flowering and fruiting were recorded on four randomly selected trees for three fruiting years (1998-2000) and was compared with the check variety – Kala Amritsari. For physico-chemical evaluation, 20 fruits were picked at random at maturity from each of the selected trees. Total soluble solids were determined by hand refractometer, acidity by titrating a known quantity of juice against 0.1 N NaOH. Phenolics were estimated as total tannins after developing colour with Folin-Denis reagent as described by Rangana (1979).

The observation on tree growth showed that the trees of Alu Bokhara Amritsari followed the upright spreading growth pattern and are moderately vigorous as compared to spreading growth habit in the check. The flowering was recorded from 22 February to 14 March and the full bloom from 4 to 6 March, whereas

the flowering was little early in check variety. The late flowering of the test variety may be due to its longer chilling requirements than that of check. It produced large sized fruits in all the three fruiting years of observations. The pooled data for three years revealed fairly large sized fruits (average fruit weight 29.0 g) as compared to check variety (12.6 g). The pulp stone ratio (>18) was much higher than the check. The fruits are larger including FLA 1-2, a latest introduction (released under name of Satluj Purple) in Punjab than all the previous varieties reported in Punjab by Dhatt *et al.* (1982, 1991). The fruit attained optimum maturity in the end of May to 1st week of June and thus adjudged as late maturing variety than the check by a week but earlier than the Santa Rosa plum produced in the hills in which the ripening period is reported to be in the month of July (Chopra *et al.* 1986). The fruits developed bright red colour at maturity. The skin is covered by heavy bloom giving a very attractive appeal to the consumers. The pulp is yellow orange at maturity which turned to rosy red at ripening, aromatic and highly juicy. Interestingly the variety is free stone type. The physico-chemical evaluation (Table 1) revealed high TSS content with low acidity. The fruits also contained low phenolics and high anthocyanins. Furthermore, it enjoys a special merit of uniform sweetness (absolutely free from sourness near the pit), the serious menace reported by Karkara *et al.* (1993) in Santa Rosa, the main variety of temperate zone of India. The fruits are also safe for post harvest handling as it can withstand long storage period up to 50 days in cold storage and 5-7 days at ambient condition as compared to only 30 days and 2-3 days, respectively in the check. The accession, thus, retained all the outstanding merits of the parental genotype identified by Bal *et al.* (1996).

The yield was low in the first year of fruiting (1998) which picked up fast in the subsequent years and is quite comparable to the check (Table 2). The small difference if any, in yield gets highly compensated with much higher market premium. It can be concluded that due to excellent fruit quality viz. - red flesh, free stone,

**Table 1.** Physico-chemical characteristics of Alu Bokhara Amritsari (ABA) and Kala Amritsari (KA)

| Fruiting Years | Average Fruit Weight (g) |      | Pulp Stone ratio |      | TSS (%) |      | Acidity (%) |     | Phenolics (mg/g) |     |
|----------------|--------------------------|------|------------------|------|---------|------|-------------|-----|------------------|-----|
|                | ABA                      | KA   | ABA              | KA   | ABA     | KA   | ABA         | KA  | ABA              | KA  |
| 1998           | 28.5                     | 12.4 | 18.5             | 10.5 | 14.0    | 12.7 | 0.8         | 1.3 | 2.2              | 4.4 |
| 1999           | 30.2                     | 13.0 | 19.2             | 10.8 | 14.2    | 12.4 | 0.8         | 1.2 | 2.0              | 4.9 |
| 2000           | 29.6                     | 13.2 | 18.8             | 11.2 | 14.0    | 12.2 | 8.0         | 1.3 | 2.1              | 4.6 |
| Mean           | 29.4                     | 12.8 | 18.5             | 10.8 | 14.0    | 12.4 | 0.8         | 1.3 | 2.1              | 4.6 |

**Table 2.** Flowering, maturity and yield attributes of Alu Bokhara Amritsari (ABA) and Kala Amritsari (KA)

| Fruiting Years | Flowering Duration |            | Date of full bloom |                | Yield kg/tree |    | Time of maturity |             |
|----------------|--------------------|------------|--------------------|----------------|---------------|----|------------------|-------------|
|                | ABA                | KA         | ABA<br>March       | KA<br>February | ABA           | KA | ABA              | KA          |
| 1998           | 24.2 – 14.3        | 7.2 – 24.2 | 5                  | 14             | 3             | 5  | 28.5 – 4.6       | 22.5 – 27.5 |
| 1999           | 25.2 – 13.3        | 6.2 – 22.2 | 6                  | 12             | 7             | 11 | 29.5 – 5.6       | 21.5 – 25.5 |
| 2000           | 22.2 – 15.3        | 9.2 – 23.2 | 4                  | 12             | 16            | 18 | 30.5 – 7.6       | 23.5 – 27.5 |

uniform sweetness, high TSS acid ratio coupled with better shelf life, the variety deserves to be exploited in the Indian subtropics as a potential fruit for export.

## References

- Bal JS, V Jit and SS Virdi (1996) Genetic diversity of plum in the Punjab plains. In *Abstracts 2<sup>nd</sup> Crop Science Congress*, New Delhi, 17–24 Nov., 279p.
- Chopra SK, SS Misra, VP Bhutani and A Kashyap (1986) Studies on maturity indices in relation to the length of storage in Santa Rosa plum. (*Prunus salicina* Lindl.) In: *Advances in Research on Temperate Fruits*, pp 319–326.
- Dhatt AS, YR Chanana, GS Nijjar, PPS Minhas, AS Dhillon and DK Uppal (1991) FLA 1-2, A new variety of plum. *J. Res. PAU* 28: 152.
- Dhatt AS, SS Gill and MP Singh (1982) Performance of plum (*P. salicina* Lindl.) cultivars under sub tropical conditions. *J. Res. PAU* 19: 165–167.
- Karkara BK, DD Uppal and KK Jindal (1993) Improvement of stone fruits and nuts. In: KL Chadha and OP Pareek (ed.) *Advances in Horticulture* Vol. 1 pp 431–44.
- Rangana S (1979) *Manual of Analysis of Fruit and Vegetable Products* Tata McGraw Hill Publicity Company Ltd., New Delhi, pp 69–73.
- Uppal DK and K Kumar (1992) Achievement and strategies of Temperature fruit breeding. Proceedings of Golden Jubilee National Seminar on Emerging Trends in Temperature Fruit Production in India, National Horticulture Board Technical Communications, pp 19–31.

## Genetic Diversity in *Azadirachta indica* as Revealed by AFLP Markers

**Rakesh Singh and GJ Randhawa**

National Research Centre on DNA Fingerprinting, National Bureau of Plant Genetic Resources, New Delhi-110012

**Key Words:** Neem, AFLP, Genetic diversity

Neem (*Azadirachta indica* A. Juss) is a notable multipurpose tree species that grows naturally in the Thailand, Indian subcontinent and Myanmar. Of late, Neem has gained tremendous significance worldwide because of its spectacular therapeutic and bioactive properties. Traditionally in India neem has a special

cultural significance and its medicinal properties are mentioned in the ancient scriptures. The important active ingredients - azadirachtin and salanin are derived from the seeds. Because of the growing interest in this important tree species the International Neem network has established an International Neem provenance trial

**Table 1.** Physico-chemical characteristics of Alu Bokhara Amritsari (ABA) and Kala Amritsari (KA)

| Fruiting Years | Average Fruit Weight (g) |      | Pulp Stone ratio |      | TSS (%) |      | Acidity (%) |     | Phenolics (mg/g) |     |
|----------------|--------------------------|------|------------------|------|---------|------|-------------|-----|------------------|-----|
|                | ABA                      | KA   | ABA              | KA   | ABA     | KA   | ABA         | KA  | ABA              | KA  |
| 1998           | 28.5                     | 12.4 | 18.5             | 10.5 | 14.0    | 12.7 | 0.8         | 1.3 | 2.2              | 4.4 |
| 1999           | 30.2                     | 13.0 | 19.2             | 10.8 | 14.2    | 12.4 | 0.8         | 1.2 | 2.0              | 4.9 |
| 2000           | 29.6                     | 13.2 | 18.8             | 11.2 | 14.0    | 12.2 | 8.0         | 1.3 | 2.1              | 4.6 |
| Mean           | 29.4                     | 12.8 | 18.5             | 10.8 | 14.0    | 12.4 | 0.8         | 1.3 | 2.1              | 4.6 |

**Table 2.** Flowering, maturity and yield attributes of Alu Bokhara Amritsari (ABA) and Kala Amritsari (KA)

| Fruiting Years | Flowering Duration |            | Date of full bloom |                | Yield kg/tree |    | Time of maturity |             |
|----------------|--------------------|------------|--------------------|----------------|---------------|----|------------------|-------------|
|                | ABA                | KA         | ABA<br>March       | KA<br>February | ABA           | KA | ABA              | KA          |
| 1998           | 24.2 – 14.3        | 7.2 – 24.2 | 5                  | 14             | 3             | 5  | 28.5 – 4.6       | 22.5 – 27.5 |
| 1999           | 25.2 – 13.3        | 6.2 – 22.2 | 6                  | 12             | 7             | 11 | 29.5 – 5.6       | 21.5 – 25.5 |
| 2000           | 22.2 – 15.3        | 9.2 – 23.2 | 4                  | 12             | 16            | 18 | 30.5 – 7.6       | 23.5 – 27.5 |

uniform sweetness, high TSS acid ratio coupled with better shelf life, the variety deserves to be exploited in the Indian subtropics as a potential fruit for export.

## References

- Bal JS, V Jit and SS Virdi (1996) Genetic diversity of plum in the Punjab plains. In *Abstracts 2<sup>nd</sup> Crop Science Congress*, New Delhi, 17–24 Nov., 279p.
- Chopra SK, SS Misra, VP Bhutani and A Kashyap (1986) Studies on maturity indices in relation to the length of storage in Santa Rosa plum. (*Prunus salicina* Lindl.) In: *Advances in Research on Temperate Fruits*, pp 319–326.
- Dhatt AS, YR Chanana, GS Nijjar, PPS Minhas, AS Dhillon and DK Uppal (1991) FLA 1-2, A new variety of plum. *J. Res. PAU* 28: 152.
- Dhatt AS, SS Gill and MP Singh (1982) Performance of plum (*P. salicina* Lindl.) cultivars under sub tropical conditions. *J. Res. PAU* 19: 165–167.
- Karkara BK, DD Uppal and KK Jindal (1993) Improvement of stone fruits and nuts. In: KL Chadha and OP Pareek (ed.) *Advances in Horticulture* Vol. 1 pp 431–44.
- Rangana S (1979) *Manual of Analysis of Fruit and Vegetable Products* Tata McGraw Hill Publicity Company Ltd., New Delhi, pp 69–73.
- Uppal DK and K Kumar (1992) Achievement and strategies of Temperature fruit breeding. Proceedings of Golden Jubilee National Seminar on Emerging Trends in Temperature Fruit Production in India, National Horticulture Board Technical Communications, pp 19–31.

## Genetic Diversity in *Azadirachta indica* as Revealed by AFLP Markers

**Rakesh Singh and GJ Randhawa**

National Research Centre on DNA Fingerprinting, National Bureau of Plant Genetic Resources, New Delhi-110012

**Key Words:** Neem, AFLP, Genetic diversity

Neem (*Azadirachta indica* A. Juss) is a notable multipurpose tree species that grows naturally in the Thailand, Indian subcontinent and Myanmar. Of late, Neem has gained tremendous significance worldwide because of its spectacular therapeutic and bioactive properties. Traditionally in India neem has a special

cultural significance and its medicinal properties are mentioned in the ancient scriptures. The important active ingredients - azadirachtin and salanin are derived from the seeds. Because of the growing interest in this important tree species the International Neem network has established an International Neem provenance trial

in 16 countries aiming at its genetic improvement (Anonymous, 1997). The information on the extent and organization of genetic diversity of the species could be useful for effective improvement program and germplasm conservation. A large number of methodologies exist for assessment of genetic diversity in the plant species. DNA based markers provide useful information regarding genetic diversity and relationship between accessions as these remain unaffected by the environmental factors. Amplified fragment length polymorphism (AFLP) has been widely used for discrimination of closely related cultivars in different crop species and also to detect genetic variability in the germplasm of a crop species. In the present study, 14 lines of neem have been subjected to AFLP analysis to detect genetic variability.

Seed of 14 lines of neem were collected from Punjab, Haryana and Rajasthan in (Table 1). These seeds were grown in the greenhouse of National Bureau of Plant Genetic Resources (NBPGR), New Delhi. Total genomic DNA was isolated from the leaves of 8-week-old seedlings using the method of Dellaporta *et al.* (1983). DNA concentration was quantified by fluorometric method and samples were diluted to a final concentration of 100 ng/ $\mu$ l. AFLP kit was procured from Perkin Elmer Applied Biosystems and the reactions were carried out according to the protocol provided by the manufacturer. The data obtained in the form of peaks during analysis was converted to numerical values using Genotyper (version 2.5). AFLP bands ranging in size from 50 to 500 bp were scored for presence (1) and absence (0). The pair-wise genetic similarity between the samples was estimated according to the Jaccard's coefficient.

**Table 1: Details of Neem lines used in the present study. Tree number represents number given to each line**

| Tree No. | Tehsil           | District    | State     |
|----------|------------------|-------------|-----------|
| N5       | Jahajpur         | Bhilwara    | Rajasthan |
| N9       | Ladpura          | Kota        | Rajasthan |
| N27      | Bikaner (CSWRI)  | Bikaner     | Rajasthan |
| N36      | Ganganagar       | Ganganagar  | Rajasthan |
| N37      | Abohar           | Firozpur    | Punjab    |
| N40      | Malot            | Mukatsar    | Punjab    |
| N45      | Bhatinda         | Bhatinda    | Punjab    |
| N48      | Ludhiana (PAU)   | Ludhiana    | Punjab    |
| N52      | Pehwa            | Kurukshetra | Haryana   |
| N56      | Kaithal          | Kaithal     | Haryana   |
| N59      | Barwala          | Hisar       | Haryana   |
| N60      | HAU Hisar        | Hisar       | Haryana   |
| N62      | Hisar (cantt.)   | Hisar       | Haryana   |
| N66      | Bawal (workshop) | Rewari      | Haryana   |

The stastical analysis was carried using NTSYS Software (version 1.70). A dendrogram was constructed by employing UPGMA and principal co-ordinate analysis was also performed.

The value of similarity for all the 14 lines ranged from 0.012 to 0.78. The two neem samples N48 and N56, collected from Ludhiana (Punjab) and Kaithal (Haryana), respectively, displayed greater genetic similarity with a similarity coefficient of 0.78. The resultant phenogram (Fig. 1) grouped all the 14 lines broadly into three subgroups. The samples from Ladpura (Rajasthan) and HAU (Hissar) form one cluster sample from Bhatinda (Punjab) and Barwala (Haryana) forms the second cluster and rest fall in the third cluster. The sample from Hissar Cantt, N62, was more distinct and it does not form cluster with any sample. The same is supported further by the principal component analysis (Fig. 2).

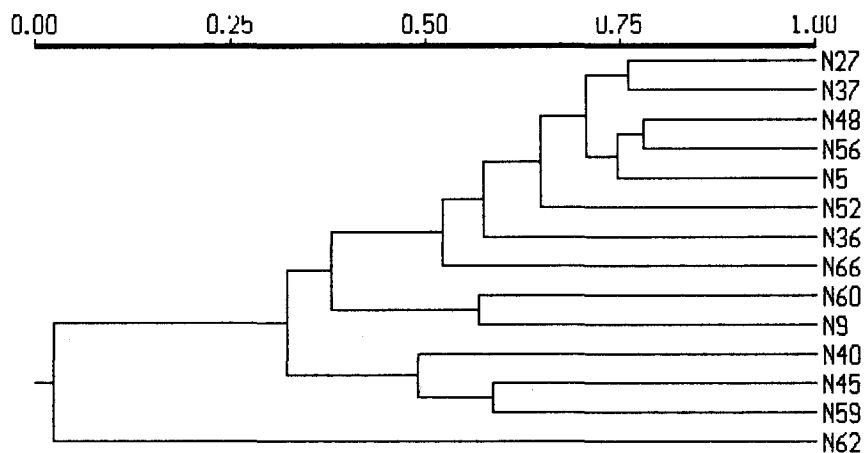


**Fig. 1. Phenogram generated using UPGMA cluster analysis, showing relationship between 14 lines of neem using AFLP**

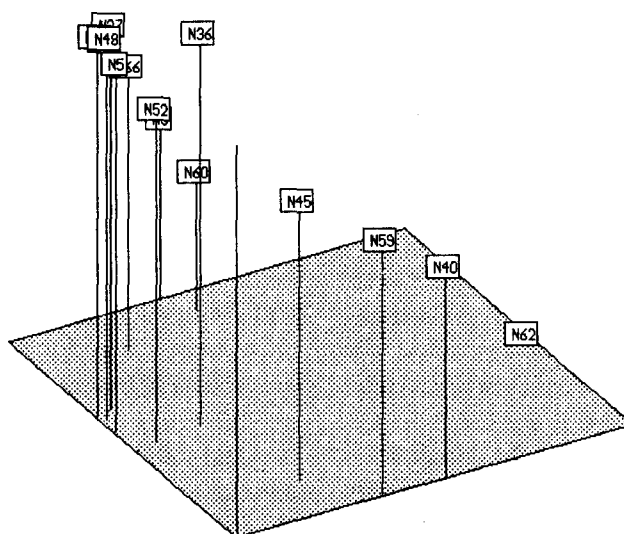


Fig. 2. Principal component analysis based on AFLP study of 14 neem lines with 523 amplicons

The present study revealed that there is large genetic diversity between the samples collected from different part of the western states of India, which is corroborated by studies of Singh *et al.* (1999). Future explorations can be carried out in these states for germplasm collections. To understand more about the extent and organization of genetic diversity of this species more exhaustive study by using more number of primers and marker systems is required.

#### References

- Anonymous (1997) Report of the workshop of the International Neem Network. Rangoon, Myanmar, 20 p.
- Dellaporta SL, J Wood and JB Hick (1983) A Plant DNA Miniprep: Version II. *Plant Mol. Biol. Rep.* 1: 19-21.
- Singh A, MS Negi, J Rajgopal, S Bhatia, UK Tomar, PS Srivastava and M Lakshmikumaran (1999) Assessment of genetic diversity in *Azadirachta indica* using AFLP markers. *Theo. Appl. Genet.* 99: 272-279.

## “Kairali” – A Mosaic Resistant Vegetable Cowpea

**VS Devadas, TR Gopalakrishnan\* and Sally K Mathew\***

*Pineapple Research Station, Kerala Agricultural University, Vazhakulam-686670, Kerala*

Vegetable cowpea is cultivated on commercial scale in Kerala. Incidence of mosaic diseases caused by viruses is a major handicap in its cultivation and the disease is very severe in summer season and is quite difficult to control. Cultivating resistant varieties is the most economical and practical method to tackle this disease. Immunity/resistance to mosaic disease have been reported in grain cowpea by Khatri and Singh (1974), Patel *et al.* (1982) and Doraiswamy *et al.* (1983). Cowpea mosaic virus symptoms, transmission and host range

studies were reported by Sreelekha (1987) from Kerala. However, no cultivars of vegetable cowpea grown in Kerala are found resistant to mosaic disease. Hence, a breeding programme was initiated to evolve mosaic resistant vegetable cowpea with good yield and pod characters suited to large scale cultivation in Kerala.

The technical programme consisted of collection of germplasm with special reference to mosaic resistant accessions and local cultivated types, cataloguing the germplasm for mosaic incidence, growth and yield attributes to locate resistance, sap inoculation of viruses to confirm the resistance in the resistant accessions

\*College of Horticulture, Kerala Agricultural University, Thrissur-680656

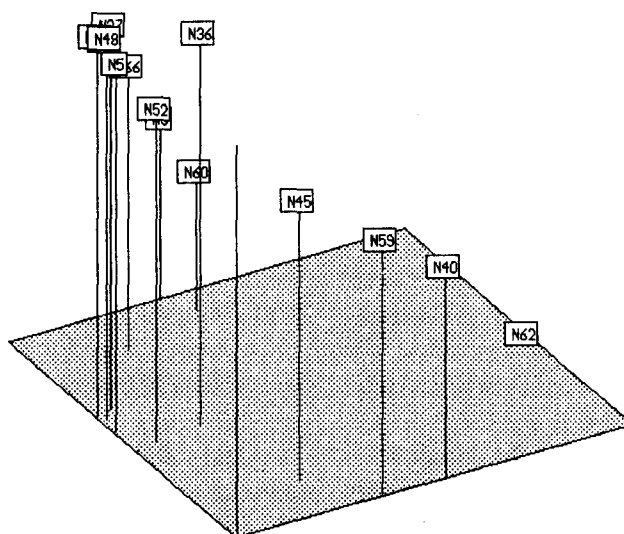


Fig. 2. Principal component analysis based on AFLP study of 14 neem lines with 523 amplicons

The present study revealed that there is large genetic diversity between the samples collected from different part of the western states of India, which is corroborated by studies of Singh *et al.* (1999). Future explorations can be carried out in these states for germplasm collections. To understand more about the extent and organization of genetic diversity of this species more exhaustive study by using more number of primers and marker systems is required.

#### References

- Anonymous (1997) Report of the workshop of the International Neem Network. Rangoon, Myanmar, 20 p.
- Dellaporta SL, J Wood and JB Hick (1983) A Plant DNA Miniprep: Version II. *Plant Mol. Biol. Rep.* 1: 19-21.
- Singh A, MS Negi, J Rajgopal, S Bhatia, UK Tomar, PS Srivastava and M Lakshmikumaran (1999) Assessment of genetic diversity in *Azadirachta indica* using AFLP markers. *Theo. Appl. Genet.* 99: 272-279.

## “Kairali” – A Mosaic Resistant Vegetable Cowpea

**VS Devadas, TR Gopalakrishnan\* and Sally K Mathew\***

*Pineapple Research Station, Kerala Agricultural University, Vazhakulam-686670, Kerala*

Vegetable cowpea is cultivated on commercial scale in Kerala. Incidence of mosaic diseases caused by viruses is a major handicap in its cultivation and the disease is very severe in summer season and is quite difficult to control. Cultivating resistant varieties is the most economical and practical method to tackle this disease. Immunity/resistance to mosaic disease have been reported in grain cowpea by Khatri and Singh (1974), Patel *et al.* (1982) and Doraiswamy *et al.* (1983). Cowpea mosaic virus symptoms, transmission and host range

studies were reported by Sreelekha (1987) from Kerala. However, no cultivars of vegetable cowpea grown in Kerala are found resistant to mosaic disease. Hence, a breeding programme was initiated to evolve mosaic resistant vegetable cowpea with good yield and pod characters suited to large scale cultivation in Kerala.

The technical programme consisted of collection of germplasm with special reference to mosaic resistant accessions and local cultivated types, cataloguing the germplasm for mosaic incidence, growth and yield attributes to locate resistance, sap inoculation of viruses to confirm the resistance in the resistant accessions

\*College of Horticulture, Kerala Agricultural University, Thrissur-680656

located, and evaluation of resistant accessions for pod and yield attributes in comparative yield trials and farm trials. Screening of the germplasm to locate the sources of resistance was done in initial evaluation trials (IET) for two years, using 91 accessions (including 8 introduced from IITA, Ibadan) in summer seasons of 1996 and 1997. Genotypes were grouped into resistant (0–10% incidence); tolerant (11–30%); susceptible (31–60 %); and highly susceptible (61–100%) based on the disease incidence. It was observed that most of the resistant accessions belonged to grain types. Two accessions with comparatively good pod characteristics for vegetable purpose such as CWP-11 (IC 45415) and CWP-16 (Co. 2) were found to be resistant. Careful selection of plants from the original population of CWP-11 for longer pods resulted in an improved accession, CWP-11-1. They were subjected to artificial sap inoculation in April, 1997 and found to be resistant. This was followed by three seasons comparative yield trials (CYT) and farm trials. CWP-11-1 is entered in the All India Co-ordinated Vegetable Improvement Project (AICVIP) trials for testing at national level also.

Two season's IET have shown that no vegetable types (with long, tender pods of 40–50 cm, and trailing growth habit) were resistant. However, two semi-trailing accessions viz.- CWP-11 (pink pods) and CWP-16 (light green pods) were found mosaic resistant, having satisfactory medium long, tender pods. CWP-11-1 is a selection with longer pods. Three season's CYT

confirmed that the accessions CWP-11 and CWP-16 were mosaic resistant with high yields (Table 1). CWP-11-1 is a semi-trailing type with a mean vine length of about 120 cm at harvest stage and characterised by green stem with pink streaks dark green leaves with green veins green petiole with pink streaks at basal portion; pink pods with a mean pod length of 22.78 cm, mean pod weight of 7.08 g, mean seed content of 16 per pod plummy reddish brown seeds of 10.6–11.0 mm length and 6.0 mm width, and 100 seed weight of 16.8 to 18.0 g. Plants take 37–42 days for flowering, 47–54 days to first harvest, and have a total crop duration of 95–108 days. Generally it gives 7–9 harvests and gives a yield of 7.13 tonnes of pods/ha under average management; and has a potential yield of 9 tonnes/ha. The variety is consistently found to be resistant to aphid transmitted cowpea mosaic disease (incidence varied from 0 to 6.67%) under field conditions. It is tolerant to aphids and pod borer. Pods of CWP-11-1, being pink in colour, had market preference; CWP-11-1, on an average gave a yield of 8.65 tonnes pods/ ha in the farm trials. CWP-11-1 is found to be highly acceptable to farmers due to its mosaic resistance, high yield and good market preference. This variety may be given adequate isolation from "Vyjayanti" plots to avoid mixing of seeds, since both these varieties have reddish brown seeds. This variety is now being tested under various centres of AICVIP at national level. This has been recommended for release in Kerala by the State Seed

Table 1. Mean performance of selected cowpea genotypes

| Acc. No.    | Mosaic incidence at harvest (%) IET-I | Mosaic incidence at harvest (%) IET-II | Pod length (cms) CYT-I (June-Sept. 1997) | Yield of pods Kg/2.4 sq m CYT-I (June-Sept. 1997) | Mosaic at harvest (%) CYT-II (Oct. 97-Jan. 98) | Pod borer %, CYT-II (Oct. 97-Jan. 98) | Yield of pods, kg/2.4 sq m CYT-I (Oct. 97-Jan. 98) |
|-------------|---------------------------------------|----------------------------------------|------------------------------------------|---------------------------------------------------|------------------------------------------------|---------------------------------------|----------------------------------------------------|
| CWP 11-1    | 6.67                                  | 8.00                                   | 17.7                                     | 1.94                                              | 4.50                                           | 14.5                                  | 1.72                                               |
| CWP 16      | 3.57                                  | 27.5                                   | 20.9                                     | 1.88                                              | 1.66                                           | 7.25                                  | 0.87                                               |
| VS 15-3-1   | 53.8                                  | 80.0                                   | 32.8                                     | 1.94                                              | 26.3                                           | 31.5                                  | 1.80                                               |
| VS 15-1     | 56.7                                  | 69.3                                   | 23.5                                     | 0.99                                              | 43.3                                           | 28.0                                  | 1.52                                               |
| VS 19-2     | 28.2                                  | 75.0                                   | 24.1                                     | 1.39                                              | 37.5                                           | 39.0                                  | 1.19                                               |
| VS 35       | 30.0                                  | 92.9                                   | 13.6                                     | 0.69                                              | 45.0                                           | 0.00                                  | 0.68                                               |
| VS 36       | 55.2                                  | 76.8                                   | 16.6                                     | 1.71                                              | 38.8                                           | 19.3                                  | 0.49                                               |
| VS 37       | 37.5                                  | 77.0                                   | 14.2                                     | 0.92                                              | 30.0                                           | 6.30                                  | 0.91                                               |
| VS 42       | 44.6                                  | -                                      | 20.1                                     | 1.19                                              | 61.7                                           | 40.0                                  | 0.39                                               |
| VS 80-1     | 57.1                                  | 50.0                                   | 19.7                                     | 1.20                                              | 45.0                                           | 35.0                                  | 1.26                                               |
| VS 95       | -                                     | 50.0                                   | 18.5                                     | 1.89                                              | 17.5                                           | 29.3                                  | 1.19                                               |
| VS 96       | -                                     | 32.0                                   | 29.4                                     | 1.55                                              | 22.5                                           | 14.8                                  | 1.27                                               |
| VS 98       | 33.8                                  | 86.0                                   | 22.5                                     | 1.18                                              | 20.0                                           | 24.0                                  | 1.15                                               |
| VS 99       | 48.0                                  | 60.3                                   | 20.0                                     | 1.33                                              | 20.0                                           | 4.00                                  | 1.06                                               |
| CD (P=0.05) | -                                     | -                                      | 2.19                                     | NS                                                | -                                              | -                                     | 0.39                                               |

sub committee under the name “ KAIRALI ” for commercial cultivation.

### References

- Doraiswamy S, GC Sekar, M Ramaiah and RJ Rajan (1983) Performance of cowpea hybrids resistant to cowpea aphids and mosaic virus. *Madras agric. J.* **70**: 692.
- Khatri HL and L Singh (1974) Studies on mosaic diseases of cowpea. *Punjab Agric. Univ. J. Res.* **11**: 289-294.
- Patel PN, JK Mligo, HK Leyna, C Kuwite, and ET Mmbaga (1982) Multiple disease resistance cowpea breeding programme in Tanzania. *Indian J. Genet. Plant Breed.* **42**: 230.
- Sreelekha L (1987) Properties, Host Range and Control of Cowpea Mosaic Virus. M.Sc. (Ag.) Thesis, College of Agriculture, KAU, Vellayani.

## Biodiversity in Banana Cultivars of Genomic Group AB

**PK Valsalakumari and PC Sivaraman Nair**

*College of Horticulture, Kerala Agriculture University, Vellanikkara, Thrissur-680656, Kerala*

**Key Words: Evaluation, Banana, Nutrition value, Pollen characters**

Biodiversity in the cultivars of banana, which consist mainly of diploids is complex, with combinations of different degrees of expression of the parental species. The cultivars grown for commercial purposes are many, and the range of productivity and quality characters are also very wide (Raman, 1970). The wide variability occurring in South Indian bananas mainly belonging to the genomic group AB, definitely requires a detailed study for proper understanding. Further, banana cultivars of AB are recognized as the gene pool for imparting resistance to leaf spot and wilt (INIBAP, 2001).

Studies on banana cultivars belonging to the genomic group AB described by Jacob (1966) were carried out at the College of Horticulture, Vellanikkara, Thrissur,

Kerala, They were scored based on the 15 morphological characters, diagnostic of *Musa acuminata* Colla and *Musa balbisiana* Colla as suggested by Simmonds and Shepherd (1966) to confirm the genomic group. Ploidy levels were confirmed by cytological studies which consisted of making somatic root-tip chromosome counts of all the cultivars (Darlington and La Cour, 1976). The quantitative, plant, fruit and pollen characters were determined and the genetic divergence was estimated.

The growth parameters of 12 cultivars of banana belonging to the AB genomic group are described in Table 1. The height of the plant at the time of flowering varied from 227 cm in Vannan to 362 cm in Venneettu mannan. The variation in girth was from 44.80 cm in

**Table 1. Mean values of the growth parameters of cultivars of banana belonging to AB genomic group**

| Cultivars        | Growth parameters |            |               |                                    |                     |
|------------------|-------------------|------------|---------------|------------------------------------|---------------------|
|                  | Height (cm)       | Girth (cm) | Leaves/ plant | Leaf area/ plant (m <sup>2</sup> ) | Petiole length (cm) |
| Krishna vazhai   | 237.00            | 58.00      | 21.75         | 19.93                              | 34.25               |
| Vannan           | 227.00            | 52.50      | 18.25         | 17.33                              | 32.75               |
| Virupakshi       | 251.00            | 54.00      | 19.25         | 17.51                              | 53.75               |
| Sirumalai        | 229.00            | 52.50      | 21.00         | 17.25                              | 33.00               |
| Agniswar         | 232.50            | 44.80      | 29.50         | 23.82                              | 37.25               |
| Adakka kunnan    | 246.00            | 62.25      | 31.25         | 31.87                              | 67.50               |
| Valiya kunnan    | 234.50            | 59.50      | 29.50         | 33.13                              | 59.50               |
| Thaen kunnan     | 245.00            | 51.50      | 36.00         | 34.82                              | 39.25               |
| Padali moongil   | 232.50            | 46.25      | 28.25         | 18.14                              | 60.75               |
| Ney poovan       | 280.50            | 55.50      | 27.25         | 19.36                              | 56.75               |
| Kostha bontha    | 315.50            | 69.50      | 35.67         | 28.88                              | 54.25               |
| Venneettu mannan | 362.00            | 77.50      | 31.00         | 34.22                              | 66.75               |
| CD (0.05)        | 9.17              | 6.08       | 1.09          | 0.10                               | 1.71                |

sub committee under the name “ KAIRALI ” for commercial cultivation.

### References

- Doraiswamy S, GC Sekar, M Ramaiah and RJ Rajan (1983) Performance of cowpea hybrids resistant to cowpea aphids and mosaic virus. *Madras agric. J.* **70**: 692.
- Khatri HL and L Singh (1974) Studies on mosaic diseases of cowpea. *Punjab Agric. Univ. J. Res.* **11**: 289-294.
- Patel PN, JK Mligo, HK Leyna, C Kuwite, and ET Mmbaga (1982) Multiple disease resistance cowpea breeding programme in Tanzania. *Indian J. Genet. Plant Breed.* **42**: 230.
- Sreelekha L (1987) Properties, Host Range and Control of Cowpea Mosaic Virus. M.Sc. (Ag.) Thesis, College of Agriculture, KAU, Vellayani.

## Biodiversity in Banana Cultivars of Genomic Group AB

**PK Valsalakumari and PC Sivaraman Nair**

*College of Horticulture, Kerala Agriculture University, Vellanikkara, Thrissur-680656, Kerala*

**Key Words: Evaluation, Banana, Nutrition value, Pollen characters**

Biodiversity in the cultivars of banana, which consist mainly of diploids is complex, with combinations of different degrees of expression of the parental species. The cultivars grown for commercial purposes are many, and the range of productivity and quality characters are also very wide (Raman, 1970). The wide variability occurring in South Indian bananas mainly belonging to the genomic group AB, definitely requires a detailed study for proper understanding. Further, banana cultivars of AB are recognized as the gene pool for imparting resistance to leaf spot and wilt (INIBAP, 2001).

Studies on banana cultivars belonging to the genomic group AB described by Jacob (1966) were carried out at the College of Horticulture, Vellanikkara, Thrissur,

Kerala, They were scored based on the 15 morphological characters, diagnostic of *Musa acuminata* Colla and *Musa balbisiana* Colla as suggested by Simmonds and Shepherd (1966) to confirm the genomic group. Ploidy levels were confirmed by cytological studies which consisted of making somatic root-tip chromosome counts of all the cultivars (Darlington and La Cour, 1976). The quantitative, plant, fruit and pollen characters were determined and the genetic divergence was estimated.

The growth parameters of 12 cultivars of banana belonging to the AB genomic group are described in Table 1. The height of the plant at the time of flowering varied from 227 cm in Vannan to 362 cm in Venneettu mannan. The variation in girth was from 44.80 cm in

**Table 1. Mean values of the growth parameters of cultivars of banana belonging to AB genomic group**

| Cultivars        | Growth parameters |            |               |                                    |                     |
|------------------|-------------------|------------|---------------|------------------------------------|---------------------|
|                  | Height (cm)       | Girth (cm) | Leaves/ plant | Leaf area/ plant (m <sup>2</sup> ) | Petiole length (cm) |
| Krishna vazhai   | 237.00            | 58.00      | 21.75         | 19.93                              | 34.25               |
| Vannan           | 227.00            | 52.50      | 18.25         | 17.33                              | 32.75               |
| Virupakshi       | 251.00            | 54.00      | 19.25         | 17.51                              | 53.75               |
| Sirumalai        | 229.00            | 52.50      | 21.00         | 17.25                              | 33.00               |
| Agniswar         | 232.50            | 44.80      | 29.50         | 23.82                              | 37.25               |
| Adakka kunnan    | 246.00            | 62.25      | 31.25         | 31.87                              | 67.50               |
| Valiya kunnan    | 234.50            | 59.50      | 29.50         | 33.13                              | 59.50               |
| Thaen kunnan     | 245.00            | 51.50      | 36.00         | 34.82                              | 39.25               |
| Padali moongil   | 232.50            | 46.25      | 28.25         | 18.14                              | 60.75               |
| Ney poovan       | 280.50            | 55.50      | 27.25         | 19.36                              | 56.75               |
| Kostha bontha    | 315.50            | 69.50      | 35.67         | 28.88                              | 54.25               |
| Venneettu mannan | 362.00            | 77.50      | 31.00         | 34.22                              | 66.75               |
| CD (0.05)        | 9.17              | 6.08       | 1.09          | 0.10                               | 1.71                |

Agniswar to 775 cm in Venneettu mannan. The variation in number of leaves/plant was from 18.25 in Vannan to 35.67 in Kostha bontha. The variation in leaf number was from 17.25 m in Sirumalai to 34.82 in Thaen kunnan. Greater vigour is associated with the predominance of B genome in banana.

Mean values of the duration of banana cultivars belonging to AB genomic group are presented in Table 2. The duration from planting to flowering varied from 170.50 days in Krishna Vazhai to 245.50 days in Venneettu mannan. Flowering to harvest interval varied from 70 days in Vannan and Virupakshi to 123.50 days in Thaen kunnan. The duration of banana is controlled by environmental factors and the genome, B genome contributing to longer duration.

The bunch characters of the banana cultivars are presented in Table 3. Bunch weight varied from 2.50 kg in Padali moongil to 15.25 kg in Venneettu mannan. Hand weight varied from 432 g in Agniswar to 1250 g in Venneettu mannan and Valiya kunnan. The variation in number of hands was from 3.5 (Padali moongil) to 12.50 (Venneettu mannan). The number of fingers was also the lowest in Padali moongil (19.50) and the highest in Venneettu mannan (209.00).

The finger characters of the varieties are presented in Table 4. Finger weight varied from 42.58 in Virupakshi to 96.50 in Padali moongil. The pulp/peel ratio varied from 1.26 in Sirumalai to 7.17 in Padali moongil. Variation in finger length was from 9.13 in Agniswar to 13.63 in Kostha bontha.

**Table 2. Mean values of the duration of banana cultivars belonging to AB genomic group**

| Cultivars        | Duration of the crop (days) |                      |
|------------------|-----------------------------|----------------------|
|                  | Planting to flowering       | Flowering to harvest |
| Krishna vazhai   | 170.50                      | 71.00                |
| Vannan           | 174.00                      | 70.00                |
| Virupakshi       | 174.00                      | 70.00                |
| Sirumalai        | 169.50                      | 70.50                |
| Agniswar         | 176.50                      | 107.50               |
| Adakka kunnan    | 232.50                      | 114.50               |
| Valiya kunnan    | 233.50                      | 99.50                |
| Thaen kunnan     | 227.50                      | 123.50               |
| Padali moongil   | 228.00                      | 114.50               |
| Ney poovan       | 186.00                      | 110.00               |
| Kostha bontha    | 232.00                      | 107.50               |
| Venneettu mannan | 245.00                      | 105.00               |
| CD (0.05)        | 4.43                        | 3.43                 |

The quality characters also showed great variation among the cultivation. The total reducing sugars varied from 12.78 in Adakka kunnan to 19.25 in Sirumalai. The reducing sugars also followed the same pattern varying from 12.78 in Valiya kunnan to 18.31 in Sirumalai. The sugar/acid ratio varied from 31.65 in Krishna vazhai to 59.25 in Ney poovan. Quality of fruits is mainly associated with A genome in banana cultivars.

With regard to the pollen characters, all the cultivars were found to be non-polleniferous but they showed variation in the degree of development of anther lobes as shown in Table 6.

The growth rates also showed significant variation among the varieties. In height the variation was from 25.00 in Venneettu mannan to 52.30 in Sirumalai. With respect to leaf number, the growth rate varied from 23.80 (Venneettu mannan) to 58.20 (Agniswar).

Using the D2 values, the cultivars were grouped into different clusters. Sirumalai, Virupakshi, Vannan and Agniswar belonged to the same cluster and the others to another cluster. The contribution of characters towards divergence was estimated. The highest contribution was for pulp/peel ratio (34.00).

Studies conducted on banana cultivars belonging to the genomic group AB, established the intra-genomic biodiversity. Diversity was expressed in all the quantitative and quality characters and the genetic divergence was estimated in AB cultivars.

**Table 3. Mean values of the bunch characters of banana cultivars belonging to AB genomic group**

| Cultivars        | Bunch weight (kg) | Hand weight (g) | Number of hands | Number of fingers |
|------------------|-------------------|-----------------|-----------------|-------------------|
| Krishna vazhai   | 5.25              | 835.00          | 5.50            | 77.50             |
| Vannan           | 3.75              | 520.00          | 5.75            | 80.50             |
| Virupakshi       | 4.00              | 475.00          | 5.00            | 63.00             |
| Sirumalai        | 4.00              | 765.00          | 6.25            | 73.50             |
| Agniswar         | 5.00              | 432.50          | 6.50            | 74.00             |
| Adakka kunnan    | 5.50              | 694.00          | 10.00           | 125.50            |
| Valiya kunnan    | 10.25             | 1250.00         | 11.50           | 160.00            |
| Thaen kunnan     | 7.25              | 675.00          | 9.50            | 108.50            |
| Padali moongil   | 2.50              | 405.00          | 3.50            | 19.50             |
| Ney poovan       | 10.00             | 925.00          | 11.50           | 187.50            |
| Kostha bontha    | 12.75             | 902.50          | 11.50           | 172.00            |
| Venneettu mannan | 15.25             | 1250.00         | 12.50           | 209.00            |
| CD (0.05)        | 0.75              | 174.98          | 1.62            | 12.08             |

**Table 4. Mean values of the finger characters of banana cultivars belonging to AB genomic group**

| Cultivars        | Pedicle length (cm) | Finger length (cm) | Finger girth (cm) | Finger weight (g) | Finger volume (cc) | Pulp weight (%) | Pulp/peel (wt. basis) | Pulp volume (%) | Pulp/peel (vol. basis) |
|------------------|---------------------|--------------------|-------------------|-------------------|--------------------|-----------------|-----------------------|-----------------|------------------------|
| Krishna vazhai   | 2.00                | 13.75              | 10.88             | 58.00             | 66.50              | 56.72           | 1.31                  | 61.77           | 1.62                   |
| Vannan           | 3.00                | 10.48              | 10.25             | 45.50             | 53.50              | 62.88           | 1.70                  | 56.85           | 1.32                   |
| Virupakshi       | 3.13                | 10.48              | 10.25             | 42.58             | 53.50              | 65.66           | 1.86                  | 66.73           | 2.01                   |
| Sirumalai        | 3.63                | 10.88              | 9.75              | 54.38             | 61.00              | 55.78           | 1.26                  | 75.25           | 3.04                   |
| Agniswar         | 2.08                | 9.13               | 7.18              | 54.64             | 56.00              | 74.80           | 2.97                  | 72.62           | 2.66                   |
| Adakka kunnan    | 3.98                | 10.68              | 8.75              | 48.45             | 45.50              | 74.50           | 2.93                  | 74.38           | 2.90                   |
| Valiya kunnan    | 4.40                | 14.25              | 10.18             | 77.79             | 71.00              | 79.75           | 3.94                  | 76.25           | 3.22                   |
| Thaen kunnan     | 3.75                | 19.61              | 8.23              | 51.25             | 69.00              | 81.26           | 4.34                  | 75.28           | 3.05                   |
| Padali moongil   | 4.13                | 11.13              | 11.88             | 96.50             | 41.50              | 87.75           | 7.17                  | 72.22           | 2.60                   |
| Ney poovan       | 4.58                | 12.63              | 8.65              | 62.63             | 70.50              | 72.87           | 2.69                  | 74.98           | 3.00                   |
| Kostha bontha    | 2.55                | 13.63              | 11.33             | 68.42             | 64.50              | 74.67           | 2.95                  | 65.57           | 1.71                   |
| Venneettu mannan | 3.63                | 10.88              | 9.48              | 78.00             | 53.00              | 66.33           | 1.97                  | 70.09           | 2.34                   |
| CD (0.05)        | 0.28                | 0.77               | 1.20              | 4.57              | 6.42               | 1.28            | 0.28                  | 1.00            | 0.06                   |

**Table 5. Mean values of the quality characters of banana cultivars belonging to AB genomic group**

| Cultivars        | TSS(%) | Total sugars (%) | Reducing sugars (%) | Non-reducing sugars | Acidity (%) | Sugaracid ratio |
|------------------|--------|------------------|---------------------|---------------------|-------------|-----------------|
| Krishna vazhai   | 24.03  | 16.11            | 15.00               | 1.05                | 0.52        | 31.65           |
| Vannan           | 21.50  | 16.91            | 14.51               | 2.28                | 0.46        | 37.15           |
| Virupakshi       | 22.50  | 19.12            | 17.85               | 1.54                | 0.35        | 55.43           |
| Sirumalai        | 24.00  | 19.25            | 18.31               | 1.19                | 0.42        | 46.40           |
| Agniswar         | 23.50  | 17.18            | 15.36               | 1.57                | 0.40        | 38.58           |
| Adakka kunnan    | 26.00  | 12.75            | 13.78               | 0.95                | 0.27        | 49.08           |
| Valiya kunnan    | 26.00  | 13.25            | 12.78               | 0.95                | 0.27        | 49.08           |
| Thaen kunnan     | 29.00  | 17.65            | 14.50               | 3.04                | 0.31        | 58.04           |
| Padali moongil   | 28.00  | 16.72            | 13.70               | 2.87                | 0.29        | 57.64           |
| Ney poovan       | 28.50  | 15.65            | 13.95               | 1.62                | 0.27        | 59.25           |
| Kostha bontha    | 27.00  | 17.54            | 15.00               | 2.42                | 0.36        | 49.17           |
| Venneettu mannan | 24.00  | 16.85            | 14.86               | 1.32                | 0.36        | 46.81           |
| CD (0.05)        | 0.82   | 1.18             | 1.77                | 1.48                | 0.40        | 7.51            |

**Table 6. Pollen characters of banana cultivars belonging to AB genomic group**

| Genomic Group | Cultivar         | Remarks                                                                           |
|---------------|------------------|-----------------------------------------------------------------------------------|
| AB            | Agniswar         | Anther lobes black, thread like structures                                        |
|               | Krishna vazhai   |                                                                                   |
|               | Virupakshi       |                                                                                   |
|               | Sirumalai        |                                                                                   |
|               | Vannan           |                                                                                   |
|               | Ney poovan       | Anther lobes well developed but contain no pollen grains                          |
|               | Adakka kunnan    |                                                                                   |
|               | Valiya kunnan    |                                                                                   |
|               | Thaen kunnan     |                                                                                   |
|               | Kostha bontha    |                                                                                   |
|               | Venneettu mannan | Anther lobes well developed, occasionally some may contain very few pollen grains |
|               | Padali moongil   |                                                                                   |
|               |                  | Male axis absent                                                                  |

Table 7. Relative growth rate (RGR) of banana cultivars belonging to AB genomic group

| Cultivars        | Growth parameters |       |              |                 |                |
|------------------|-------------------|-------|--------------|-----------------|----------------|
|                  | Height            | Girth | Leaves/plant | Leaf area/plant | Petiole length |
| Krishna vazhai   | 42.20             | 28.40 | 36.90        | 107.50          | 20.53          |
| Vannan           | 50.80             | 37.60 | 45.10        | 166.30          | 21.61          |
| Virupakshi       | 41.80             | 29.90 | 32.90        | 126.30          | 29.99          |
| Sirumalai        | 52.30             | 43.70 | 51.50        | 172.00          | 26.53          |
| Agniswar         | 51.20             | 38.00 | 58.20        | 189.20          | 23.31          |
| Adakka kunnan    | 32.30             | 28.60 | 39.40        | 153.50          | 32.10          |
| Valiya kunnan    | 37.40             | 33.00 | 39.70        | 161.20          | 29.20          |
| Thaen kunnan     | 37.60             | 25.60 | 35.20        | 121.30          | 17.41          |
| Padali moongil   | 33.90             | 24.70 | 38.80        | 116.20          | 23.57          |
| Ney poovan       | 52.00             | 46.10 | 50.20        | 159.20          | 41.40          |
| Kostha bontha    | 39.40             | 27.40 | 43.40        | 91.65           | 26.30          |
| Venneettu mannan | 25.00             | 16.50 | 23.80        | 59.00           | 15.10          |

## References

- Darlington CD and LF La Cour (1976) *The Handling of Chromosomes*, 6<sup>th</sup> ed, London, George Allen and Unwin Ltd., pp 36-39.
- INIBAP (2001) Minutes of the second PROMUSA steering committee meeting, Bangkok, Thailand, 7-8, November 2000 *INFOMUSA 9*: I-XIV.
- Jacob KC (1966) Note on classification of banana *Madras Agric. J.* **53**: 220.
- Raman VS (1970) *Breeding New Varieties of Banana*, Souvenir, All India banana and miscellaneous fruit show, Madras, Part B, pp 9-10.
- Simmonds W (1966) *Bananas*. 2<sup>nd</sup> ed, London, Longman, NW.
- Simmonds and K Shepherd, 1955. The taxonomy and origin of cultivated bananas. *J. Linn Soc. London* **55**: 302-312.

## Assessing Variability among Indian *Capsicums* by AFLP

**Ambika Baldev Gaikwad, Sunil Archak, Diksha Gautam, JL Karihaloo**

National Research Centre on DNA Fingerprinting, National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012

Chilli pepper is one of the most widely grown spice crops of India. Cultivated *Capsicum* comprising of *C. annum*, *C. frutescens*, *C. baccatum*, *C. pubescence* and *C. chinense* originated in Central and South America. Chillies were introduced into India in the sixteenth century and from the agricultural perspective, the most important species is *C. annum*. The widely different agro-climatic regimes of the country have led to the selection of a wide range of hot pepper, bell pepper and paprika types, thus, giving rise to a large amount of variability. Extensive diversity has been reported among the chilli germplasm in India (Singh and Singh, 1976). Variation in chilli germplasm has been analysed using AFLP, RFLP and ISSR markers (Prince *et al.* 1995; Paran *et al.* 1998). Molecular markers have also

been used for constructing intra-specific integrated linkage maps of pepper (Lefebvre *et al.* 1995). In the present study, 28 Indian accessions that included released varieties as well as landraces were characterised using AFLP markers. The latter detect polymorphism within a subset of genomic DNA defined by the restriction sites of the enzymes, and the additional nucleotide used for selective amplification in the technique.

Seeds of 28 accessions of *C. annum* were sown in pots under green house conditions. Two grams of young leaves were ground to a fine powder using liquid nitrogen, suspended in 10 ml of homogenisation buffer (100 mM Tris, pH 8, 20 mM EDTA, 1.4 M NaCl, 2% CTAB, 0.2% 2-Mercaptoethanol), by vortexing and incubated at 65°C for 1h. The homogenate was extracted

Table 7. Relative growth rate (RGR) of banana cultivars belonging to AB genomic group

| Cultivars        | Growth parameters |       |              |                 |                |
|------------------|-------------------|-------|--------------|-----------------|----------------|
|                  | Height            | Girth | Leaves/plant | Leaf area/plant | Petiole length |
| Krishna vazhai   | 42.20             | 28.40 | 36.90        | 107.50          | 20.53          |
| Vannan           | 50.80             | 37.60 | 45.10        | 166.30          | 21.61          |
| Virupakshi       | 41.80             | 29.90 | 32.90        | 126.30          | 29.99          |
| Sirumalai        | 52.30             | 43.70 | 51.50        | 172.00          | 26.53          |
| Agniswar         | 51.20             | 38.00 | 58.20        | 189.20          | 23.31          |
| Adakka kunnan    | 32.30             | 28.60 | 39.40        | 153.50          | 32.10          |
| Valiya kunnan    | 37.40             | 33.00 | 39.70        | 161.20          | 29.20          |
| Thaen kunnan     | 37.60             | 25.60 | 35.20        | 121.30          | 17.41          |
| Padali moongil   | 33.90             | 24.70 | 38.80        | 116.20          | 23.57          |
| Ney poovan       | 52.00             | 46.10 | 50.20        | 159.20          | 41.40          |
| Kostha bontha    | 39.40             | 27.40 | 43.40        | 91.65           | 26.30          |
| Venneettu mannan | 25.00             | 16.50 | 23.80        | 59.00           | 15.10          |

## References

- Darlington CD and LF La Cour (1976) *The Handling of Chromosomes*, 6<sup>th</sup> ed, London, George Allen and Unwin Ltd., pp 36-39.
- INIBAP (2001) Minutes of the second PROMUSA steering committee meeting, Bangkok, Thailand, 7-8, November 2000 *INFOMUSA 9*: I-XIV.
- Jacob KC (1966) Note on classification of banana *Madras Agric. J.* **53**: 220.
- Raman VS (1970) *Breeding New Varieties of Banana*, Souvenir, All India banana and miscellaneous fruit show, Madras, Part B, pp 9-10.
- Simmonds W (1966) *Bananas*. 2<sup>nd</sup> ed, London, Longman, NW.
- Simmonds and K Shepherd, 1955. The taxonomy and origin of cultivated bananas. *J. Linn Soc. London* **55**: 302-312.

## Assessing Variability among Indian *Capsicums* by AFLP

**Ambika Baldev Gaikwad, Sunil Archak, Diksha Gautam, JL Karihaloo**

National Research Centre on DNA Fingerprinting, National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012

Chilli pepper is one of the most widely grown spice crops of India. Cultivated *Capsicum* comprising of *C. annum*, *C. frutescens*, *C. baccatum*, *C. pubescence* and *C. chinense* originated in Central and South America. Chillies were introduced into India in the sixteenth century and from the agricultural perspective, the most important species is *C. annum*. The widely different agro-climatic regimes of the country have led to the selection of a wide range of hot pepper, bell pepper and paprika types, thus, giving rise to a large amount of variability. Extensive diversity has been reported among the chilli germplasm in India (Singh and Singh, 1976). Variation in chilli germplasm has been analysed using AFLP, RFLP and ISSR markers (Prince *et al.* 1995; Paran *et al.* 1998). Molecular markers have also

been used for constructing intra-specific integrated linkage maps of pepper (Lefebvre *et al.* 1995). In the present study, 28 Indian accessions that included released varieties as well as landraces were characterised using AFLP markers. The latter detect polymorphism within a subset of genomic DNA defined by the restriction sites of the enzymes, and the additional nucleotide used for selective amplification in the technique.

Seeds of 28 accessions of *C. annum* were sown in pots under green house conditions. Two grams of young leaves were ground to a fine powder using liquid nitrogen, suspended in 10 ml of homogenisation buffer (100 mM Tris, pH 8, 20 mM EDTA, 1.4 M NaCl, 2% CTAB, 0.2% 2-Mercaptoethanol), by vortexing and incubated at 65°C for 1h. The homogenate was extracted

twice with chloroform:isoamyl alcohol (24:1) by centrifugation at 12,000 rpm at 25°C for 15 min. Total cellular DNA was precipitated with 0.6 volumes of isopropanol and pelleted by centrifugation at 15,000 rpm for 20 min. The pellet was washed with 70% ethanol, air dried, dissolved in TE buffer (Tris 10 mM, EDTA 1 mM, pH 8.0), treated with bovine pancreatic RNase and extracted with phenol:chloroform:isoamyl alcohol (25:24:1) and chloroform:isoamyl alcohol (24:1).

The AFLP reactions were performed with the AFLP Plant Mapping Kit (regular genomes) of Perkin Elmer according to the manufacturers protocol. Six primer combinations were employed for generation of markers. These were *Mse*I+CTC/*Eco*RI+ACG, *Mse*I+CTC/*Eco*RI+ACT, *Mse*I+CTC/*Eco*RI+ACC, *Mse*I+CTG/*Eco*RI+ACA, *Mse*I+CTG/*Eco*RI+AGC, *Mse*I+CTG/*Eco*RI+AAG. The *Eco*RI primers were labelled with fluorescent dyes which allowed detection of amplification products that were resolved by an ABI Prism 310 Genetic Analyzer. Fragment sizes were determined in relation to the GeneScan - 500 ROX size standard. The binary matrix was obtained for the presence and absence of markers by sequential analyses using softwares GeneScan Version 3.1 and Genotyper version 2.5.

Six primer pairs were used to amplify targeted sites of the genome. A total of 332 amplification products (visualised as peaks) were detected. These ranged from 50 to 350 nucleotides in size. The average number of bands/primer-pair was 55, with all but one of the markers being polymorphic. The polymorphism information content detected by AFLP markers among the Indian cultivars was 0.29 which is higher than that obtained for a collection including the exotic types. Based on the AFLP data a matrix of genetic similarity was constructed for these accessions. The value of Jaccard's coefficient ranged from 0.15 to 0.83 with the maximum similarity existing between K-2 and PMK-1. In the phenetic analysis, loose clusters were distinguished on the basis of the geographical locations, with the accessions from south India being close to

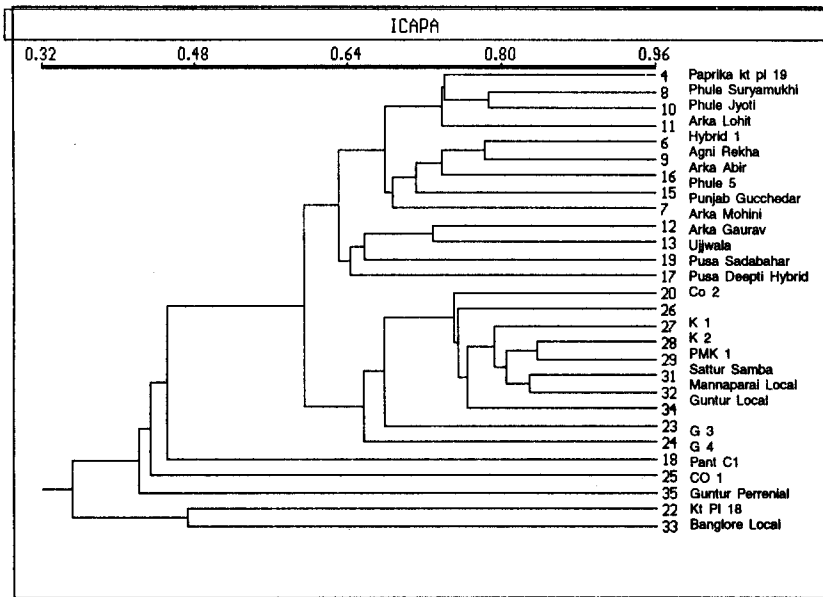


Fig. 1. UPGMA dendrogram based on AFLP analysis of Indian *Capsicums*

each other.

The high Marker Index of 15.5 obtained from the analysis of AFLP data can be attributed to the high multiplex ratio of the AFLP markers. The polymorphic bands obtained in this study were seven times more than that reported previously (Paran *et al.* 1998). The high percentage of polymorphism may be a reflection of the highly divergent group of hot chilli types that dominate the accessions included in this study. These results indicate the presence of a high level of genetic diversity in the Indian accessions of *C. annuum* and support the contention of some workers of India being the secondary centre of diversity of chilli pepper.

## References

- Lefebvre V, A Polloix, C Caranta and E Pochard (1995) Construction of an integrated linkage map of pepper using molecular markers and doubled haploid progenies. *Genome* 38: 112-121.
- Paran I, E Aftergoot and C Shiffriss (1998) Variation in *Capsicum annuum* revealed by RAPD and AFLP markers. *Euphytica* 99: 167-173.
- Prince JP and VK Lackney (1995) A survey of DNA polymorphism within the genus *Capsicum* and the fingerprinting of pepper cultivars. *Genome* 38: 224-231.
- Singh A and HN Singh (1976) Genetic divergence in chilli. *Indian J. Genet. Plant Breed.* 36: 425-430.

## Application of Inter Simple Sequence Repeat (ISSR) Polymorphism in Assessing Diversity in Crop Plants

**N Sarla, M Pradeep Reddy and EA Siddiq**

National Professor, Project Directorate of Rice Research, Rajendranagar, Hyderabad-500030, Andhra Pradesh

**Key Words:** Assessment, Diversity, Polymorphism, Finger printing

Simple sequence repeats (SSRs) or microsatellites are short tandem repeats (STRs) of 1-4 bases of DNA ubiquitously present in eukaryote genomes. They are dispersed throughout the genome and vary in the number of repeat units. Inter simple sequence repeat (ISSR)-PCR is a technique, which involves the use of microsatellite sequences as primers in a polymerase chain reaction to amplify mainly the inter-SSR regions. These are multilocus, unmapped markers which are usually dominant. ISSR-PCR is also known as SSR-anchored PCR(I), anchored SSR-PCR (ASSR-PCR) microsatellite primed PCR(MP-PCR), anchored microsatellite primed PCR(AMP-PCR), single primer amplification reaction (SPAR), randomly amplified microsatellites (RAM),

randomly amplified microsatellite polymorphism (RAMP). It is a simple and quick method that combines most of the advantages of SSR polymorphism and amplified fragment length polymorphism (AFLP) to the universality of random amplified polymorphic DNA (RAPD). The technique is specially useful in studies on genetic diversity in a wide range of crop species (Table 1).

ISSR markers are more reproducible than RAPD markers possibly due to the use of longer primers (16-25 mers) as compared to RAPD primers (10 mers) and the associated use of high annealing temperature (45-60°C) leading to higher stringency. ISSR polymorphism depends on the nature of primer used, template DNA, and the method of detection (agarose-ethidium bromide

**Table 1. List of references on ISSR-PCR for fingerprinting (f) and diversity analysis in plants**

| Crop                                                         | Reference                                                                  |
|--------------------------------------------------------------|----------------------------------------------------------------------------|
| Potato cultivars (f)                                         | Prevost, Wilkinson (1999) <i>Theor. Appl. Genet.</i> 98, 1125-1131         |
| <i>Chrysanthemum</i> cultivars (f)                           | Wolff <i>et al.</i> (1995) <i>Theor. Appl. Genet.</i> 91, 439-447          |
| Rice cultivars (f)                                           | Virk <i>et al.</i> (2000) <i>Euphytica</i> 112, 275-284                    |
| Wheat ( <i>Triticum</i> sp.)                                 | Nagaoka, Ogihara (1997) <i>Theor. Appl. Genet.</i> 94, 597-602             |
| Maize inbred lines ( <i>Zea mays</i> )                       | Lu <i>et al.</i> 1996 <i>Theor. Appl. Genet.</i> 93, 1103-1111             |
| Finger millet ( <i>Eleusine</i> sp.)                         | Salimath <i>et al.</i> (1995) <i>Genome</i> 38, 757-763                    |
| Sorghum (Chinese) ( <i>Sorghum bicolor</i> )                 | Yang <i>et al.</i> (1996) <i>Crop Sci.</i> 36, 16 96 1086-1096             |
| White lupin germplasm ( <i>Lupinus albus</i> )               | Gilbert <i>et al.</i> (1999), <i>Theor. Appl. Genet.</i> 98, 1125-1131     |
| <i>Vigna</i> sp.                                             | Ajibade <i>et al.</i> (2000) <i>Euphytica</i> 1111, 47-55                  |
| Pea germplasm ( <i>Pisum sativum</i> )                       | Lu <i>et al.</i> <i>Theor. Appl. Genet.</i> 93, 1103-1111                  |
| Soybean ( <i>Glycine max</i> )                               | Wang (1998) <i>Theor. Appl. Genet.</i> 96, 1086-1096                       |
| Oil seed rape cultivars ( <i>Brassica napus</i> )            | Charters <i>et al.</i> 1996 <i>Theor. Appl. Genet.</i> 92, 442-447         |
| Sweet potato, wild relatives ( <i>Ipomoea</i> sp)            | Huang, Sun (2000) <i>Theor. Appl. Genet.</i> 100, 1050-1060                |
| Potato cultivars ( <i>Solanum tuberosum</i> )                | McGregor <i>et al.</i> (2000) <i>Euphytica</i> 113, 135-144                |
| Red currant germplasm ( <i>Ribes</i> sp.)                    | Lanham, Brennan (1998) <i>Theor. Appl. Genet.</i> 96, 917-921              |
| Grapevine germplasm ( <i>Vitis vinifera</i> )                | Moreno <i>et al.</i> (1998) <i>Euphytica</i> 101, 117-125                  |
| Citrus cultivars ( <i>Citrus</i> sp.)                        | Fang Roose (1997) <i>Theor. Appl. Genet.</i> 95, 408-417                   |
| Trifoliolate orange germplasm ( <i>Poncirus trifoliata</i> ) | Fang <i>et al.</i> (1997) <i>Theor. Appl. Genet.</i> 95, 211-219           |
| <i>Plantago major</i> subspecies                             | Wolff Morgan-Richards (1998) <i>Theor. Appl. Genet.</i> 96, 282-286        |
| Gymnosperms, Douglas fir and sugi                            | Tsumura <i>et al.</i> (1996) <i>Theor. Appl. Genet.</i> 92, 40-45          |
| Diploid hybrid speciation in <i>Penstemon</i>                | Wolff <i>et al.</i> (1998) <i>PNAS USA</i> 95, 5112-5115                   |
| Genome specific markers in <i>Lolium</i> and <i>Festuca</i>  | Pasakinskiene <i>et al.</i> (2000) <i>Theor. Appl. Genet.</i> 100, 384-390 |
| Putative genome specific markers in <i>Oryza</i>             | Joshi <i>et al.</i> (2000) <i>Theor. Appl. Genet.</i> 98, 780-792          |

or polyacrylamide-silver nitrate staining or polyacrylamide with radiolabelling).

The extent of polymorphism varies with the nature (unanchored, 3'-anchored, or 5'-anchored) and sequence of the repeats (motif) in the primer employed. When unanchored *i.e.* only the SSRs (MP-PCR) are used as primers, the primer tends to slip within the repeat units during amplification leading to smears instead of clear bands. Extending the primer with 1 to 4 degenerate nucleotides at the 3' or 5' end (anchor) assures annealing only to the ends of a microsatellite in template DNA thus, obviating internal priming and smear formation. Also, the anchor allows only a subset of the microsatellites to serve as priming sites. When 5'-anchored primers are used the amplified products include the microsatellite sequences and their length variations across a genome give more number of bands and a higher degree of polymorphism. Usually di-nucleotide repeats, anchored either at 3'- or 5'- end give high polymorphism. The primers anchored at 3'- end give clearer banding pattern as compared to 5'-anchored primer. The frequency and distribution (clustered or dispersed) of the microsatellite repeats in different species also influences the generation of bands. (AT)<sup>n</sup> are the most abundant dinucleotide repeats in plants but the primers based on (AT)<sup>n</sup> would self-anneal and not amplify. In general, primers with (AG), (GA), (CT) (TC), (AC) (CA) repeats show higher polymorphism than primers with other di- tri- or tetra-nucleotide repeats.

As the need to protect propriety germplasm is likely to increase in the future, ISSRs can have an important role in securing plant variety rights by virtue of its unique efficiency in fingerprinting and distinguishing even closely related germplasm. To date, more polymorphism has

been detected with the use of ISSRs than with any other assay procedure. In most of the studies for determining the extent of polymorphism only one class of SSRs *e.g.* di-, tri- or tetra-nucleotides are used as primers. The few studies where more than one class of SSRs are used as primers show that dinucleotide repeats are more useful as primers for obtaining clear bands and stable classification of germplasm. ISSR analysis provides insights into the organization (clustered or not), frequency and levels of polymorphism of different simple sequence repeats in a genome. As more data on the occurrence and distribution of SSR motifs in different crop plants becomes available, it should be possible to select primers that give a more accurate span of the whole genome. Also, different combinations of the motif, anchor and length of primers can be used to short-list a suite of very informative primers to obtain maximum polymorphism. In rice, anchored primers based on (GA) and (AG) repeats detect high levels of polymorphism (90 to 100%) and have proved useful for diversity analysis. However, the resolving power of each primer varies in landraces, improved varieties and wild germplasm. It saves time and labour if the most informative primers are used in diversity analysis. Strategies to detect more polymorphism could include use of ISSRs in combination with RAPD or AFLP primers and restriction digestion of ISSR products.

The technique is not without limitations. There is the possibility as in RAPD, that fragments with same mobility originate from non-homologous regions, which can lead to some distortion in the estimates of genetic similarities. The molecular nature of the polymorphisms can be known only if the fragments extracted from the gel are sequenced.

## Chemical Investigation of Some Aromatic Plants of Uttaranchal

**Poonam Suneja, CS Raghav, VK Srivastava, Jitendra Mohan, BM Singh, KS Negi\*, DS Pillania and Mahendra Singh**

National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012

**Key Words:** Collection, Essential oils, GLC, Aroma constituents

Uttaranchal is well known for possessing rich heritage of important medicinal and aromatic plants. Out of hundreds of important plant species of this area, only few have been domesticated so far. There are many plant species occurring wild in nature, which are yet to be examined for their useful chemical constituents so that the ways for their domestication may be opened. Keeping this in view, a study was undertaken to examine the aroma content of four aromatic plants namely, *Acorus calamus*, *Hedychium spicatum*, *Litsea glutinosa* and *Thymus serpyllum*. Since the chemical composition and the aroma content of aromatic plants greatly fluctuate with the changing habitats and climate, it is important to document the information in the light of these factors. Thus, in the present investigation, the germplasm was collected from the wild habitats viz.-rocky, stony pieces with sparse grasslands of Auli forest area from 1350 msl to 2720 msl height in the month of May.

All the material was collected from wild habitats from Auli forest areas and partially disturbed habitats, where agro-climatic conditions and physiography were different. The altitude of their occurrence varied from 1350 m to 2720 m. The material was collected in the form of rhizomes and live plants.

The plant material collected from forest area were subjected to hydro-distillation using Clevenger's apparatus in the chemistry laboratory at NBPGR, New Delhi. The essential oils so obtained were dried over anhydrous  $\text{Na}_2\text{SO}_4$ . These dried oils were analysed for their aroma constituents using Gas Liquid Chromatograph (GLC) model Perkin Elemer Auto System equipped with capillary column Carbowax 20M of 50 m length, Flame ionization detector, Okidata 320 M recorder, Digital computer DEC station fed with Turbochrom-3 software and nitrogen as carrier gas. Volatile aroma constituents were identified on the chromatogram by comparing their retention time with authentic compounds.

*Acorus calamus*: The *A. calamus*, commercially known as sweet flag or Buch, belongs to family Araceae. It is a semi-aquatic perennial herb with creeping rhizomes. It is found growing wild throughout India up to an altitude of 2200 m. This plant material was collected from Ghorsari village at the height of 1700 m in Chamoli district. Rhizomes were somewhat pale to dark brown in colour. Rhizomes yielded 0.26% yellow coloured oil. The oil is aromatic and has spicy odour. In ayurvedic system of medicine, the rhizomes are considered to possess antispasmodic, carminative, anthelmintic properties and are used to cure many disorders such as epilepsy and mental diseases. Both, the dried rhizomes and its essential oil are used as insecticide (Chowdhary *et al.* 1997). Chemical composition of *A. calamus* was studied by GLC. Major components identified were Terpinen-4-ol-4.72%, Geraniol-3.06%, Methyl-iso-eugenol-9.43%,  $\beta$ -Asarone-60.49% (Table 1).

*Hedychium spicatum*: The plant belongs to Zingiberaceae. It is leafy, up to 2 m tall having camphoraceous horizontal rhizome. It grows wild in sub-tropical to temperate areas of Himalayas. A live bulbous herbaceous plant sample was collected in the month of May from Pothivasa village of Rudraprayag district of at an altitude of 2020 m for its chemical analysis. The plant is well known for its therapeutic activity as antiseptic, carminative and bronchodilator (Chauhan, 1999). Because of its camphoraceous odour, this drug is often considered a substitute of *Curcuma zedoaria*.

The rhizome of the plant was subjected to chemical analysis. The oil content of rhizome was recorded as 0.26%. It was further subjected to GLC for aroma constituents. The major constituents found were 1-8 cineole-18.67%, Linalool-5.11%, Terpineol-4-ol-2.29%,  $\alpha$ -Terpineol-5.51%, Nerol-6.20%, Eugenyl acetate-3.14%, Eugenol-4.77%, Isoeugenol-8.75% (Table 1).

*Litsea glutinosa*: It belongs to family Lauraceae and is commonly known as Medal kadi. It is an evergreen shrub or tree up to 25 m in height and 1.5 m in girth. This plant is found throughout in India, ascending up

\*National Bureau of Plant Genetic Resources, Regional Station, Bhowali, Nainital, Uttaranchal

**Table 1. Chemical analysis of essential oil of aromatic plants collected from Uttarakhand**

| Plant species             | Common Name   | Village   | Site of collection<br>District | Altitude (m) | Oil yield (%) | Major constituents identified                                                                                                                                                                            |
|---------------------------|---------------|-----------|--------------------------------|--------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Hedychium spicatum</i> | Kapur kachari | Pothivasa | Rudraprayag                    | 2020         | 0.26          | 1-8 cineole-18.67%, Linalool-5.11%, Terpineol-4-ol-2.29%, $\alpha$ -Terpineol-5.51%, Nerol-6.20%, Eugenyl acetate-3.14%, Eugenol-4.77%, Isoeugenol-8.75%.                                                |
| <i>Litsea glutinosa</i>   | Medal kadi    | Dugabitta | Rudraprayag                    | 2330         | 0.32          | Camphor-10.98%, Citronellyl-formate-2.70%, Terpinen-4-ol-4.61%, Methyl chavicol-11.07%, Citral-a-6.18%, Citronellol-7.39%, Geraniol-6.71%, Methyl-iso-eugenol-5.46%, Eugenol-6.69%, Unidentified-12.84%. |
| <i>Acorus calamus</i>     | Buch          | Ghorsari  | Chamoli                        | 1700         | 0.26          | Terpinen-4-ol-4.72%, Geraniol-3.06%, Methyl-iso-eugenol-9.43%, $\beta$ -Asarone-60.49%.                                                                                                                  |
| <i>Thymus serpyllum</i>   | Wild thyme    | Auli      | Chamoli                        | 2720         | 0.13          | Camphor-1.84%, Linalool-0.85%, Terpineol-4-ol-2.35%, $\alpha$ -Terpineol-0.11%, $\alpha$ -Terpenyl acetate-8.48%, Thymol-18.78%.                                                                         |

to an altitude of 1350 m in the outer Himalayas. This live plant was collected from Duga bitta village of Rudraprayag district at a height of 2330 m. The bark of *L. glutinosa* constitutes the common drug sold in Indian bazars under the name "Maida Lakri" or "Maida Lakadi". It is available in the form of broken quills. It is mucilaginous, feebly balsamic and mildly astringent. It is used in diarrhoea and dysentery. Ground and pasted material is used as an emollient for strain, bruises and rheumatic joints. The bulbous herb yielded 0.32% volatile oil. The GC examination of the oil revealed the presence of 52 compounds, out of which, 19 have been identified. Major components identified were Camphor-10.98%, Terpene-4-ol-4.61%, Methyl chavicol-11.07%, Citronellol-7.39% and Geraniol-6.71% (Table 1).

*Thymus serpyllum*: *Thymus serpyllum*, commonly known as, wild thyme is a member of family Labiatae. The plant is found in the Himalaya Region. In Himachal Pradesh, the plant is frequently found in the open rocky slopes. The plant is a variable, aromatic, hairy, prostrate

and evergreen perennial herb with spreading habit. It is pungent in taste. The herb possesses anti spasmodic, antiseptic, carminative, anthelmintic and stimulating properties. The oil is used as a flavouring agent in non-alcoholic beverages and medicinal preparations in all systems of medicines.

The plant was collected from Auli village of Chamoli district at an altitude of 2720 m. The chemical analysis of *Thymus serpyllum* herb yielded 0.13 % of aromatic oil. The dried oil was further analysed on GLC for its volatile constituents. Major constituents identified were Camphor-1.84%, Terpinen-4-ol-2.35%,  $\alpha$ -Terpineol-0.11%,  $\alpha$ -Terpenyl acetate-8.48%, Thymol 18.79%, p-Cymene- 7.17% (Table 1).

#### References

- Chowdhary AR, Gupta RC and Sharma ML (1997) Essential oil from the rhizomes of *Acorus calamus* Linn. raised on alkaline soil. *Indian Perfumer* 41: 154-156.
- Chauhan NS (1999) *Medicinal and Aromatic Plants of Himachal Pradesh*, Indus Publication Company, New Delhi.

## Sustainable Use of Winter Wheat Ecotypes for Breaking the Yield Barriers in Spring Wheats

**HK Choudhary, GS Sethi, S Singh and A Pratap**

*Cytogenetics and Tissue Culture Laboratory., Department of Plant Breeding and Genetics, Himachal Pradesh Krishi Vishwavidyalaya, Palampur-176062, Himachal Pradesh*

**Key Words:** Winter x Spring wheat, High yielding resistance, Cold tolerant

On the basis of physiological development wheats have been classified into two ecotypes viz. -winter and spring types. The former group is being cultivated only in the dry and wet temperate regions of North-West Himalayas covering a very small fraction of the total area under wheat in India, whereas the rest of the wheat cultivation in the country is under the latter group. After realizing the effect of the incorporation of the genes for semi-dwarfness in wheat alongwith the application of high doses of fertilizers assured and frequent irrigation facilities, a standstill in the grain yield potential of almost all the varieties of spring ecotypes has been observed. Several efforts are afoot to achieve a breakthrough in the yield potential. One of the most efficient way-out is to inter-cross for seldom crossed winter and spring wheat gene-pools for combining complementarily the yield contributing traits. An endeavour in this direction is underway at the Department of Plant Breeding and Genetics, HPKV, Palampur as well as its satellite station at Kukumseri (Lahaul and Spiti).

Several genotypes of the two wheat ecotypes viz. -winter and spring types were used for the present investigation. Amongst the winter wheats, 'Armada', 'Atou', 'Aurora', 'Amargas 2', 'Beacon', 'Burgas 2', 'Bezstaya', 'Blueboy', 'Bouquet', 'Bountry', 'Backa', 'Enboy', 'Flanders', 'Fuddin', 'Hensih VII', 'J.O. 3057', 'Pnfjoumee', 'Stepova', 'Sentry', 'TJB 987/5', 'Virtue', 'WW 24', 'Yubiely' of exotic group and 'WWC 1' to 'WWC 8' and 'Saptdhara' (released from HPKV, Palampur) of indigenous group and amongst the spring wheat ecotype certain leading genotypes of different maturity groups viz. - 'HD 2380', 'HPW 42', 'HPW DL (30)', 'HS 207', 'HUW 258', 'PBW 65', 'VERRY S'S', and 'VL 616' (selected from All India Coordinated Wheat Trials) were isolated as two gene-pools for initiating the present effort. The winter wheat genotypes 'WWC 1' to 'WWC 8' were collected from different snow-bound pockets of Himachal Pradesh. About 200 winter x spring wheat and their reciprocal crosses were attempted

at two locations viz.- HPKV, Palampur (representing the mid-hills of North-West Himalayas) and HPKV, RRS, Kukumseri, Lahaul and Spiti (representing the dry temperate zone of the North-West Himalayas). By applying the pedigree breeding approach, the crosses were handled and advanced through shuttling differentiating generations between two different locations viz. - HPKV, Research Sub-station, Sundernagar (main season) and HPKV, Regional Research Station, Kukumseri, Lahaul and Spiti (off season).

The winter wheats have been characterised as having long duration, very high grain yield, profuse tillering square heads accommodating good number of spikelets, well developed crown root system, drought and cold tolerance and additional sources of disease resistance. By hybridizing the winter wheats with the spring group, most of the aforesaid beneficial traits were proposed to be transferred for realizing a breakthrough in the spring ecotypes of bread wheat (Choudhary *et al.* 1994).

The efficiency of the hybridization between the winter and spring wheat genotypes was compared at two locations viz.- Palampur (main season having short photoperiod and variable temperature regime) and Kukumseri (off-season having long photoperiod and static temperature regime). Kukumseri proved to be an ideal location for attempting successful winter x spring wheat and their reciprocal crosses (Choudhary, 1997). About 200 winter x spring wheat  $F_1$ s and their reciprocals were achieved in four different seasons during two consecutive years (1989-90 and 1990-91) by involving different elite genotypes of both the ecotypes. The  $F_1$ s and the advance generations were shuttled between the HPKV, Regional Research Sub-Station, Sundernagar and HPKV, Regional Research station, Kukumseri (Lahaul and Spiti) for harvesting two crops in a year.

In all, 30 derivatives of the winter x spring wheat and their reciprocals viz.- 'KWS 1' to 'KWS 30' were identified in the  $F_6$  generation as the potential spring

type genotypes with respect to grain yield, drought and cold tolerance and disease resistance. In general, the spring x winter wheat combinations proved to be better than their reciprocals indicating the significant difference between the effect of the cytoplasm of the two ecotypes (Choudhary, 1996).

Out of 30 spring type derivatives of winter x spring wheat and their reciprocals, two genotypes viz.- 'KWS 22' and 'KWS 29' were observed as very high yielding, drought tolerant, resistant to yellow and brown rusts and powdery mildew and medium bold amber grained. Both these lines have been included in the National Integrated Disease Screening Nursery (IDSN) and if found resistant, will be included in the Initial Varietal Trials for rainfed and timely sown conditions of northern hill zone proposed and conducted under All India Coordinated Wheat Improvement Project.

Although, by exploiting the off-season facilities of Kukumseri (Lahaul and Spiti) the time period required for attaining the homozygosity in the segregating generations was reduced to half yet some other innovative breeding approaches viz.- androgenesis-mediated and wheat x maize systems are being executed for the transfer of winter wheat traits into spring wheats in a single step through the development of polyhaploids and doubled haploids, which in turn, further shorten the breeding cycle. For this purpose, an *ad-hoc* research project entitled "Genetic amelioration of winter and spring wheat ecotypes through androgenesis and wheat x maize systems" has

been sanctioned by the ICAR and being executed since 1997 at the Department of Plant Breeding and Genetics, HPKV, Palampur.

The present endeavour being executed for the spring wheat improvement has been made sustainable by conserving the most endangered winter wheat landraces collected from the snow-bound regions of North-West Himalayas. Besides, certain elite exotic winter wheat collections of diverse origin are also being introduced and conserved under naturally prevailing cold and dry conditions at HPKV, RRS, Kukumseri (Lahaul and Spiti) for the future sustainable use and posterity. Every year, the crosses between the winter and spring wheats are planned according to the need of the different hill regions of North-West Himalayas, attempted during the off-season at Kukumseri (Lahaul and Spiti), evaluated during the main season at Palampur and advanced in the shuttled breeding programme by exploiting the off-season facilities available in the high-hills of Himachal Pradesh.

#### References

- Choudhary HK, AS Kapoor, SC Sharma and S Nago (1994) Evaluation of exotic winter wheat (*Triticum aestivum*) varieties in dry temperate region of north west Himalayas. *Indian J. Agric. Sci.* **64**: 409-411.
- Choudhary HK (1996) Reciprocal differences in winter x spring wheat crosses. *Crop Improvement* **23**: 281-283.
- Choudhary HK (1997) Genetic amelioration of spring wheat ecotypes for drought prone regions through spring x winter wheat hybridization. *Proc. Int. Symp. Tropical Crop Res. and Dev.*, Kerala.

## Correlation and Path Coefficient Analysis in Walnut (*Juglans regia* L.)

**SD Sharma and SK Yadav\***

Department of Fruit Breeding and Genetic Resources, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan-173230, Himachal Pradesh

**Key Words:** Correlation, *Juglans regia*, Walnut

A total of 133 walnut seedlings were used to study the association between nut weight and its attributes. Nut weight was significantly and positively correlated with nut width, nut height, nut thickness, pad width, shell thickness and kernel weight. Path analysis of nut

weight and its components revealed that nut width, nut height, nut thickness, shell thickness and kernel weight had direct positive effect on nut weight.

Nut weight is an important character for in-shell marketing of nuts. The nut weight depends on many characters and selection is more effective when based on component characters which are highly heritable and

\* NBPGR Regional Station, Phagli, Shimla-171004 Himachal Pradesh

type genotypes with respect to grain yield, drought and cold tolerance and disease resistance. In general, the spring x winter wheat combinations proved to be better than their reciprocals indicating the significant difference between the effect of the cytoplasm of the two ecotypes (Choudhary, 1996).

Out of 30 spring type derivatives of winter x spring wheat and their reciprocals, two genotypes viz.- 'KWS 22' and 'KWS 29' were observed as very high yielding, drought tolerant, resistant to yellow and brown rusts and powdery mildew and medium bold amber grained. Both these lines have been included in the National Integrated Disease Screening Nursery (IDSN) and if found resistant, will be included in the Initial Varietal Trials for rainfed and timely sown conditions of northern hill zone proposed and conducted under All India Coordinated Wheat Improvement Project.

Although, by exploiting the off-season facilities of Kukumseri (Lahaul and Spiti) the time period required for attaining the homozygosity in the segregating generations was reduced to half yet some other innovative breeding approaches viz.- androgenesis-mediated and wheat x maize systems are being executed for the transfer of winter wheat traits into spring wheats in a single step through the development of polyhaploids and doubled haploids, which in turn, further shorten the breeding cycle. For this purpose, an *ad-hoc* research project entitled "Genetic amelioration of winter and spring wheat ecotypes through androgenesis and wheat x maize systems" has

been sanctioned by the ICAR and being executed since 1997 at the Department of Plant Breeding and Genetics, HPKV, Palampur.

The present endeavour being executed for the spring wheat improvement has been made sustainable by conserving the most endangered winter wheat landraces collected from the snow-bound regions of North-West Himalayas. Besides, certain elite exotic winter wheat collections of diverse origin are also being introduced and conserved under naturally prevailing cold and dry conditions at HPKV, RRS, Kukumseri (Lahaul and Spiti) for the future sustainable use and posterity. Every year, the crosses between the winter and spring wheats are planned according to the need of the different hill regions of North-West Himalayas, attempted during the off-season at Kukumseri (Lahaul and Spiti), evaluated during the main season at Palampur and advanced in the shuttled breeding programme by exploiting the off-season facilities available in the high-hills of Himachal Pradesh.

#### References

- Choudhary HK, AS Kapoor, SC Sharma and S Nago (1994) Evaluation of exotic winter wheat (*Triticum aestivum*) varieties in dry temperate region of north west Himalayas. *Indian J. Agric. Sci.* **64**: 409-411.
- Choudhary HK (1996) Reciprocal differences in winter x spring wheat crosses. *Crop Improvement* **23**: 281-283.
- Choudhary HK (1997) Genetic amelioration of spring wheat ecotypes for drought prone regions through spring x winter wheat hybridization. *Proc. Int. Symp. Tropical Crop Res. and Dev.*, Kerala.

## Correlation and Path Coefficient Analysis in Walnut (*Juglans regia* L.)

**SD Sharma and SK Yadav\***

*Department of Fruit Breeding and Genetic Resources, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan-173230, Himachal Pradesh*

**Key Words:** Correlation, *Juglans regia*, Walnut

A total of 133 walnut seedlings were used to study the association between nut weight and its attributes. Nut weight was significantly and positively correlated with nut width, nut height, nut thickness, pad width, shell thickness and kernel weight. Path analysis of nut

weight and its components revealed that nut width, nut height, nut thickness, shell thickness and kernel weight had direct positive effect on nut weight.

Nut weight is an important character for in-shell marketing of nuts. The nut weight depends on many characters and selection is more effective when based on component characters which are highly heritable and

\* NBPGR Regional Station, Phagli, Shimla-171004 Himachal Pradesh

positively correlated. When more number of variables are considered in correlation the association becomes more complex and less obvious. The use of path coefficient analysis is helpful under such situation. This analysis shows the direct and indirect associations and reveals the most reliable nut weight contributing characters. In walnut, there is wide range of variability due to seed propagation. This variability provides a great scope for improving fruit weight through a systematic and planned selection programme for one or more direct or indirect nut weight components. Keeping in view the facts explained above, the present investigation was undertaken to determine the nature and degree of association among the characters and their direct and indirect effects on nut weight.

The present study was conducted in Chamba and Kullu districts of Himachal Pradesh. Data was recorded on 133 walnut seedling trees. Twenty sun dried randomly selected nuts were used for recording data on nut characters. The correlation coefficients were calculated as per methods given by Panse and Sukhatme (1985). The path analysis was performed according to the methods followed by Dewey and Lu (1959).

Correlation among various nut and kernel characters were worked out at phenotypic level and results are presented in Table 1.

Nut weight had positive and significant association with nut width (0.589), nut height (0.403), nut thickness (0.618), pad width (0.472), shell thickness (0.319) and kernel weight (0.772). However, it was found significantly and negatively associated with kernel recovery (-0.202). Nut width showed positive and significant correlation with nut height (0.483), nut thickness

(0.783), pad width (0.350) and kernel weight (0.521). Similarly nut height showed positive and significant correlation with nut thickness (0.292), pad width (0.209), kernel weight (0.362). Nut thickness showed significant positive correlation with pad width (0.236), pad thickness (0.245) and kernel width (0.535). Pad width showed significant positive correlation with shell thickness (0.416) and kernel width (0.233) while significant negative correlation with kernel recovery (-0.324). Shell thickness had significant negative correlation with kernel recovery (-0.314). Kernel weight had significant positive correlation with kernel recovery (0.437).

In path analysis, 7 different nut and kernel characters were considered as causal variables and nut weight was taken as a dependent variable. The direct and indirect effects of various characters were worked out at phenotypic level and presented in Table 2. The direct positive effects of various traits on nut weight can be arranged in a descending order, nut width (0.0459), nut height (0.0358), nut thickness (0.0413), shell thickness (0.0807), kernel weight (0.9764) while direct negative effects were found with pad width (-0.0105) and kernel recovery (0.6090). Nut weight had positive and significant relationship with nut width, nut height, nut thickness, pad width, shell thickness and kernel weight. The significant positive correlation between different pairs can be helpful for the improvement of different characters in a single step if the higher or lower value of each is required, while the negatively associated traits where increased or decreased value of both the characters is required cannot be improved in a single step. The character which had non-significant correlation suggest that they are independent of each other. The present correlation results

Table 1. Coefficients among various nut and kernel characters in seedling trees of Persian walnut

| Characters      | 1       | 2      | 3      | 4      | 5       | 6      | 7       | 8      | 9     |
|-----------------|---------|--------|--------|--------|---------|--------|---------|--------|-------|
| Nut weight      | 1.000   |        |        |        |         |        |         |        |       |
| Nut width       | 0.589*  | 1.000  |        |        |         |        |         |        |       |
| Nut height      | 0.403*  | 0.483* | 1.000  |        |         |        |         |        |       |
| Nut thickness   | 0.618*  | 0.708* | 0.292* | 1.000  |         |        |         |        |       |
| Pad width       | 0.472*  | 0.350* | 0.209* | 0.236* | 1.000   |        |         |        |       |
| Pad thickness   | 0.125   | 0.016  | -0.082 | 0.245* | -0.046  | 1.000  |         |        |       |
| Shell thickness | 0.319*  | 0.029  | 0.059  | 0.064  | 0.416*  | 0.105  | 1.000   |        |       |
| Kernel weight   | 0.772*  | 0.521* | 0.362* | 0.555* | 0.223*  | 0.093  | 0.051   | 1.000  |       |
| Kernel recovery | -0.202* | 0.018  | 0.022  | 0.018  | -0.324* | -0.013 | -0.314* | 0.437* | 1.000 |

\*Significant at  $p=0.05$

Table 2. Direct and indirect effect of various nut kernel characters on nut weight in seedling trees of Persian walnut

| S. No. | Characters      | 1      | 2       | 3      | 4       | 5       | 6      | 7       |
|--------|-----------------|--------|---------|--------|---------|---------|--------|---------|
| 1.     | Nut width       | 0.0459 | 0.0173  | 0.0292 | -0.0037 | 0.0023  | 0.509  | -0.0108 |
| 2.     | Nut height      | 0.0221 | 0.0358  | 0.0120 | -0.002  | -0.0047 | 0.3535 | -0.0131 |
| 3.     | Nut thickness   | 0.0325 | 0.0105  | 0.0413 | -0.0025 | 0.0052  | 0.5419 | -0.0111 |
| 4.     | Pad width       | 0.0160 | 0.0075  | 0.0097 | -0.0105 | 0.0336  | 0.2180 | 0.1975  |
| 5.     | Shell thickness | 0.0013 | -0.0021 | 0.0026 | -0.0024 | 0.0041  | 0.9764 | -0.2661 |
| 6.     | Kernel weight   | 0.0239 | 0.0130  | 0.0229 | -0.0024 | 0.0041  | 0.9764 | -0.2661 |
| 7.     | Kernel recovery | 0.0008 | 0.0008  | 0.0008 | 0.0034  | -0.0254 | 0.4266 | -0.6090 |

Residual effect = 0.0354

are in agreement with the results obtained by Sharma (1999) in similar type of study.

#### References

Dewey DR, and KH Lu (1959) Correlation and path coefficient analysis of crested wheat grass seed production *Agron J.* 51: 515-518.

Panse VG and PV Sukhatme (1985) *Statistical Methods for Agricultural Workers*. ICAR, New Delhi, India.

Sharma OC (1999) Studies on Variability and Selection of Superior Persian Walnut (*Juglans regia* L.) Seedling Trees in Himachal Pradesh. Ph.D. Thesis, Dr. YS Parmar University of Hort. and Forestry, Solan, H.P., India.

## Sustenance of Production of Rajmash – A Cash Crop of the Dry and Wet Temperate Regions of North-West Himalayas

**HK Chaudhary, GS Sethi, and A Pratap**

*Cytogenetics and Tissue Culture Laboratory, Department of Plant Breeding and Genetics, Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur-176062, Himachal Pradesh*

**Key Words:** French bean, Evaluation, Landraces, Temperate region

The dry and wet temperate region of North-West Himalayas are endowed with huge variability in respect of French bean (*Phaseolus vulgaris*) – an important pulse crop of these zones. It is being cultivated during summers as mixture of different landraces, which in turn, hampers the grain yield production of the crop. Besides, certain other constraints such as disease susceptibility, asynchrony in flowering and maturity and shattering susceptibility also reduce the average production drastically. Lack of uniformity in seed size and colour fetches poor premium in the market. Therefore, keeping in view the aforesaid constraints, a systematic breeding programme was planned for the genetic amelioration of *rajmash* – a most important precious pulse crop, which can play a significant role in improving the economy of the farmers of the hill regions of North-West Himalayas.

Almost all the regions especially tribal tracts of

the dry and wet temperate regions of North-West Himalayas were explored during the years 1987-1989 and 400 different landraces were collected. This germplasm was subjected to pure line selection breeding procedure for developing improved varieties for the high-hills of the North-West Himalayas. Simultaneously, the genetic resources were preserved by utilizing the naturally prevailing cold and dry conditions in the tribal areas of the zones.

All the landraces of *rajmash* were divided into two groups viz.- determinate (bush type) and indeterminate (pole type). The former group covers a larger area in the dry and wet temperate zones of North-West Himalayas, hence the improvement programme was also initiated in the same group of *rajmash* during the year 1989 at HPKV, Regional Research Station, Kukumseri (Lahaul and Spiti).

Table 2. Direct and indirect effect of various nut kernel characters on nut weight in seedling trees of Persian walnut

| S. No. | Characters      | 1      | 2       | 3      | 4       | 5       | 6      | 7       |
|--------|-----------------|--------|---------|--------|---------|---------|--------|---------|
| 1.     | Nut width       | 0.0459 | 0.0173  | 0.0292 | -0.0037 | 0.0023  | 0.509  | -0.0108 |
| 2.     | Nut height      | 0.0221 | 0.0358  | 0.0120 | -0.002  | -0.0047 | 0.3535 | -0.0131 |
| 3.     | Nut thickness   | 0.0325 | 0.0105  | 0.0413 | -0.0025 | 0.0052  | 0.5419 | -0.0111 |
| 4.     | Pad width       | 0.0160 | 0.0075  | 0.0097 | -0.0105 | 0.0336  | 0.2180 | 0.1975  |
| 5.     | Shell thickness | 0.0013 | -0.0021 | 0.0026 | -0.0024 | 0.0041  | 0.9764 | -0.2661 |
| 6.     | Kernel weight   | 0.0239 | 0.0130  | 0.0229 | -0.0024 | 0.0041  | 0.9764 | -0.2661 |
| 7.     | Kernel recovery | 0.0008 | 0.0008  | 0.0008 | 0.0034  | -0.0254 | 0.4266 | -0.6090 |

Residual effect = 0.0354

are in agreement with the results obtained by Sharma (1999) in similar type of study.

#### References

Dewey DR, and KH Lu (1959) Correlation and path coefficient analysis of crested wheat grass seed production *Agron J.* 51: 515-518.

Panse VG and PV Sukhatme (1985) *Statistical Methods for Agricultural Workers*. ICAR, New Delhi, India.

Sharma OC (1999) Studies on Variability and Selection of Superior Persian Walnut (*Juglans regia* L.) Seedling Trees in Himachal Pradesh. Ph.D. Thesis, Dr. YS Parmar University of Hort. and Forestry, Solan, H.P., India.

## Sustenance of Production of Rajmash – A Cash Crop of the Dry and Wet Temperate Regions of North-West Himalayas

**HK Chaudhary, GS Sethi, and A Pratap**

*Cytogenetics and Tissue Culture Laboratory, Department of Plant Breeding and Genetics, Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur-176062, Himachal Pradesh*

**Key Words:** French bean, Evaluation, Landraces, Temperate region

The dry and wet temperate region of North-West Himalayas are endowed with huge variability in respect of French bean (*Phaseolus vulgaris*) – an important pulse crop of these zones. It is being cultivated during summers as mixture of different landraces, which in turn, hampers the grain yield production of the crop. Besides, certain other constraints such as disease susceptibility, asynchrony in flowering and maturity and shattering susceptibility also reduce the average production drastically. Lack of uniformity in seed size and colour fetches poor premium in the market. Therefore, keeping in view the aforesaid constraints, a systematic breeding programme was planned for the genetic amelioration of *rajmash* – a most important precious pulse crop, which can play a significant role in improving the economy of the farmers of the hill regions of North-West Himalayas.

Almost all the regions especially tribal tracts of

the dry and wet temperate regions of North-West Himalayas were explored during the years 1987-1989 and 400 different landraces were collected. This germplasm was subjected to pure line selection breeding procedure for developing improved varieties for the high-hills of the North-West Himalayas. Simultaneously, the genetic resources were preserved by utilizing the naturally prevailing cold and dry conditions in the tribal areas of the zones.

All the landraces of *rajmash* were divided into two groups viz.- determinate (bush type) and indeterminate (pole type). The former group covers a larger area in the dry and wet temperate zones of North-West Himalayas, hence the improvement programme was also initiated in the same group of *rajmash* during the year 1989 at HPKV, Regional Research Station, Kukumseri (Lahaul and Spiti).

Out of 400 landraces, in all 94 single plant selections (70 of 'K' group and 24 of 'KRC' group) were made on the basis of early and synchronous maturity, high value of first order yield components, disease and shattering resistance, bold seeds with attractive colour (Table 1) and raised during the following year for isolating the potential pure lines. Five pure lines of 'KRC' group viz.- 'KRC 1', 'KRC 5', 'KRC 8', 'KRC 11' and 'KRC 17' and 30 pure lines of 'K' group viz.- 'K 2', 'K 5', 'K 26', 'K 38', 'K 53', 'K 93', 'K 100', 'K 158', 'K 180', 'K 190-1', 'K 191', 'K 198', 'K 205', 'K 206', 'K 222', 'K 231', 'K 254', 'K 255', 'K 258', 'K 294', 'K 296', 'K 298', 'K 310', 'K 319', 'K 321', 'K 325', 'K 326', 'K 331', 'K 339' and 'K 341' were selected from 94 single plant progenies. These 35 pure lines were evaluated during two consecutive years for their performance with respect to yield performance

alongwith four standard checks viz.- 'Kanchan', 'Him 1', 'Jwala' and 'Hans'. Out of these lines, six best genotypes viz.- 'K 180', 'K 198', 'K 222', 'K 258', 'K 319' and 'KRC 8' were isolated and evaluated in the multilocal evaluation trials over the years.

'KRC 8' out of 'KRC' group in the name of 'Baspa' and 'K 198' from 'K' group in the name of 'Triloki' were released as new potential varieties during the years 1994 and 1996, respectively for the dry temperate regions of North-West Himalayas (Table 2). Such an attempt has also been reported by Asthana (1988) in different pulses crops.

To make the present endeavour sustainable, care has also been taken to preserve the precious genetic wealth. For this purpose, the peculiar climatic situation of the dry temperate zone of Himachal Pradesh is quite suitable. This region remains covered under snow for

**Table 1. Pure line selection procedure applied for generating elite genotypes of *rajmash***

| Operation                                                                                                                                                                                                                                                       | Results                                                                                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Exploration of the <i>rajmash</i> growing region of the dry and wet temperate zones of North-West Himalayas.                                                                                                                                                    | Collected the huge variability available in different pockets of the hill regions.                                                                                        |
| Collected landraces raised in augmented design at HPKV, RRS, Kukumseri (Lahaul and Spiti) and characterized for various descriptors.                                                                                                                            | Identified 400 landraces and accessioned as 'K1' to 'K369' and 'KRC1' to 'KRC 31'.                                                                                        |
| i. One set of the 400 accessions preserved under naturally prevailing cold and dry conditions at HPKV, RRS, Kukumseri (Lahaul and Spiti).                                                                                                                       | Isolated 94 single plant selections (70 of 'K' group and 24 of 'KRC' group).                                                                                              |
| ii. Executed single plant selections for determinate plant type amongst the 400 lines.                                                                                                                                                                          |                                                                                                                                                                           |
| 95 single plant progenies evaluated in comparison to the standard checks.<br>Multi-locational screening of 35 pure lines over the years                                                                                                                         | Five pure lines of 'KRC' group and 30 of 'K' group were identified as elite genotypes.                                                                                    |
| i. Periodic review of the conserved germplasm                                                                                                                                                                                                                   | i. Released 'KRC 8' as 'Bhaspa' and 'K 198' as 'Triloki' from the State level and notified by the Central Sub-committee on Crop Standards.                                |
|                                                                                                                                                                                                                                                                 | ii. 'Triloki' included in the All India Coordinated trials conducted by IIPR, Kanpur.                                                                                     |
| ii. Keeping in view certain new constraints and as per the need of the specific location in the dry and wet temperate regions of northwest Himalayas, certain new lines were isolated and included in the evaluation trials planned for the specific locations. | iii. Other elite lines viz.- 'KRC1', 'KRC 5', 'KRC 11', 'KRC 17', 'K 180', 'K 222', 'K 258' and 'K 319' are in the pipe line and under rigorous screening for future use. |
|                                                                                                                                                                                                                                                                 | i. On an average, the germination was 85% after five year of preservation under the natural conditions at HPKV, RRS, Kukumseri (Lahaul and Spiti).                        |
|                                                                                                                                                                                                                                                                 | ii. All the lines were preserved afresh for future sustainable use and posterity.                                                                                         |

**Table 2.** Characteristic features of the two new released varieties of *rajmash* in comparison to the standard checks

| Traits                       | Description             |                 |                        |          |          |                         |
|------------------------------|-------------------------|-----------------|------------------------|----------|----------|-------------------------|
|                              | New released varieties  |                 | Standard checks        |          |          |                         |
|                              | 'Baspa'                 | 'Triloki'       | 'Him 1'                | 'Jwala'  | 'Hans'   | 'Kanchan'               |
| Plant height (cm)            | 50–55                   | 45–55           | 45–55                  | 45–55    | 45–55    | 45–55                   |
| Days to maturity             | 110–120                 | 98–100          | 90–95                  | 90–95    | 90–95    | 95–100                  |
| Average grain yield (q/ha)   | 18–20                   | 25–27           | 8–9                    | 9–10     | 10–12    | 18–20                   |
| Seed size                    | Bold                    | Bold            | Medium                 | Bold     | Small    | Bold                    |
| Seed Colour                  | Maroon with pink specks | Creamish yellow | Cream with pink specks | Maroon   | White    | Pink with maroon specks |
| Disease resistance           |                         |                 |                        |          |          |                         |
| i. Bacterial blight          | R                       | R               | S                      | S        | S        | MS                      |
| ii. Anthracnose              | R                       | R               | S                      | S        | S        | MR                      |
| iii. Common mosaic           | R                       | R               | S                      | S        | S        | MR                      |
| Shattering                   | No                      | No              | Yes                    | Yes      | Yes      | Moderate                |
| Cooking quality              | Good                    | Good            | Good                   | Good     | Good     | Good                    |
| Acceptability to the farmers | Acceptable              | Acceptable      | Acceptable             | Rejected | Rejected | Rejected                |

R=Resistant, S=Susceptible, MS=Moderately Susceptible, MR=Moderately Resistant

whole of the winters (when the temperature regime is – 15°C to 9°C) whereas the summers are mild (10°C to 28°C) and dry (annual rainfall 25 cm). Such a naturally prevailing cold and dry climate has been utilized for the preservation of the collected germplasm as active collections for the future use in the *rajmash* breeding programme.

As per the suitability of these regions and acceptability to the farming community, different varieties are being developed for further release. Farmers are being assured for providing new potential varieties in case of failure of the old ones due to any reason. The contiguous chain has been established between the varieties released, in

the adaptive trials, under preliminary screening and the related indigenous and exotic genepools, which in turn, provides sustenance to the production of *rajmash* crop. In this way, *rajmash* has become a cash crop in the dry and wet temperate zones of North-West Himalayas and the farming community fetches a good premium in the market enabling them to improve their economy.

#### References

- Asthana AN (1998) Collection and utilization of genetic diversity in pulse crops. In: RS Paroda, RK Arora and KPS Chandel (ed.) *Plant Genetic Resources: Indian Perspective*, NBPGR, New Delhi, pp 243-260.

## Characterization of Genetic Diversity of Cashew (*Anacardium occidentale* L.) in India by RAPD and AFLP Analyses

**Sunil Archak, Ambika Baldev, Diksha Gautam and JL Karihaloo**

National Research Centre on DNA Fingerprinting, National Bureau of Plant Genetic Resources, New Delhi-110012

**Key Words:** Cashew (*Anacardium occidentale* L.), Genetic diversity, RAPD, AFLP

Cashew was introduced in India by Portuguese during 16<sup>th</sup> century (Rao *et al.*, 1998). Existence of substantial genetic diversity in India is evident from the variation recorded in the yield and the quality of cashewnuts. Thus, crop improvement programmes can benefit greatly

by germplasm collection, characterization and selection of elite lines. Genetic characterization of the cashew accessions is presently based entirely on the morphological characters (Swamy *et al.*, 1998). Although morphological characteristics are still extremely useful, these are often

**Table 2.** Characteristic features of the two new released varieties of *rajmash* in comparison to the standard checks

| Traits                       | Description             |                 |                        |          |          |                         |
|------------------------------|-------------------------|-----------------|------------------------|----------|----------|-------------------------|
|                              | New released varieties  |                 | Standard checks        |          |          |                         |
|                              | 'Baspa'                 | 'Triloki'       | 'Him 1'                | 'Jwala'  | 'Hans'   | 'Kanchan'               |
| Plant height (cm)            | 50–55                   | 45–55           | 45–55                  | 45–55    | 45–55    | 45–55                   |
| Days to maturity             | 110–120                 | 98–100          | 90–95                  | 90–95    | 90–95    | 95–100                  |
| Average grain yield (q/ha)   | 18–20                   | 25–27           | 8–9                    | 9–10     | 10–12    | 18–20                   |
| Seed size                    | Bold                    | Bold            | Medium                 | Bold     | Small    | Bold                    |
| Seed Colour                  | Maroon with pink specks | Creamish yellow | Cream with pink specks | Maroon   | White    | Pink with maroon specks |
| Disease resistance           |                         |                 |                        |          |          |                         |
| i. Bacterial blight          | R                       | R               | S                      | S        | S        | MS                      |
| ii. Anthracnose              | R                       | R               | S                      | S        | S        | MR                      |
| iii. Common mosaic           | R                       | R               | S                      | S        | S        | MR                      |
| Shattering                   | No                      | No              | Yes                    | Yes      | Yes      | Moderate                |
| Cooking quality              | Good                    | Good            | Good                   | Good     | Good     | Good                    |
| Acceptability to the farmers | Acceptable              | Acceptable      | Acceptable             | Rejected | Rejected | Rejected                |

R=Resistant, S=Susceptible, MS=Moderately Susceptible, MR=Moderately Resistant

whole of the winters (when the temperature regime is – 15°C to 9°C) whereas the summers are mild (10°C to 28°C) and dry (annual rainfall 25 cm). Such a naturally prevailing cold and dry climate has been utilized for the preservation of the collected germplasm as active collections for the future use in the *rajmash* breeding programme.

As per the suitability of these regions and acceptability to the farming community, different varieties are being developed for further release. Farmers are being assured for providing new potential varieties in case of failure of the old ones due to any reason. The contiguous chain has been established between the varieties released, in

the adaptive trials, under preliminary screening and the related indigenous and exotic genepools, which in turn, provides sustenance to the production of *rajmash* crop. In this way, *rajmash* has become a cash crop in the dry and wet temperate zones of North-West Himalayas and the farming community fetches a good premium in the market enabling them to improve their economy.

#### References

- Asthana AN (1998) Collection and utilization of genetic diversity in pulse crops. In: RS Paroda, RK Arora and KPS Chandel (ed.) *Plant Genetic Resources: Indian Perspective*, NBPGR, New Delhi, pp 243-260.

## Characterization of Genetic Diversity of Cashew (*Anacardium occidentale* L.) in India by RAPD and AFLP Analyses

**Sunil Archak, Ambika Baldev, Diksha Gautam and JL Karihaloo**

National Research Centre on DNA Fingerprinting, National Bureau of Plant Genetic Resources, New Delhi-110012

**Key Words:** Cashew (*Anacardium occidentale* L.), Genetic diversity, RAPD, AFLP

Cashew was introduced in India by Portuguese during 16<sup>th</sup> century (Rao *et al.*, 1998). Existence of substantial genetic diversity in India is evident from the variation recorded in the yield and the quality of cashewnuts. Thus, crop improvement programmes can benefit greatly

by germplasm collection, characterization and selection of elite lines. Genetic characterization of the cashew accessions is presently based entirely on the morphological characters (Swamy *et al.*, 1998). Although morphological characteristics are still extremely useful, these are often

quantitative in nature and influenced by environment and hence may not be very distinctive and dependable. DNA markers have been shown to complement the characterization exercise. Among the various molecular markers, PCR-based markers RAPD and AFLP could be directly employed even in the absence of prior knowledge about the sequence information. In cashew, the only molecular diversity study made thus far is of Mneney *et al.*, (1997) wherein the feasibility of RAPD for distinguishing Tanzanian cultivars has been demonstrated.

The present study aimed at identifying molecular markers for exploring the genetic diversity and developing molecular profiles for identification of cashew in India, was carried out on a small subset of National Cashew genebank collections, employing RAPD and AFLP techniques.

Soft grafts of old cultivars as well as germplasm accessions have been maintained in the National Cashew genebank at National Research Centre for Cashew, Puttur. A random subset of 18 cashew accessions was used for the study. Young leaves from single trees of each accession were collected for DNA isolation by CTAB method. Fifty RAPD primers and six fluorescent AFLP primer combinations were employed. Amplicons were scored as discrete variables. Generation of pair-wise similarity matrix, UPGMA cluster analysis and principal co-ordinate analysis were performed using the programme NTSYS-pc version 1.7 (Rohlf, 1993). Genetic diversity was estimated as mean marker diversity (Villand *et al.*, 1998).

Fifty selected random primers generated 564 bands of different sizes ranging between 220 bp and 3 kb, with a mean of 11.3 bands/primer (Fig 1). In all, 87.9% bands were polymorphic. Average Jaccard's Similarity Co-efficient (JSC) was 0.528 and the range was 0.454. In AFLP analysis, six primer pairs generated 456 bands of sizes ranging from 50 bp to 500 bp in the 19 accessions, with a mean of 76 bands/primer pair (Fig 2). All the bands were polymorphic. Average JSC was 0.346 and the range was 0.708. Significant correlation was observed when product moment correlation coefficients between similarity matrices and cophenetic matrices derived from RAPD and AFLP were statistically analysed. Both the techniques distinguished all the accessions. Mean marker diversity values of the accessions obtained by RAPD and AFLP techniques were 0.310 and 0.306 respectively and were statistically similar. The

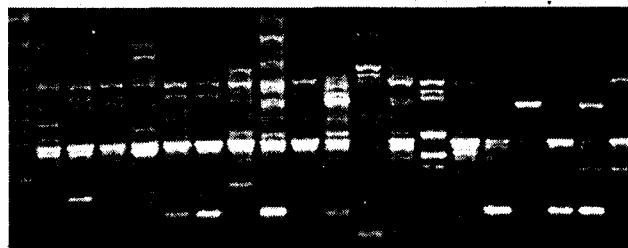


Fig. 1

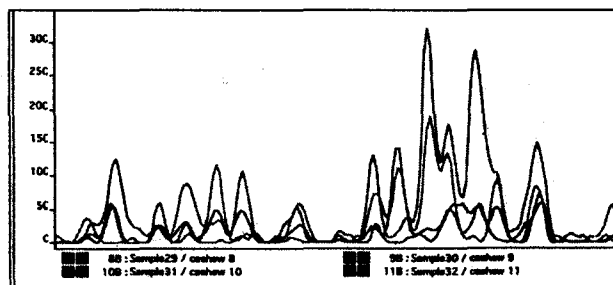


Fig. 2

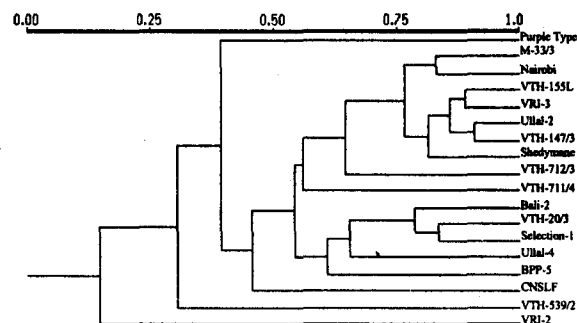


Fig. 3

dendrogram generated based on AFLP is presented (Fig 3).

The variability expressed in the form of JSC and mean marker diversity, falls in the higher bracket. This is explained as follows. Cashew is an allogamous tree species. Owing to the nature of its introduction, where the genotypes were not added from the centre of diversity constantly, only a part of genepool is expected to be present in India. However, following introduction, cashew trees were extensively planted in soil amelioration exercises of the coastal wastelands. This led to the development of natural populations of high heterozygosity and heterogeneity without any kind of human intervention. The plants were seed propagated till recently. These factors resulted in high variability between individuals within the available genepool.

Molecular genetic analysis in cashew is immediately

useful for germplasm management. However, subsequently with increased availability of characterisation data the molecular characterisation results would be valuable for trait mapping, marker assisted selection and further genomic analyses which may be useful for enhancing the efficiency of breeding efforts (Lee 1995). Result in one crop species with a set of molecular techniques cannot be extrapolated to other species (Virk *et al.*, 2000). Thus far, molecular marker studies in cashew have been scarce and inadequate *vis-à-vis* its enormous importance in commerce. In conclusion, this study provides first insights into the molecular diversity in cashew accessions employing RAPD and AFLP techniques. Primers/pairs for AFLP and RAPD are designated for identification of accessions and to carry out future experiments with larger samples.

### References

- Lee M (1995) DNA markers and plant breeding programs. *Adv Agron*, 55: 265-344.
- Mneney EE, SH Mantell, G Tsoktouridis, S Amin, AMS Bessa and M Thangavelu (1997) RAPD-profiling of Tanzanian cashew (*Anacardium occidentale* L.) *Proceed. Intl. Cashew Coconut Conf.*, Dar-e-Salaam, pp108-115.
- Rao EVVB, KRM Swamy and MG Bhat (1998) Status of cashew breeding and future priorities. *J. Plantation Crops* 26: 103-114.
- Rohlf FJ (1993) NTSYS-pc: Numerical taxonomy and multivariate analysis system. Exeter Software, New York.
- Swamy KRM, EVVB Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.) germplasm accessions-II. National Research Centre for Cashew, Puttur, Karnataka. 41p.
- Villand J, PW Skroch, T Lai, P Hanson, CG Kuo and J Nienhuis (1998) Genetic variation among tomato accessions from primary and secondary centres of diversity. *Crop Sci.* 38: 1339-1347.
- Virk PS, J Zhu, GJ Bryan, MT Jackson and BV Ford-Lloyd (2000) Effectiveness of different classes of markers for classifying and revealing variation in rice (*Oryza sativa*) germplasm. *Euphytica* 112: 275-284.

## Evaluation of Exotic Dura Germplasm for Water Use Efficiency in Oil Palm (*Elaeis guineensis* Jacq.)

**RK Mathur, K Suresh, S Nair, K Parimala and VNP Shivaramakrishna**

National Research Centre for Oil Palm (ICAR), Gdog Gdo-534450, West Godavari District, Eluru, Andhra Pradesh

**Key Words:** Dura, Oil palm (*Elaeis guineensis* L.), Exotic germplasm, Water use efficiency

Targeted area expansion of oil palm, the highest oil yielding crop in states like Andhra Pradesh, Tamil Nadu, Karnataka and Gujarat under irrigated conditions and Kerala and Andaman and Nicobar Islands under rainfed conditions, requires the genotypes having high water use efficiency. Presently available commercial plantations of tenera hybrids [dura x pisifera] necessitate more irrigation, thereby increasing the expenditure on electricity by the growers. This increases the cost of cultivation, and thus, reduces the profit margin. The potential solution to this could be the development of tenera hybrids having high water use efficiency, which can thrive well under limited moisture conditions. With this background, an exploration was carried out in Zambia, Tanzania and Guinea-Bissau to select and collect drought-tolerant genotypes. The present investigation is based on the germplasm collected from these places to screen for their response to moisture stress.

Ten exotic dura genotypes were raised in randomized complete block design with three replications under two environments namely, irrigated and stress. The plot size was four palms/genotype/treatment planted in triangular design of planting at a spacing of 9 m between palms. The irrigation was managed through drip system. Fourteen-month-old seedlings were transplanted in field. Under irrigated conditions the IW/CPE ratio was one while under stress, it was kept at 0.8. The ablation (removal of inflorescences from the palms), as recommended, was done for two years. Observations were recorded on morphological characters like plant height (m), leaflet length (cm), leaflet width (cm), number of leaflets/ leaf, petiole width (mm), petiole depth (mm), and rachis length (m). Non-destructive growth analysis was carried out as per Corley *et al.* (1971). The physiological observations like stomatal conductance (mol/m<sup>2</sup>/s), photosynthetic rate (μmol/m<sup>2</sup>/s), transpiration rate (mmol/m<sup>2</sup>/s), leaf

useful for germplasm management. However, subsequently with increased availability of characterisation data the molecular characterisation results would be valuable for trait mapping, marker assisted selection and further genomic analyses which may be useful for enhancing the efficiency of breeding efforts (Lee 1995). Result in one crop species with a set of molecular techniques cannot be extrapolated to other species (Virk *et al.*, 2000). Thus far, molecular marker studies in cashew have been scarce and inadequate *vis-à-vis* its enormous importance in commerce. In conclusion, this study provides first insights into the molecular diversity in cashew accessions employing RAPD and AFLP techniques. Primers/pairs for AFLP and RAPD are designated for identification of accessions and to carry out future experiments with larger samples.

### References

- Lee M (1995) DNA markers and plant breeding programs. *Adv Agron*, 55: 265-344.
- Mneney EE, SH Mantell, G Tsoktouridis, S Amin, AMS Bessa and M Thangavelu (1997) RAPD-profiling of Tanzanian cashew (*Anacardium occidentale* L.) *Proceed. Intl. Cashew Coconut Conf.*, Dar-e-Salaam, pp108-115.
- Rao EVVB, KRM Swamy and MG Bhat (1998) Status of cashew breeding and future priorities. *J. Plantation Crops* 26: 103-114.
- Rohlf FJ (1993) NTSYS-pc: Numerical taxonomy and multivariate analysis system. Exeter Software, New York.
- Swamy KRM, EVVB Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.) germplasm accessions-II. National Research Centre for Cashew, Puttur, Karnataka. 41p.
- Villand J, PW Skroch, T Lai, P Hanson, CG Kuo and J Nienhuis (1998) Genetic variation among tomato accessions from primary and secondary centres of diversity. *Crop Sci.* 38: 1339-1347.
- Virk PS, J Zhu, GJ Bryan, MT Jackson and BV Ford-Lloyd (2000) Effectiveness of different classes of markers for classifying and revealing variation in rice (*Oryza sativa*) germplasm. *Euphytica* 112: 275-284.

## Evaluation of Exotic Dura Germplasm for Water Use Efficiency in Oil Palm (*Elaeis guineensis* Jacq.)

**RK Mathur, K Suresh, S Nair, K Parimala and VNP Shivaramakrishna**

National Research Centre for Oil Palm (ICAR), Gdog Gdo-534450, West Godavari District, Eluru, Andhra Pradesh

**Key Words:** Dura, Oil palm (*Elaeis guineensis* L.), Exotic germplasm, Water use efficiency

Targeted area expansion of oil palm, the highest oil yielding crop in states like Andhra Pradesh, Tamil Nadu, Karnataka and Gujarat under irrigated conditions and Kerala and Andaman and Nicobar Islands under rainfed conditions, requires the genotypes having high water use efficiency. Presently available commercial plantations of tenera hybrids [dura x pisifera] necessitate more irrigation, thereby increasing the expenditure on electricity by the growers. This increases the cost of cultivation, and thus, reduces the profit margin. The potential solution to this could be the development of tenera hybrids having high water use efficiency, which can thrive well under limited moisture conditions. With this background, an exploration was carried out in Zambia, Tanzania and Guinea-Bissau to select and collect drought-tolerant genotypes. The present investigation is based on the germplasm collected from these places to screen for their response to moisture stress.

Ten exotic dura genotypes were raised in randomized complete block design with three replications under two environments namely, irrigated and stress. The plot size was four palms/genotype/treatment planted in triangular design of planting at a spacing of 9 m between palms. The irrigation was managed through drip system. Fourteen-month-old seedlings were transplanted in field. Under irrigated conditions the IW/CPE ratio was one while under stress, it was kept at 0.8. The ablation (removal of inflorescences from the palms), as recommended, was done for two years. Observations were recorded on morphological characters like plant height (m), leaflet length (cm), leaflet width (cm), number of leaflets/ leaf, petiole width (mm), petiole depth (mm), and rachis length (m). Non-destructive growth analysis was carried out as per Corley *et al.* (1971). The physiological observations like stomatal conductance (mol/m<sup>2</sup>/s), photosynthetic rate (μmol/m<sup>2</sup>/s), transpiration rate (mmol/m<sup>2</sup>/s), leaf

temperature ( $^{\circ}\text{C}$ ) and photosynthetic assimilation rate ( $\mu\text{mol}/\text{m}^2/\text{s}$ ) were recorded using the portable photosynthesis system (LCA-4, ADC, UK). The water use efficiency was computed as the ratio of photosynthetic rate to transpiration rate ( $\mu\text{mol CO}_2/\text{mmol H}_2\text{O}$ ). The analysis of variance was done following Panse and Sukhatme (1985).

Substantial variation among the germplasm was found for all the morphological and physiological parameters studied under two moisture regimes (Table 1). The means of morphological characters under irrigated conditions were not significantly different when compared with the stress environment. The means of all the physiological parameters except inter-cellular  $\text{CO}_2$  concentration and leaf canopy temperature were higher under irrigated conditions when compared with the stress environment. The water use efficiency was recorded highest in dura genotype ZS 1 followed by ZS 3. The water use efficiency was highest in germplasm received from Zambia under both irrigated and stress environments.

The positive and significant association (Table 2) was observed between water use efficiency and photosynthetic rate ( $r = 0.83$ ) while it was negatively related with inter-cellular  $\text{CO}_2$  concentration ( $r = -0.90$ ). The leaf area had positive and significant association with number of leaflets/leaf and petiole width. Taniputra and Manurung (1988) have also reported that the significance of rachis length and number of leaflets as the major components affecting bunch yield. On the other hand, leaf area has also been found associated with yield (Subronto and Taniputra, 1989).

Leaf dry weight was positively associated with petiole width and depth while negatively with stomatal conductance and transpiration. Leaf length and cross-section of the petiole were considered the most accurate indicators of stress caused by inter-plant competition (Sterling, 1996). The multiple regression coefficient between water use efficiency and eight independent physiological parameters was very high and significant ( $r = 0.99$ ). The order of significance of physiological

**Table 1. Genotypic means for different physiological and morphological characters under irrigated and stress environments in oil palm**

| Dura genotype    | Leaflet length (cm) | Leaflet width (cm) | Number of leaflets | Petiole width (cm) | Petiole depth (cm) | Plant height (m) | Rachis length (m) | Leaf area ( $\text{cm}^2$ ) | Leaf dry weight (kg) | Photo-synthetic rate ( $\mu\text{mol}/\text{m}^2/\text{s}$ ) | Stomatal conductance ( $\text{mol}/\text{m}^2/\text{s}$ ) | Transpiration ( $\text{mmol}/\text{m}^2/\text{s}$ ) | P.A.R ( $\mu\text{mol}/\text{m}^2/\text{s}$ ) | Leaf temperature ( $^{\circ}\text{C}$ ) | Inter-cellular $\text{CO}_2$ conc. (ppm) | WUE ( $\mu\text{mol CO}_2/\text{mmol H}_2\text{O}$ ) |
|------------------|---------------------|--------------------|--------------------|--------------------|--------------------|------------------|-------------------|-----------------------------|----------------------|--------------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------|-----------------------------------------|------------------------------------------|------------------------------------------------------|
| <b>IRRIGATED</b> |                     |                    |                    |                    |                    |                  |                   |                             |                      |                                                              |                                                           |                                                     |                                               |                                         |                                          |                                                      |
| GB-22/311        | 62.88               | 3.05               | 140.0              | 2.80               | 2.05               | 3.68             | 2.25              | 2538                        | 0.79                 | 3.10                                                         | 0.030                                                     | 1.96                                                | 1713                                          | 41.9                                    | 246.0                                    | 1.58                                                 |
| GB/25/314        | 77.47               | 2.82               | 144.6              | 2.80               | 2.63               | 3.97             | 2.46              | 3194                        | 0.96                 | 1.88                                                         | 0.040                                                     | 2.17                                                | 1933                                          | 43.6                                    | 247.5                                    | 0.87                                                 |
| GB/21/310        | 65.45               | 2.48               | 140.5              | 2.80               | 2.15               | 4.30             | 2.77              | 2624                        | 0.82                 | 3.47                                                         | 0.040                                                     | 1.51                                                | 1529                                          | 40.1                                    | 181.9                                    | 2.29                                                 |
| ZS-1             | 58.73               | 2.66               | 180.0              | 3.68               | 2.50               | 4.19             | 2.44              | 3038                        | 1.15                 | 4.86                                                         | 0.035                                                     | 1.38                                                | 1517                                          | 40.7                                    | 74.4                                     | 3.54                                                 |
| ZS-2             | 64.94               | 3.59               | 187.3              | 3.87               | 2.67               | 4.33             | 2.98              | 3530                        | 1.26                 | 2.05                                                         | 0.020                                                     | 1.07                                                | 1990                                          | 42.4                                    | 159.0                                    | 1.92                                                 |
| ZS-3             | 60.12               | 3.83               | 173.5              | 3.93               | 2.85               | 4.43             | 2.83              | 3051                        | 1.35                 | 4.71                                                         | 0.027                                                     | 1.66                                                | 1926                                          | 44.6                                    | 126.9                                    | 2.84                                                 |
| ZS-5             | 61.03               | 3.22               | 169.3              | 3.77               | 2.90               | 4.07             | 2.63              | 2992                        | 1.32                 | 3.85                                                         | 0.025                                                     | 1.27                                                | 1612                                          | 41.4                                    | 89.4                                     | 3.03                                                 |
| ZS-8             | 62.98               | 2.77               | 199.3              | 4.03               | 2.40               | 4.03             | 2.41              | 3604                        | 1.20                 | 4.68                                                         | 0.033                                                     | 1.64                                                | 1861                                          | 42.4                                    | 94.1                                     | 2.86                                                 |
| TS-9             | 64.65               | 3.20               | 164.5              | 3.98               | 3.98               | 4.34             | 2.69              | 3069                        | 1.82                 | 1.21                                                         | 0.007                                                     | 0.75                                                | 1871                                          | 45.2                                    | 143.2                                    | 1.62                                                 |
| TS-11            | 68.70               | 2.95               | 211.3              | 4.03               | 3.10               | 4.68             | 2.82              | 4163                        | 1.49                 | 3.44                                                         | 0.023                                                     | 1.14                                                | 1855                                          | 41.4                                    | 85.2                                     | 3.01                                                 |
| Mean             | 64.69               | 3.06               | 171.0              | 3.57               | 2.72               | 4.20             | 2.63              | 3180                        | 1.22                 | 3.32                                                         | 0.028                                                     | 1.45                                                | 1780                                          | 42.4                                    | 144.7                                    | 2.35                                                 |
| SE ( $\pm$ )     | 1.60                | 0.13               | 7.36               | 0.16               | 0.16               | 0.08             | 0.07              | 144.0                       | 0.09                 | 0.38                                                         | 0.003                                                     | 0.13                                                | 52.3                                          | 0.50                                    | 19.2                                     | 0.25                                                 |
| <b>STRESS</b>    |                     |                    |                    |                    |                    |                  |                   |                             |                      |                                                              |                                                           |                                                     |                                               |                                         |                                          |                                                      |
| GB-22/311        | 71.10               | 3.28               | 142.0              | 2.75               | 1.85               | 3.81             | 2.50              | 2904                        | 0.73                 | 2.58                                                         | 0.025                                                     | 1.49                                                | 1815                                          | 44.8                                    | 142.4                                    | 1.73                                                 |
| GB/25/314        | 70.78               | 2.83               | 140.0              | 2.77               | 2.17               | 3.40             | 2.35              | 2833                        | 0.82                 | 0.09                                                         | 0.005                                                     | 0.68                                                | 1879                                          | 47.0                                    | 290.7                                    | 0.13                                                 |
| GB/21/310        | 63.33               | 3.33               | 120.0              | 2.90               | 2.35               | 3.58             | 2.30              | 2199                        | 0.90                 | 0.25                                                         | 0.005                                                     | 0.91                                                | 1885                                          | 46.7                                    | 273.5                                    | 0.28                                                 |
| ZS-1             | 56.13               | 2.96               | 202.0              | 3.55               | 2.40               | 3.88             | 2.60              | 3281                        | 1.08                 | 0.10                                                         | 0.000                                                     | 0.42                                                | 1745                                          | 45.6                                    | 292.2                                    | 0.24                                                 |
| ZS-2             | 63.02               | 3.51               | 176.0              | 3.95               | 2.85               | 4.23             | 2.73              | 3219                        | 1.36                 | 1.85                                                         | 0.010                                                     | 0.68                                                | 1777                                          | 43.2                                    | 73.7                                     | 2.73                                                 |
| ZS-3             | 59.08               | 4.29               | 170.6              | 3.53               | 2.73               | 3.82             | 2.65              | 2974                        | 1.19                 | 0.17                                                         | 0.015                                                     | 1.27                                                | 1889                                          | 45.9                                    | 283.1                                    | 0.13                                                 |
| ZS-5             | 65.02               | 3.87               | 178.0              | 3.95               | 3.08               | 4.41             | 2.91              | 3372                        | 1.45                 | 2.70                                                         | 0.020                                                     | 1.55                                                | 1873                                          | 46.8                                    | 180.4                                    | 1.74                                                 |
| ZS-8             | 75.02               | 3.24               | 168.0              | 4.00               | 2.60               | 4.23             | 2.85              | 3615                        | 1.27                 | 2.01                                                         | 0.017                                                     | 0.78                                                | 1576                                          | 40.7                                    | 145.2                                    | 2.56                                                 |
| TS-9             | 64.31               | 3.43               | 185.5              | 4.08               | 2.63               | 4.45             | 2.85              | 3455                        | 1.30                 | 0.30                                                         | 0.013                                                     | 0.79                                                | 1648                                          | 41.9                                    | 296.0                                    | 0.38                                                 |
| TS-11            | 59.67               | 3.05               | 186.0              | 3.35               | 2.65               | 3.55             | 2.55              | 3207                        | 1.11                 | 0.43                                                         | 0.010                                                     | 1.08                                                | 1865                                          | 47.4                                    | 259.0                                    | 0.39                                                 |
| Mean             | 64.74               | 3.38               | 166.8              | 3.48               | 2.53               | 3.93             | 2.63              | 3106                        | 1.12                 | 1.05                                                         | 0.01                                                      | 0.96                                                | 1795                                          | 45.0                                    | 223.6                                    | 1.03                                                 |
| SE ( $\pm$ )     | 1.79                | 0.13               | 7.55               | 0.16               | 0.11               | 0.11             | 0.06              | 120.8                       | 0.07                 | 0.33                                                         | 0.00                                                      | 0.11                                                | 32.77                                         | 0.69                                    | 24.25                                    | 0.31                                                 |

**Table 2. Interrelationship among different physiological and morphological characters under irrigated (above diagonal) and stress (below diagonal) environments in oil palm**

| Dura genotype | Leaflet length | Leaflet width | Number of leaflets | Petiole width | Petiole depth | Plant height | Rachis length | Leaf area | Leaf dry weight | Photosynthetic rate | Stomatal conductance | Transpiration rate | P.A.R | Leaf temperature | Intercellular CO <sub>2</sub> conc | WUE   |
|---------------|----------------|---------------|--------------------|---------------|---------------|--------------|---------------|-----------|-----------------|---------------------|----------------------|--------------------|-------|------------------|------------------------------------|-------|
|               | LLL            | LLW           | NLL                | PW            | PD            | PHt          | RacL          | LA        | LDW             | A                   | Cs                   | E                  |       | TL               | Ci                                 | WUE   |
| LLL           |                | -0.25         | -0.21              | -0.42         | 0.07          | -0.01        | 0.00          | 0.28      | -0.15           | -0.61               | 0.22                 | 0.33               | 0.43  | 0.18             | 0.56                               | -0.69 |
| LLW           | -0.22          |               | 0.19               | 0.46          | 0.38          | 0.23         | 0.50          | 0.11      | 0.45            | -0.12               | -0.59                | -0.23              | 0.60  | 0.60             | -0.05                              | -0.05 |
| NLL           | -0.51          | 0.10          |                    | 0.86          | 0.30          | 0.58         | 0.35          | 0.88      | 0.56            | 0.33                | -0.32                | -0.48              | 0.32  | -0.03            | -0.79                              | 0.62  |
| PW            | -0.14          | 0.39          | 0.72               |               | 0.60          | 0.59         | 0.43          | 0.65      | 0.83            | 0.22                | -0.63                | -0.68              | 0.34  | 0.29             | -0.83                              | 0.57  |
| PD            | -0.35          | 0.56          | 0.56               | 0.81          |               | 0.52         | 0.40          | 0.34      | 0.94            | -0.45               | -0.83                | -0.70              | 0.38  | 0.63             | -0.33                              | -0.05 |
| PHt           | 0.10           | 0.43          | 0.50               | 0.87          | 0.59          |              | 0.83          | 0.59      | 0.61            | 0.02                | -0.38                | -0.64              | 0.22  | 0.07             | -0.54                              | 0.39  |
| RacL          | 0.05           | 0.45          | 0.67               | 0.93          | 0.70          | 0.93         |               | 0.38      | 0.46            | -0.19               | -0.42                | -0.60              | 0.33  | 0.12             | -0.28                              | 0.13  |
| LA            | 0.09           | 0.05          | 0.81               | 0.80          | 0.48          | 0.70         | 0.87          |           | 0.49            | 0.01                | -0.25                | -0.33              | 0.54  | 0.07             | -0.49                              | 0.26  |
| LDW           | -0.22          | 0.51          | 0.66               | 0.95          | 0.95          | 0.80         | 0.88          | 0.68      |                 | -0.22               | -0.85                | -0.79              | 0.39  | 0.55             | -0.57                              | 0.21  |
| A             | 0.52           | 0.22          | -0.04              | 0.23          | 0.14          | 0.52         | 0.48          | 0.33      | 0.25            |                     | 0.46                 | 0.23               | -0.43 | -0.43            | -0.57                              | 0.83  |
| Cs            | 0.49           | 0.49          | -0.09              | 0.15          | 0.04          | 0.44         | 0.46          | 0.28      | 0.14            | 0.77                |                      | 0.79               | -0.40 | -0.54            | 0.26                               | 0.06  |
| E             | 0.15           | 0.57          | -0.22              | -0.14         | 0.08          | 0.09         | 0.15          | -0.10     | 0.00            | 0.54                | 0.81                 |                    | -0.02 | -0.07            | 0.59                               | -0.31 |
| Q             | -0.36          | 0.21          | -0.38              | -0.60         | -0.05         | -0.60        | -0.57         | -0.67     | -0.35           | -0.17               | -0.10                | 0.44               |       | 0.74             | 0.19                               | -0.44 |
| TL            | -0.43          | -0.03         | -0.22              | -0.60         | -0.09         | -0.67        | -0.59         | -0.57     | -0.38           | -0.30               | -0.28                | 0.30               | 0.92  |                  | 0.19                               | -0.45 |
| Ci            | -0.43          | -0.14         | 0.03               | -0.27         | -0.16         | -0.43        | -0.37         | -0.28     | -0.26           | -0.86               | -0.53                | -0.22              | 0.24  | 0.43             |                                    | -0.90 |
| WUE           | 0.51           | 0.13          | 0.05               | 0.43          | 0.25          | 0.57         | 0.52          | 0.43      | 0.39            | 0.87                | 0.52                 | 0.15               | -0.42 | -0.57            | -0.97                              |       |

parameters as assessed by stepwise regression analysis was inter-cellular CO<sub>2</sub> concentration> photosynthetic rate> leaf temperature> transpiration rate. Further, for leaf dry weight, the step-wise regression analysis revealed significant role played by petiole depth and petiole width.

## References

- Corley RHV, JJ Hardon and GY Tan (1971) Analysis of growth of the oil palm 1. Estimation of growth parameters and application in breeding. *Euphytica* 20: 307-315.
- Panase VG and PV Sukhatme (1985) *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi.
- Taniputra SB and A Manurung (1988) The possibility of using the number of leaflets in the oil palm for yield prediction. *Bulletin-Perkebunan*. 19: 119-127.
- Subronto AM and B Taniputra (1989) Correlation between vegetative characters of the oil palm in the nursery and yield. *Bulletin-Perkebunan*. 20: 107, 111-116.
- Sterling F (1996) Inter-plant competition and thinning of an oil palm plantation. *Agronomia-Costarricense*. 20: 25-37.

## Augmentation of Plant Genetic Resources through Assembly of Indian Released Varieties and Registered Germplasm

**SK Jain, Anjali Kak, Neeta Singh, Sanjeev Saxena, Kalyani Srinivasan, Veena Gupta, J Radhamani, Manju Uprety, AD Sharma, Abha Sharma, Toshi and AK Singh**

*Germplasm Conservation Division, National Bureau of Plant Genetic Resources, New Delhi-110012*

**Key Words:** Released Varieties, Registered Germplasm, Genebank, Conservation

Genebanks, in addition to landraces, old (traditional) varieties, wild and weedy relatives of crop species and breeding lines, conserve finished products, such as varieties released under the national system. Therefore, the Indian National Genebank, in addition to conservation of germplasm collected through exploration, expeditions or introductions, assembles germplasm developed at various institutions as a part of the national network on National Agricultural Research System (NARS). These materials are ready-made (man-made) improved constellations of genes of potential value available for utilisation as the base material for further genetic improvement.

The need for conservation of seed material of released varieties was also realised by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties of Agricultural Crops (CNVRC) established at ICAR under the Ministry of Agriculture, Government of India. Similar sentiments were expressed by the crop improvement programmes, which desired that the seeds of all the released varieties should be conserved at a central place like National Genebank for facilitated access and use. Need for registration of plant germplasm has been considered at the ICAR with a view to accord due recognition to scientists/researchers who develop and identify improved strains of crops, which do not qualify for variety release. Recognising the importance of the value-added germplasm in crop improvement and other areas of plant research, the need for establishment of a national mechanism for documentation of such germplasm was recognised. To an extent, this mechanism helps to provide a soft protection to such material in present regime of Intellectual Property Rights (IPR) as per the international community code. This mechanism will help in meeting the national commitment towards the provisions of Convention on Biological Diversity (CBD) of which India is a signatory, which emphasizes on fair and equitable benefit sharing and sustainable use of germplasm. Also, it will help to meet the

requirement of recent developments on IPR under the provisions of World Trade Organisation (WTO) for documentation of the potentially valuable genetic resources as per the established and recognised national mechanism.

*Augmentation through assembly of released varieties:* To assemble the seed material of released varieties, NBPGR addressed a letter to all the Project Director's and Co-ordinators of various crops in the Indian Council of Agricultural Research (ICAR), and to the Director Research of various State Agricultural Universities in NARS network under the signature of Director, NBPGR. This was supported with a list of available varieties and requesting for the remaining. Also both CNVRC and NBPGR made an effort to strictly abide by the recommendation of 30<sup>th</sup> meeting of CNVRC by not accepting or notifying the varieties or hybrid at national level without fulfilment of this requirement, i.e. deposition of seed material of released varieties for long-term conservation in National Genebank.

*Augmentation through assembly of registered germplasm:* The constituted Plant Germplasm Registration Committee under the chairmanship of Deputy Director General (Crops Sciences) and with the Head, Germplasm Conservation Division, NBPGR as the Member Secretary, has made the deposition of seed material mandatory in the guidelines for registration of plant germplasm and has strictly followed it for conservation of seeds.

*Augmentation of Released Varieties:* The efforts have resulted in enriching the national genebank holding with addition of seed material of 389 varieties, raising the number of conserved released varieties from 1376 to 1765 (Table 1).

*Augmentation of registered germplasm:* Wide circulation of guidelines on registered germplasm has encouraged the deposition of seed material with the National Genebank. There has been an overwhelming response to this national mechanism of documentation of value-added germplasm. Since its inception seven meetings have been held. A total number of 420 applications were received. Of these,

**Table 1. Released varieties conserved at National Genebank**

| Crop Group                    | Accession numbers* deposited with NGB |                                      |                                   | Total |
|-------------------------------|---------------------------------------|--------------------------------------|-----------------------------------|-------|
|                               | Before 30 <sup>th</sup> CNRVC Meeting | After 30 <sup>th</sup> CNRVC Meeting |                                   |       |
|                               |                                       | For LTS                              | Against Proposal for Notification |       |
| Cereals                       | 492                                   | 32                                   | 61                                | 585   |
| Millets and Forages           | 159                                   | 28                                   | 19                                | 206   |
| Pseudo cereals                |                                       | 1                                    | 3                                 | 4     |
| Grain Legumes                 | 222                                   | 31                                   | 44                                | 297   |
| Oilseeds                      | 222                                   | 76                                   | 31                                | 329   |
| Fibre Crops                   | 96                                    | 6                                    | 17                                | 119   |
| Vegetables                    | 100                                   | 1                                    | 8                                 | 109   |
| Spices and Condiments         | 3                                     | 5                                    | 13                                | 21    |
| Medicinal and Aromatic Plants | 7                                     | 3                                    | —                                 | 10    |
| Others                        | 75                                    | 4                                    | 6                                 | 85    |
| Total                         | 1376                                  | 187                                  | 202                               | 1765  |

\* As on 31<sup>st</sup> March 2001

a total of 124 potentially valuable germplasm accessions in 30 crop species have been registered (Table 2).

Conservation of released varieties and value-added registered germplasm in the National Genebank helps in bringing all the elite plant material to a central repository and facilitate availability of these varieties to researchers to meet various interests, such as evaluation, molecular characterisation *etc.* The conservation of varieties shall also facilitate their restoration in various production systems, if needed. From exchange of

**Table 2. Number of crop germplasm registered under national mechanism of documentation under ICAR**

| Crop Group   | Source wise No. of Accessions |           |                            |              |           | Total      |
|--------------|-------------------------------|-----------|----------------------------|--------------|-----------|------------|
|              | ICAR                          | SAU       | State Dept. of Agriculture | Seed Company | Others    |            |
| Millets      |                               | 10        | 1                          |              |           | 11         |
| Cereals      | 16                            | 19        |                            |              |           | 35         |
| Oilseeds     | 14                            | 9         |                            |              | 5         | 28         |
| Ornamental   | 1                             |           |                            |              | 4         | 5          |
| Beverages    |                               |           | 5                          |              |           | 5          |
| Fruits       |                               | 4         |                            |              |           | 4          |
| Forages      |                               |           |                            |              | 1         | 1          |
| Legumes      | 3                             | 9         |                            |              |           | 12         |
| Fibres       | 3                             | 1         |                            | 2            |           | 6          |
| Vegetables   | 8                             | 7         |                            |              | 2         | 17         |
| <b>Total</b> | <b>44</b>                     | <b>56</b> | <b>6</b>                   | <b>2</b>     | <b>12</b> | <b>124</b> |

germplasm point of view at international level, the distribution of released varieties has also received approval of international community. Hence, these materials can be easily made available for sharing as the part of the international multilateral system of germplasm exchange. Inventorisation of released varieties and potentially valuable germplasm with National Genebank and its record will provide greater publicity and exposure to these materials to the users worldwide for their effective use and provide a soft protection.

## Evaluation of Germplasm for Yield Traits in Arecanut (*Areca catechu* L.)

**KS Ananda**

Central Plantation Crops Research Institute, Regional Station, Vittal-574243, Karnataka

**Key Words:** Arecanut, Evaluation trials, Nut yield, Yield traits

The Arecanut palm (*Areca catechu* L.) is an important plantation crop in India and is grown in the states of Karnataka, Kerala, West Bengal, N.E. Region and Andaman and Nicobar group of Islands. It is an essential requisite for several religious and social ceremonies in India and extensively used by all sections of the society as a masticator. Arecanut is one of the few examples wherein crop improvement work combined with improved input technologies have contributed to revolutionize the production and productivity within the last 40 years

(Nair, 1999). Genetic manipulations for higher yield and quality through varietal evaluation and selection is one of the earliest and known methods of crop improvement. One such attempt by Bavappa (1977) with several cultivars of arecanut including exotic types led to the isolation of Mangala (VTL-3) for better yields and early bearing. In subsequent studies critical observations recorded for yield and its component characters on exotic accessions showed that the cultivars introduced from Indonesia (VTL-11) and Singapore

**Table 1. Released varieties conserved at National Genebank**

| Crop Group                    | Accession numbers* deposited with NGB |                                      |                                   | Total |
|-------------------------------|---------------------------------------|--------------------------------------|-----------------------------------|-------|
|                               | Before 30 <sup>th</sup> CNRVC Meeting | After 30 <sup>th</sup> CNRVC Meeting |                                   |       |
|                               |                                       | For LTS                              | Against Proposal for Notification |       |
| Cereals                       | 492                                   | 32                                   | 61                                | 585   |
| Millets and Forages           | 159                                   | 28                                   | 19                                | 206   |
| Pseudo cereals                |                                       | 1                                    | 3                                 | 4     |
| Grain Legumes                 | 222                                   | 31                                   | 44                                | 297   |
| Oilseeds                      | 222                                   | 76                                   | 31                                | 329   |
| Fibre Crops                   | 96                                    | 6                                    | 17                                | 119   |
| Vegetables                    | 100                                   | 1                                    | 8                                 | 109   |
| Spices and Condiments         | 3                                     | 5                                    | 13                                | 21    |
| Medicinal and Aromatic Plants | 7                                     | 3                                    | —                                 | 10    |
| Others                        | 75                                    | 4                                    | 6                                 | 85    |
| Total                         | 1376                                  | 187                                  | 202                               | 1765  |

\* As on 31<sup>st</sup> March 2001

a total of 124 potentially valuable germplasm accessions in 30 crop species have been registered (Table 2).

Conservation of released varieties and value-added registered germplasm in the National Genebank helps in bringing all the elite plant material to a central repository and facilitate availability of these varieties to researchers to meet various interests, such as evaluation, molecular characterisation *etc.* The conservation of varieties shall also facilitate their restoration in various production systems, if needed. From exchange of

**Table 2. Number of crop germplasm registered under national mechanism of documentation under ICAR**

| Crop Group   | Source wise No. of Accessions |           |                            |              |           | Total      |
|--------------|-------------------------------|-----------|----------------------------|--------------|-----------|------------|
|              | ICAR                          | SAU       | State Dept. of Agriculture | Seed Company | Others    |            |
| Millets      |                               | 10        | 1                          |              |           | 11         |
| Cereals      | 16                            | 19        |                            |              |           | 35         |
| Oilseeds     | 14                            | 9         |                            |              | 5         | 28         |
| Ornamental   | 1                             |           |                            |              | 4         | 5          |
| Beverages    |                               |           | 5                          |              |           | 5          |
| Fruits       |                               | 4         |                            |              |           | 4          |
| Forages      |                               |           |                            |              | 1         | 1          |
| Legumes      | 3                             | 9         |                            |              |           | 12         |
| Fibres       | 3                             | 1         |                            | 2            |           | 6          |
| Vegetables   | 8                             | 7         |                            |              | 2         | 17         |
| <b>Total</b> | <b>44</b>                     | <b>56</b> | <b>6</b>                   | <b>2</b>     | <b>12</b> | <b>124</b> |

germplasm point of view at international level, the distribution of released varieties has also received approval of international community. Hence, these materials can be easily made available for sharing as the part of the international multilateral system of germplasm exchange. Inventorisation of released varieties and potentially valuable germplasm with National Genebank and its record will provide greater publicity and exposure to these materials to the users worldwide for their effective use and provide a soft protection.

## Evaluation of Germplasm for Yield Traits in Arecanut (*Areca catechu* L.)

**KS Ananda**

Central Plantation Crops Research Institute, Regional Station, Vittal-574243, Karnataka

**Key Words:** Arecanut, Evaluation trials, Nut yield, Yield traits

The Arecanut palm (*Areca catechu* L.) is an important plantation crop in India and is grown in the states of Karnataka, Kerala, West Bengal, N.E. Region and Andaman and Nicobar group of Islands. It is an essential requisite for several religious and social ceremonies in India and extensively used by all sections of the society as a masticator. Arecanut is one of the few examples wherein crop improvement work combined with improved input technologies have contributed to revolutionize the production and productivity within the last 40 years

(Nair, 1999). Genetic manipulations for higher yield and quality through varietal evaluation and selection is one of the earliest and known methods of crop improvement. One such attempt by Bavappa (1977) with several cultivars of arecanut including exotic types led to the isolation of Mangala (VTL-3) for better yields and early bearing. In subsequent studies critical observations recorded for yield and its component characters on exotic accessions showed that the cultivars introduced from Indonesia (VTL-11) and Singapore

(VTL-17) have higher yield potential and released as Sumangala and Sreemangala for West Coast of India in 1985. The evaluation of indigenous cultivars resulted in identification of high yield potential Mohitnagar and Calicut-17 cultivars and same were released in 1991 for coastal Karnataka, Kerala and West Bengal and in 1995 for Andaman and Nicobar (A&N) group of Islands, respectively. The present study was undertaken to evaluate the germplasm collected from A & N group of Islands for yield performance, consistency in their yielding behaviour and identifying desirable donor genes present in the collections.

Evaluation trial was laid out during 1985 at the Central Plantation Crops Research Institute, Regional Station, Vittal, Dakshina Kannada, Karnataka with seventeen arecanut indigenous accessions collected from A&N group of Islands along with check Mangala in a randomized block design with three replications and each treatment consisted of nine palms. Since the objectives of the study were to evaluate accessions for economic traits such as yield and its component characters and consistency of the collections, the observations on palm height (m), crown length (m), stem girth (cm), number of leaves, leaf length (cm), leaf breadth (cm), and internodal length (cm) were recorded after stabilization of the yield (eighth year of planting). The yield parameters viz.- number of nuts produced/palm/year and weight of

fresh nuts (kg)/palm/year have been recorded from 1990-91 to 1997-98. Twenty nuts from each accessions have been sampled randomly for fruit component studies. Fruit characters such as fruit length (cm), fresh fruit weight (g), kernel breadth (cm), dry kernel weight (g) and recovery of chali/kernel from the fresh fruit were measured. All the morphological, yield and fruit characters were statistically analyzed and interpreted. Variety x year interaction was also worked out to assess the consistency of the accessions.

**Growth parameters:** The observations recorded on growth characters such as plant height, crown length, stem girth above the fixed mark, internodal length, leaf length, leaf breadth and number of leaves, revealed the significant differences among the accessions in respect of plant height, stem girth and crown length while the accessions did not differ for number of leaves and internodal length (Table 1). Accession Cal-10 grew tallest (11.06 m) followed by accessions Cal-33 (10.40 m) and Cal-4 (10.31 m). Accession Cal-17 recorded higher values for stem girth (19.76 cm), internodal length (21.08 cm) and leaf production (10.20 nos). While maximum crown length was noticed in Cal-5 (3.55 m) and Cal-32 (3.48 m). Among the accessions, check Mangala recorded significantly lower height (5.4 m) and least internodal length (13.44 cm), however, produced maximum mean number of leaves (10.23). Similar trend was observed

**Table 1. Growth performance of arecanut accessions**

| Accessions/<br>Character | Plant ht.<br>(m) | Crown<br>length (m) | Stem<br>girth (cm) | Internodal<br>length(cm) | No.of<br>leaves | Leaf<br>length (cm) | Leaf<br>breadth (cm) |
|--------------------------|------------------|---------------------|--------------------|--------------------------|-----------------|---------------------|----------------------|
| Calicut-1                | 9.31             | 2.83                | 16.63              | 18.86                    | 9.35            | 189.13              | 97.00                |
| Calicut-2                | 9.65             | 3.28                | 15.32              | 19.75                    | 9.14            | 201.66              | 106.25               |
| Calicut-4                | 10.31            | 3.38                | 2.15               | 20.61                    | 9.80            | 220.24              | 95.56                |
| Calicut-5                | 7.90             | 3.55                | 16.50              | 12.91                    | 9.75            | 160.25              | 83.87                |
| Calicut-6                | 6.55             | 3.47                | 17.85              | 14.50                    | 10.00           | 156.50              | 91.75                |
| Calicut-7                | 9.67             | 2.90                | 14.43              | 17.73                    | 10.15           | 186.33              | 116.65               |
| Calicut-10               | 11.06            | 2.67                | 13.90              | 27.76                    | 9.34            | 166.15              | 92.68                |
| Calicut-17               | 9.86             | 3.40                | 19.76              | 21.08                    | 10.20           | 227.00              | 94.67                |
| Calicut-21               | 8.10             | 3.20                | 21.01              | 17.78                    | 9.18            | 189.15              | 114.66               |
| Calicut-27               | 7.49             | 2.85                | 19.06              | 16.64                    | 8.60            | 220.50              | 106.50               |
| Calicut-29               | 8.05             | 2.89                | 13.82              | 15.80                    | 9.72            | 209.67              | 99.00                |
| Calicut-32               | 9.98             | 3.48                | 13.80              | 17.73                    | 9.66            | 233.67              | 118.20               |
| Calicut-33               | 10.40            | 3.28                | 13.46              | 19.18                    | 8.66            | 216.90              | 83.60                |
| Calicut-35               | 9.42             | 2.82                | 13.10              | 18.06                    | 8.67            | 228.33              | 106.75               |
| SCRDTC-18                | 9.88             | 3.24                | 13.33              | 16.13                    | 8.34            | 201.55              | 105.60               |
| SCRDTC-43                | 9.34             | 3.46                | 15.36              | 17.60                    | 9.46            | 236.15              | 118.50               |
| SCRDTC-92                | 9.42             | 2.82                | 13.10              | 18.06                    | 8.67            | 228.33              | 106.75               |
| Mangala                  | 5.45             | 3.10                | 18.70              | 13.44                    | 10.23           | 145.78              | 86.87                |
| GM                       | 8.99**           | 3.14                | 16.07**            | 17.97**                  | 9.38            | 200.96**            | 101.38**             |
| CV(%)                    | 10.06            | 11.96               | 12.43              | 14.96                    | 8.33            | 22.68               | 16.95                |
| CD(0.05)                 | 4.07             | NS                  | 0.22               | 3.61                     | NS              | 45.71               | 39.32                |

by Salve *et al.* (1985), Rekha *et al.* (1991) and Ananda *et al.* (2000) wherein Mangala palm attained lower height compared to other varieties in Konkan region of Maharashtra and Malnad tracts of Karnataka. This indicates semi-tall nature of Mangala, which is also expressed under coastal agro-climatic conditions. From the results of morphological parameters, accession Cal-10 appears to be vigorous in terms of taller palms and more internodal length (27.76 cm) while check Mangala and accession Cal-17 were found to be superior for the trait, production of more number of leaves.

**Yield characters:** The yield parameters viz.- number of nuts produced/palm and ripe nut weight/palm of the seventeen indigenous accessions collected from Andaman and Nicobar group of Islands along with check Mangala are presented in Table 2 and 3. The mean number of nuts/palm and ripe nut weight (kg)/palm revealed significant differences among the accessions. The performance of the accession Cal-33 was better as it has produced maximum number of nuts/palm (280.15 nuts/palm/year) and the second best accession was Cal-17, which produced 274.62 ripe nuts/palm/year. The check Mangala also showed superiority for this yield trait with 259.38 nuts/palm/year. About 7.14% and 5.54% increase in production of nuts/palm over Mangala (check) were noticed in accessions Cal-33 and Cal-17, respectively. Accessions SCRDTC 18 (218.46 nuts) and

Cal-1 (218.33 nuts) were found to be medium yielders while poor yield (147.47 nos.) was noticed in accession Cal-21.

With regard to the character ripe nut yield/palm, accession Cal-33 exhibited maximum mean yield of 9.27 kg/palm/year followed by the accession Cal-17 (9.02 kg/palm/year) among the Calicut series of collections. Accession Cal-33 registered 4.60% increase in yield over the check Mangala. The check Mangala showed its superiority for mean ripe nut yield with 9.17 kg/palm/year since Mangala is a high yielding and early stabilizing variety (Bavappa and Nair, 1982, Ananda, 1999; Ananda *et al.*, 2000; Bavappa, 1977). Consistency in the performance among the selected high yielding accessions in the present study in respect of ripe nut yield/palm showed that the accessions SCRDTC 18, Cal-2 and Cal-17 exhibited linear trend giving consistently higher ripe nut yield/palm over the years (Fig. 1) and significant accessions x year interaction was observed in respect of both number of nuts/palm and ripe nut weight/palm. The performance of the accessions Cal-33 and Cal-17 were found to be superior among the Calicut series of indigenous accessions evaluated for their yield traits in the present study.

**Nut component traits:** There were significant variations observed among the accessions for all the nut characters studied except for fruit length and breadth

**Table 2. Yield performance of arecanut accessions (number of nuts/palm)**

| Accessions/Year | 90-91   | 91-92   | 92-93   | 93-94   | 94-95   | 95-96   | 96-97   | 97-98   | Mean    | % ↑ or ↓ over Mangala |
|-----------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-----------------------|
| Calicut-1       | 168.51  | 196.70  | 212.83  | 237.18  | 242.07  | 191.33  | 177.67  | 320.33  | 218.33  | -18.80                |
| Calicut-2       | 141.70  | 174.49  | 200.67  | 232.33  | 187.67  | 214.67  | 167.60  | 180.45  | 186.20  | -39.30                |
| Calicut-4       | 126.80  | 131.05  | 139.30  | 261.67  | 130.67  | 134.67  | 260.00  | 290.23  | 184.30  | -40.73                |
| Calicut-5       | 160.00  | 165.55  | 189.17  | 213.00  | 213.20  | 164.33  | 167.67  | 144.33  | 177.16  | -46.41                |
| Calicut-6       | 170.85  | 195.50  | 210.00  | 212.83  | 151.66  | 268.17  | 120.52  | 323.35  | 206.61  | -25.53                |
| Calicut-7       | 153.67  | 161.42  | 186.50  | 232.16  | 195.60  | 177.33  | 221.67  | 206.27  | 191.83  | -35.21                |
| Calicut-10      | 145.00  | 150.70  | 155.00  | 197.33  | 135.60  | 174.00  | 186.90  | 176.00  | 165.07  | -57.13                |
| Calicut-17      | 245.80  | 280.02  | 305.50  | 298.67  | 210.10  | 260.33  | 286.00  | 310.60  | 274.62  | +05.54                |
| Calicut-21      | 115.80  | 153.65  | 160.13  | 180.00  | 184.97  | 134.33  | 117.53  | 111.33  | 147.47  | -75.88                |
| Calicut-27      | 126.97  | 140.67  | 168.70  | 202.67  | 179.08  | 144.00  | 186.17  | 113.33  | 158.20  | -63.95                |
| Calicut-29      | 120.50  | 112.90  | 121.63  | 191.00  | 77.40   | 170.67  | 231.33  | 286.98  | 164.05  | -58.10                |
| Calicut-32      | 160.60  | 146.00  | 157.70  | 211.17  | 172.68  | 145.67  | 215.83  | 298.00  | 188.46  | -37.63                |
| Calicut-33      | 256.50  | 281.58  | 308.50  | 318.17  | 358.25  | 255.68  | 239.20  | 226.33  | 280.15  | +07.41                |
| Calicut-35      | 206.60  | 211.83  | 222.85  | 214.83  | 129.67  | 182.58  | 235.17  | 193.83  | 199.67  | -29.90                |
| SCRDTC-18       | 215.00  | 202.56  | 225.03  | 246.85  | 242.28  | 212.03  | 187.17  | 216.74  | 218.46  | -18.72                |
| SCRDTC-43       | 164.33  | 140.47  | 155.33  | 204.00  | 181.03  | 134.00  | 197.50  | 211.40  | 186.13  | -39.34                |
| SCRDTC-92       | 199.59  | 173.00  | 184.70  | 215.33  | 217.33  | 154.67  | 181.06  | 171.40  | 187.17  | -38.47                |
| Mangala (check) | 197.66  | 229.39  | 237.63  | 303.55  | 270.82  | 211.83  | 329.00  | 295.33  | 259.38  | -                     |
| GM              | 169.92* | 185.19* | 203.15* | 233.32* | 196.21* | 187.01* | 219.15* | 241.43* | 204.42* |                       |
| CV(%)           | 11.83   | 13.79   | 8.87    | 6.74    | 11.49   | 8.70    | 7.31    | 5.44    | 9.14    |                       |
| CD(0.05)        | 33.14   | 42.11   | 29.73   | 25.92   | 37.07   | 26.82   | 26.39   | 21.65   |         |                       |

**Table 3. Yield performance of indigenous germplasm (ripe nut yield(kg)/palm)**

| Accessions/Year | 90-91  | 91-92  | 92-93  | 93-94  | 94-95  | 95-96  | 96-97  | 97-98  | Mean   | % ↑ or ↓ over Mangala |
|-----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-----------------------|
| Calicut-1       | 4.85   | 6.03   | 6.80   | 7.67   | 8.73   | 4.94   | 5.96   | 8.68   | 6.71   | -23.04                |
| Calicut-2       | 3.96   | 5.47   | 5.78   | 6.95   | 5.39   | 5.60   | 6.31   | 8.07   | 5.94   | -34.56                |
| Calicut-4       | 4.00   | 4.02   | 4.54   | 8.46   | 4.88   | 4.40   | 9.11   | 8.72   | 6.02   | -30.87                |
| Calicut-5       | 4.25   | 4.95   | 5.57   | 7.03   | 5.71   | 5.46   | 6.29   | 5.11   | 5.55   | -36.40                |
| Calicut-6       | 3.85   | 5.43   | 6.19   | 6.76   | 6.19   | 8.15   | 6.43   | 10.76  | 6.72   | -28.57                |
| Calicut-7       | 4.35   | 5.06   | 6.14   | 7.82   | 7.50   | 5.12   | 7.67   | 6.67   | 6.29   | -27.64                |
| Calicut-10      | 3.41   | 3.67   | 4.18   | 6.41   | 4.01   | 4.48   | 7.29   | 6.00   | 4.93   | -43.31                |
| Calicut-17      | 6.58   | 7.18   | 9.12   | 9.11   | 8.04   | 7.13   | 8.73   | 9.88   | 8.22   | -5.52                 |
| Calicut-21      | 2.95   | 3.85   | 3.78   | 5.38   | 4.34   | 3.25   | 4.38   | 4.88   | 4.27   | -51.15                |
| Calicut-27      | 3.33   | 3.67   | 4.69   | 6.68   | 5.32   | 4.10   | 7.06   | 3.86   | 4.86   | -44.23                |
| Calicut-29      | 3.87   | 3.91   | 4.76   | 6.84   | 2.75   | 5.61   | 8.73   | 9.56   | 6.65   | -35.02                |
| Calicut-32      | 4.21   | 8.23   | 4.53   | 6.62   | 5.38   | 3.78   | 7.32   | 9.26   | 5.62   | -35.48                |
| Calicut-33      | 7.56   | 6.15   | 9.91   | 10.95  | 2.08   | 7.82   | 9.12   | 7.23   | 9.11   | 4.60                  |
| Calicut-35      | 4.37   | 6.31   | 4.74   | 7.23   | 4.20   | 5.41   | 8.45   | 5.25   | 5.48   | -36.86                |
| SCRDTC-18       | 5.95   | 4.91   | 7.08   | 7.51   | 5.61   | 6.86   | 6.56   | 7.14   | 6.63   | -23.46                |
| SCRDTC-43       | 4.34   | 4.02   | 5.24   | 7.11   | 6.24   | 4.26   | 7.35   | 9.77   | 6.15   | -29.49                |
| SCRDTC-92       | 4.43   | 8.53   | 4.46   | 6.05   | 4.98   | 4.11   | 5.32   | 4.60   | 4.75   | -45.62                |
| Mangala (check) | 6.48   | 8.55   | 9.21   | 10.36  | 10.19  | 6.99   | 11.60  | 9.80   | 9.05   |                       |
| GM              | 4.72** | 5.51** | 6.21** | 7.68** | 6.19** | 5.47** | 7.90** | 7.81** | 6.44** |                       |
| CV(%)           | 12.98  | 17.19  | 11.91  | 10.67  | 14.22  | 9.58   | 8.25   | 5.73   | 11.40  |                       |
| CD(0.05)        | 1.01   | 1.21   | 1.22   | 1.35   | 1.85   | 0.86   | 1.08   | 0.74   |        |                       |

**Table 4. Fruit component traits of arecanut accessions**

| Accessions/Character | Fruit length (cm) | Fruit breadth (cm) | Fresh fruit wt. (g) | Kernel length (cm) | Kernel breadth (cm) | Dry kernel wt. (g) | Kernel recovery (%) |
|----------------------|-------------------|--------------------|---------------------|--------------------|---------------------|--------------------|---------------------|
| Calicut-1            | 5.28              | 4.43               | 37.15               | 2.12               | 2.88                | 9.52               | 24.38               |
| Calicut-2            | 4.82              | 3.91               | 41.50               | 2.28               | 3.08                | 12.67              | 26.55               |
| Calicut-4            | 4.75              | 3.66               | 37.14               | 2.54               | 2.67                | 9.95               | 26.85               |
| Calicut-5            | 5.29              | 3.98               | 35.10               | 2.75               | 2.78                | 8.50               | 24.22               |
| Calicut-6            | 5.28              | 4.60               | 32.60               | 2.55               | 2.88                | 7.80               | 23.92               |
| Calicut-7            | 5.18              | 3.94               | 33.80               | 2.06               | 2.23                | 8.84               | 24.30               |
| Calicut-10           | 4.56              | 4.29               | 35.65               | 2.41               | 2.99                | 8.91               | 24.90               |
| Calicut-17           | 5.43              | 4.34               | 38.54               | 2.58               | 2.81                | 9.42               | 27.73               |
| Calicut-21           | 4.15              | 4.18               | 31.96               | 1.83               | 2.91                | 6.22               | 27.11               |
| Calicut-27           | 4.49              | 3.53               | 19.08               | 1.78               | 2.20                | 4.85               | 25.16               |
| Calicut-29           | 4.85              | 3.65               | 35.20               | 2.30               | 2.42                | 7.19               | 20.45               |
| Calicut-32           | 4.61              | 4.36               | 33.80               | 1.82               | 2.59                | 7.96               | 23.56               |
| Calicut-33           | 5.90              | 4.10               | 40.06               | 2.48               | 2.12                | 10.60              | 26.46               |
| Calicut-35           | 5.94              | 4.15               | 36.87               | 2.10               | 2.29                | 6.58               | 22.76               |
| SCRDTC-18            | 5.34              | 3.53               | 37.30               | 2.50               | 2.20                | 7.46               | 20.00               |
| SCRDTC-43            | 5.84              | 4.30               | 32.59               | 2.15               | 2.92                | 7.48               | 22.95               |
| SCRDTC-92            | 4.20              | 3.40               | 32.60               | 1.90               | 2.70                | 8.00               | 24.57               |
| Mangala              | 5.10              | 4.02               | 36.07               | 2.56               | 2.75                | 8.60               | 24.32               |
| GM                   | 5.30**            | 4.04**             | 34.64**             | 2.20**             | 2.55**              | 7.80**             | 24.29**             |
| CV(%)                | 4.52              | 2.97               | 7.19                | 3.85               | 3.10                | 8.19               | 4.96                |
| CD(0.05)             | 0.36              | 0.23               | 4.05                | NS                 | NS                  | 0.93               | 2.65                |

\*\* Significant at 1% level, \* Significant at 5% level

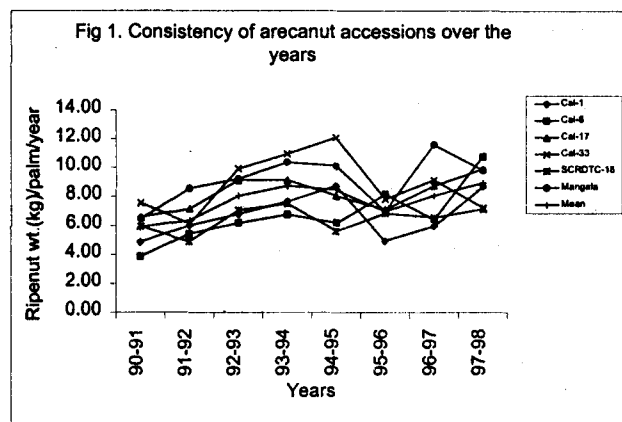


Fig. 1. Consistency in field of arecanut accessions over the years

(Table 4). The fresh weight of nuts ranged between 19.08 g (Cal-27) and 41.50 g (Cal-2) with a mean of 34.64 g, while for the dry kernel weight minimum weight of 4.85 g and maximum of 12.67 g were observed in Cal-27 and Cal-2, respectively with a mean being the 7.80 g/nut. The maximum fruit length of 5.94 cm was measured in accession Cal-35 while the accession Cal-6 recorded highest fruit breadth (4.60 cm). The maximum kernel length (2.74 cm) was noticed in Cal-5, while maximum kernel breadth (3.08 cm) was observed in Cal-2 accession. Accessions Cal-17 (27.73%), Cal-4 (26.85%), Cal-2 (26.55%), Cal-21 (27.11%) and Cal-

33 (26.46%) showed significantly higher recovery of chali/dry kernel from the fresh fruit compared to other accessions. The high recovery may be due to low content of husk in the nuts of these accessions and similar results were obtained for fruit component traits in dwarf arecanut hybrids by Ananda (2000). Overall the accession Cal-2 was found to be superior for most of the fruit component characters studied in the present collections. Thus, nuts with less husk is a desirable trait and such accessions could be utilized as donor parents for improvement of arecanut.

### References

- Ananda KS (1999) Genetic Improvement in Arecanut. In: MJ Ratnambal, et al. (ed.) *Improvement of Plantation Crop*, pp 52-57.
- Ananda KS, Anuradha Sane and BS Chaudhary (2000) Growth and yield performance of Arecanut Varieties in Malanad Region of Karnataka. *J. Plant. Crop* 28: 105-109.
- Bavappa KVA (1977) *Arecanut and Spices Bull.* 3: 65.
- Bavappa KVA and Nair MK (ed.) (1982) *Cytogenetics and Breeding in The Arecanut Palm – Monograph* pp. 51-96.
- Nair MK (1999) Coconut and Arecanut Development—A Futuristic Approach In: MJ Ratnambal et al. (ed.), *Improvement of Plantation Crops*, pp. 4-11.
- Rekha A, KB Abdul Khader and BS Chaudhary (1991) Yielding behaviour of 'Mangala' arecanut in comparison with local south Kanara types. *J. Plantation Crops* 18: 47-51.
- Salve MJ, SP Singh and SB Deshpande (1985) *Silver Jubilee Symposium on Arecanut Research and Development*. pp 10-12.

## Plant Genetic Resources of Spiti – a Cold Desert in the Western Himalaya

NS Chauhan

Department of Forest Products, Dr YS Parmar University of Horticulture and Forestry, Nauni-Solan-173230, Himachal Pradesh

**Key Words:** PGR, Medicinal Plants, Himalayas

For centuries a mystic area surrounded the trans-Himalayan tracts of Tibet, Lahaul and Spiti. Spiti is an introversive culture of life focussed around its several monasteries and faith as deep as the river swift. Spiti a sub division of Lahaul and Spiti district of Himachal Pradesh is lying at the extreme North-East corner between 31°49' and 33°00' N latitude, and 77°37' and 78°35' E longitude. It is bordered by Ladakh on the west, Lahaul on the

south and Kinnaur on South-East, covering an area of 7,460 Km<sup>2</sup>. Mountain ranges belong to the great and middle Himalayas. The sub-division lies at a mean elevation of about 4,570 m and average elevation of mountain ranges is over 5,485 m above mean sea level (msl). The whole area is drained by Spiti river and its tributaries and finally merges into Sutlej at Khab in Kinnaur. Villages are established on flat pieces of land

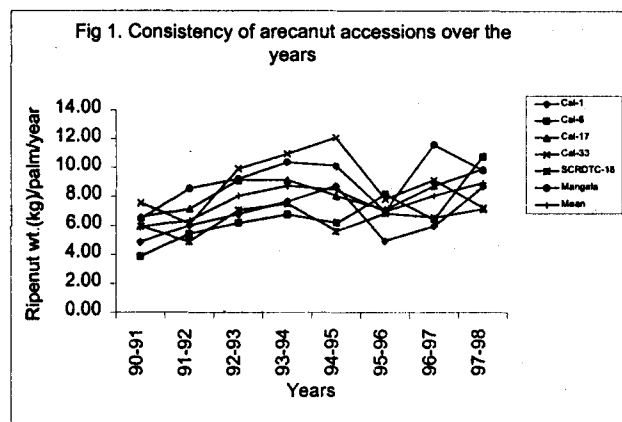


Fig. 1. Consistency in field of arecanut accessions over the years

(Table 4). The fresh weight of nuts ranged between 19.08 g (Cal-27) and 41.50 g (Cal-2) with a mean of 34.64 g, while for the dry kernel weight minimum weight of 4.85 g and maximum of 12.67 g were observed in Cal-27 and Cal-2, respectively with a mean being the 7.80 g/nut. The maximum fruit length of 5.94 cm was measured in accession Cal-35 while the accession Cal-6 recorded highest fruit breadth (4.60 cm). The maximum kernel length (2.74 cm) was noticed in Cal-5, while maximum kernel breadth (3.08 cm) was observed in Cal-2 accession. Accessions Cal-17 (27.73%), Cal-4 (26.85%), Cal-2 (26.55%), Cal-21 (27.11%) and Cal-

33 (26.46%) showed significantly higher recovery of chali/dry kernel from the fresh fruit compared to other accessions. The high recovery may be due to low content of husk in the nuts of these accessions and similar results were obtained for fruit component traits in dwarf arecanut hybrids by Ananda (2000). Overall the accession Cal-2 was found to be superior for most of the fruit component characters studied in the present collections. Thus, nuts with less husk is a desirable trait and such accessions could be utilized as donor parents for improvement of arecanut.

### References

- Ananda KS (1999) Genetic Improvement in Arecanut. In: MJ Ratnambal, et al. (ed.) *Improvement of Plantation Crop*, pp 52-57.
- Ananda KS, Anuradha Sane and BS Chaudhary (2000) Growth and yield performance of Arecanut Varieties in Malanad Region of Karnataka. *J. Plant. Crop* 28: 105-109.
- Bavappa KVA (1977) *Arecanut and Spices Bull.* 3: 65.
- Bavappa KVA and Nair MK (ed.) (1982) *Cytogenetics and Breeding in The Arecanut Palm – Monograph* pp. 51-96.
- Nair MK (1999) Coconut and Arecanut Development—A Futuristic Approach In: MJ Ratnambal et al. (ed.), *Improvement of Plantation Crops*, pp. 4-11.
- Rekha A, KB Abdul Khader and BS Chaudhary (1991) Yielding behaviour of 'Mangala' arecanut in comparison with local south Kanara types. *J. Plantation Crops* 18: 47-51.
- Salve MJ, SP Singh and SB Deshpande (1985) *Silver Jubilee Symposium on Arecanut Research and Development*. pp 10-12.

## Plant Genetic Resources of Spiti – a Cold Desert in the Western Himalaya

NS Chauhan

Department of Forest Products, Dr YS Parmar University of Horticulture and Forestry, Nauni-Solan-173230, Himachal Pradesh

**Key Words:** PGR, Medicinal Plants, Himalayas

For centuries a mystic area surrounded the trans-Himalayan tracts of Tibet, Lahaul and Spiti. Spiti is an introversive culture of life focussed around its several monasteries and faith as deep as the river swift. Spiti a sub division of Lahaul and Spiti district of Himachal Pradesh is lying at the extreme North-East corner between 31°49' and 33°00' N latitude, and 77°37' and 78°35' E longitude. It is bordered by Ladakh on the west, Lahaul on the

south and Kinnaur on South-East, covering an area of 7,460 Km<sup>2</sup>. Mountain ranges belong to the great and middle Himalayas. The sub-division lies at a mean elevation of about 4,570 m and average elevation of mountain ranges is over 5,485 m above mean sea level (msl). The whole area is drained by Spiti river and its tributaries and finally merges into Sutlej at Khab in Kinnaur. Villages are established on flat pieces of land

along springs and streams. Gete, the highest village in the World, has only 8 houses and recently connected with road. The area is mostly dominated by mountains of brown and grey rocks, steppes and pasture lands with flat plateaus along the banks of river Spiti at Rangrik, Kee, Kiamo, Kiato *etc.* The climate of this valley is predominantly cool and dry throughout the year, except the months of May to September, when it receives very little showers. For rest of the year valley remains covered under snow.

During investigations in the entire Spiti division, field trips of one to one and half months duration were undertaken in different seasons of the years between 1988-94 and the area covered ranges from 3200-5500 m above msl. The areas explored during these surveys include Kaza, (Kewang, Kwalang, Langza, Hikkim, Gete, Tashigang, Shego, Maran, Ledang, Lingti, Shoulochouk, Cubhrung, Talung and Demul), Kibber area (Kee, Kee Gompa, Chicham, Ladarcha); Gue area (Hurling, Sumdo, Gue and Kaurik), Kunzum Pass, Demul Pass; Rongtong area (Rangrik, Khurik, Sichling, Maran, Hull, Pangmo, Chisighar, Kiato, Hansa, Lossar and Kiamo); Pin valley area (Senling, Gulling, Bhar, Chud, Kungri, Hikkim, Sagnam, Attargu, Sagnam glaciers, Tialing, Mud, Khar, Todan, Lingti Gompa and Chhidang) and Sichling area (Sichiling, Dankhar, Mane, Gogma, Mane Yogma, Lundupdin, Poh, Morang, Kurith, Tabo and Lari). The main objective of these field trips was to inventorise the floristic composition of the area for preparing an account of different vegetation types. The information on local/common names, uses to which various plants are put by the local inhabitants for their domestic use, edible plants, plants used in household medicines and other related information about the plant species along with their product was collected during these field investigations.

To record morphological variations, attempts were made to collect same species from different habitats/localities. Depending upon the availability, at least 4-6 voucher specimens were collected under one collection number. Specimens were usually collected in both flowering and fruiting periods. Complete field notes regarding habit, habitat, height, subterranean organs, flowering and fruiting season(s), flower colour, abundance, associations, types of soil and other interesting features which can not be observed in pressed specimens were entered in the field notebook along with other related information. The voucher specimens are

deposited in the UHF herbarium in the Department of Forest Products.

Spiti has only two seasons – short lived summer and a long freezing winter. As a result of survey and exploratory studies conducted in Spiti, the vegetation was found to be sparse, discontinuous and scattered, clearly showing the rugged landscape with brown and barren rocks, but at the same time most varied and attractive owing to the dry alpine nature. The vegetation is dominated by coarsely shaped bushes majority of which form spinescent cushions. The stunted forms, twisted and bent nature of stem, succulence, wooliness, perennation, by underground parts, cushiony and matted habit and strong root systems are the characteristic features of the vegetation of this cold desert area.

A total of 477 species covering 218 genera belonging to 50 families were recorded. Asteraceae is the most cosmopolitan and largest family (72 species) followed by Fabaceae (43) and Poaceae is placed third with (34 species). Of these, 23 families are monogeneric and 11 families are monospecific. Various ecological niches revealed that tree species account for only 1.89%. Most important ones are: *Juniperus macropoda*, *Populus balsamifera*, *P. nigra*, *Salix viminalis*, *S. elegans*, *Betula utilis* and *Hippophae* at places. Shrubs account for 49 species (10.27%). Important species are *Rosa webbiana*, *Hippophae rhamnoides*, *Myricaria germanica*, *Salix flabellaris*, *S. fragilis*, *S. hastata*, *S. lindeleyana*, *Juniperus recurva*, *J. communis*, *Ribes orientale*, *Lonicera obovalata*, *Rhododendron lepidotum*, *Ephedra gerardiana*, *Colutea nepalensis*, *Capparis spinosa* *etc.* The herbaceous elements (both annual and perennials) account for 431 species (86.58%). Herbaceous element is dominated by members of pea family *i.e.* Leguminosae followed by Asteraceae and Boraginaceae. Among monocots members of Liliaceae are prominent and grasses are sparse and scattered. Plants prominently found include *Cicer microphyllum*, *Lindelophia stylosa*, *Allium carollianum*, *Hyoscyamus niger*, *Cousinia thomsonii*, *Caltha palustris*, *Thermopsis inflata*, *Rumex nepalensis*, *Oxyris digyna*, *Crepis flexuosus*, *Aconogonum tortuosum*, *Lepidium latifolium*, *Nepeta podostachya*, *Plantago depressa*, *Eriophyton wallichii*, *Lamium rhomboideum*, *Aquilegia fragrans*, *Codonopsis ovata*, *Chenopodium foliosum*, *Bistorta affinis*, *Taraxacum officinale*, *Geranium wallichianum*, *Lactuca macrorrhiza*, *Hyssopus officinalis*, *Cymbopogon jwarankusha*, several species of *Artemisia*, *Potentilla*, *Chaerophyllum*, *Astragalus*, *Chesneya*, *Oxytropis*,

*Gentianella*, *Gentiana*, *Pedicularis* etc. The parasites and saprophytes were only 6 (1.26%) and mainly include *Orobanche*, *Cuscuta* and *Boschniakia*.

Out of the identified species, 74 have been categorized as medicinal and aromatic plants. Among the plants of commerce and known medicinal importance mention can be made of *Ephedra gerardiana*, *Artemisia brevifolia*, *Arnebia euchroma*, *Onosma hispidum*, *Rheum australe*, *R. moorcroftianum*, *Hyoscyamus niger*, *Corydalis gowaniana*, *Gentiana tianschanica*, *Thymus serpyllum*, *Dactylorhiza hatagirea*, *Heracleum candicans*, *Allium carolinianum*, *A. rubellum*, *Bergenia stracheyi*, *Malva rotundifolia*, *Tanacetum nubigenum*, *Hyssopus officinalis*, *Achillea millefolium*, *Traxacum officinale*, *Betula jacquemontii*, *Juniperus communis*, *Rhododendron lepidotum* and *Physochlaina praealta*. All these can be commercially exploited on systematic basis for pharmaceutical industry. *Salix* trees and shrubs (Changma, Lagma and Goo) form the main fodders for the cattle. *Lonicera spinosa*, *Caragana gerardiana* and *Ephedra gerardiana* etc. along with roots of perennial herbs are used as fuel wood and heaps of these shrubby species can be seen piled on the thatched house roof in each household.

During the study, it was revealed that 103 plant species are of ethnobotanical importance i.e. used by local inhabitants in their daily life for curing of various ailments. *Thermopsis inflata* (Lamo) is used in ascites to remove water from the body. The flowers of *Astragalus grhahaminus* (Chhichhar, Khilla) are used in fevers and insanity. *Convolvulus arvensis* (Marshi) is used as detergent to wash clothes. *Saussurea obvallata* (Pangchi) bracts are used in cough and respiratory problems. The twigs of *Cassiope fastigiata* (Gangachu) are used for inducing suppuration (Puss formation) in boils. *Delphinium vestitum* (Changuathpa) is used in diabetes in combination with other herbs. The roots of *Bergenia stracheyi* (Gatikpa) are used as massage to cure joint pains and body swellings. Flowers of *Aquilegia fragrans* (Lundud dorje) are used in leucorrhoea and diabetes. *Thymus serpyllum* (Pangdum, Padumba) is used in stomach problems and as flea repellent. Its dried leaves and flowers are used as condiments. The floral parts of *Hyssopus officinalis* (Tengu) are used as substitute for saffron in Tibetan medicines useful for fevers and blood related diseases. The extract of the wood of *Fraxinus xanthoxyloides* (Pipjul) quite bitter in taste is given orally in bone feature after tying the affected organ with wooden pieces in

proper position. *Ferula jaeschkeana* (Kati) is reported to labour mushrooms under it in Pin Valley. The plant is used as a mulch and organic manure in the fields. It is also utilized as mulching with *Lindelophia stylosa* (Shuara) and Khamet (*Arnebia euchroma*) in cattle shed to produce organic manure for the agricultural field in crops like wheat, barley (2 types), buckwheat, peas, potatoes, mustard and off season vegetables. Recently introduced fruit crops are apple and apricot.

As a result of survey and exploratory studies conducted in Spiti, the vegetation was found to be sparse, discontinuous and scattered, clearly showing the rugged landscape with brown and barren rocks, but at the same time most varied and attractive owing to the dry alpine nature. Pin valley is comparatively greener and richer in vegetation. The main cultivated crops include wheat, barley (2 types), buckwheat, peas, potatoes, mustard and off season vegetables. Recently introduced fruit crops are apple and apricot only. The only green patches soothing to the eyes are available around the villages with cultivated fields and hay lands. Thick forest patch of *Hippophae* existing in Mane village, a tree size *Myricaria* in Gue and dilapidated *Juniper* patch near Gue and Kaa loops reminds us of the past forests and the present day destruction by biotic interference.

Spiti provides ample water and land resources in a typical environment. If these are properly harnessed and plantation programmes judiciously executed with the close co-operation of the people, time is not far off when the valley can boast itself as the unique biosphere reserve on the land. Being close to nature, people make maximum use of herbs for meeting their daily needs and curing themselves from various diseases. Their system is very close to the Tibetan Medical System.

## References

- Anonymous (1986) *The Useful Plants of India*. PID-CSIR, New Delhi.
- Aswal BS and BN Mehrotra (1994) *Flora of Lahaul-Spiti: A cold desert in North-West Himalaya*. Bishen Singh Mahendra Pal Singh, Dehra Dun, 761 p.
- Bajpai SC (1987) *Lahaul Spiti: A forbidden land in the Himalaya*. Indus Publishing Company, New Delhi, 164 p.
- Bor NL (1973) *Grasses of Burma, Ceylon, India and Pakistan*. Koenigsegin, Otto Koltz, 767 p.
- Chadha SK (1988) *Himalayas: Ecology and Environment*, Mittal Publications, New Delhi, 183 p.
- Champion GH and SK Seth (1965) *Forest types of India (Revised edition)*. For. Res. Inst. Dehra Dun. (Mimeo).

- Chauhan NS (1988) Ethnobotanical study of medicinal plants of Himachal Pradesh. In: P. Kaushik (ed.) *Indigenous Medicinal Plants*, Today and Tomorrow's Printers and Publishers, New Delhi, pp 198-205.
- Chauhan NS (1989) Herbal wealth of cold desert area of Himachal Pradesh. *Proceedings National Seminar-cum-Workshop on Cold Desert Area in India*, Govt. Press, Shimla, pp 65-68
- Chauhan NS (1989b) Potential of aromatic plants flora in Himachal Pradesh. *Indian Perfumer* 33: 118-122.
- Chauhan NS and Sanjeev Thakur (1995) Conservation of plant genetic resources of HP. *Indian J. For.* 18: 226-238.
- Chowdhery HJ and BM Wadhwa (1984b) *Flora of Himachal Pradesh, Analysis* Vols. 1-3. Botanical Survey of India, Calcutta.
- Collett H (1902) *Flora Simlensis*. Thacker Spink. & Co. Calcutta and Simla, Reprinted 1971, Bishen Singh Mahendra Pal, Dehra Dun.
- Hooker JD (Hook. f.) (ed.) (1872-1897) *The Flora of British India*. Vol. 1-7 L. Reeve and Co. London. Reprinted 1973, Dehra Dun and Periodical Experts, Delhi.
- Jain SK (ed.) (1989) *Methods and Approaches in Ethnobotany*. Soc. Ethnobot., Lucknow.
- Kachroo P, BL Sapru and U Dhar (1977) *Flora of Ladakh*, Dehra Dun.
- Kapahi BK (1990) Ethnobotanical investigations in Lahaul (Himachal Pradesh). *J. Econ. Tax. Bot.* 14: 49-55.
- Maheshwari JK (1984) Biosphere reserves in the Himalayas. In: G.S. Paliwal (ed.) *The Vegetational Wealth of Himalayas*, Puja Publishers, Delhi, pp 439-449.
- Maheshwari ML, KPS Chandel and MJ Chien (1988) The composition of essential oils from *Hyssopus officinalis* L. and *Cymbopogon jwarancusa* (Jones) Schult. collected in the cold desert of Himalaya. *Developments Food Sci.* 18: 171-176.
- Mani MS (1978) *Ecology and Phytogeography of High Altitude Plants of the North-West Himalaya*. Oxford and IBH Publishing Co., New Delhi.
- Nautiyal S (1991) Willow a multipurpose tree of cold desert of India. *Indian Forester* 117: 153-155.
- Nautiyal S, VK Pandita and HB Naithani (1994) Exploration and collection of fodder grasses and legumes germplasm from cold desert of India. *Ann. Forestry* 2: 77-79.
- Polunin P and A Stainton (1984) *Flowers of Himalayas*. Oxford University Press, Delhi. 580 p.
- Puri GS (1960) *Indian Forest Ecology*, Vols. 1-2. Oxford Book and Stationary Co., New Delhi and Calcutta.
- Rau MA (1961) A recent survey of medicinal plant resources of Lahaul Valley (Punjab, India). *Pakistan J. Sci. Ind. Res. Spl. No. International Symposium* 4: 202-205.
- Sarkar AK (1990) Endemic genera of Angiosperms and their species in India. In: BK Gupta (ed.) *Higher Plants of Indian Subcontinent* 1: 235-257. Bishen Singh Mahendra Pal Singh, Dehra Dun.
- Uniyal MR and NS Chauhan (1979) A preliminary study of the indigenous drugs used at the Tibetan medical Centre, Dharamsala (HP). *Nagarjun*, Vol. XXII 8: 190-193.
- Uniyal MR, AV Bhat and PN Chaturvedi (1982) Preliminary observation on the medicinal plants of Lahaul and Spiti Forest Division in Himachal Pradesh. *Bull. Medic-Ethnobotanical Res.* 3: 1-26.

## Collection of Plant Genetic Resources from Parts of Arid and Semi-Arid Regions in India

**NK Dwivedi, Neelam Bhatnagar and DC Bhandari\***

*National Bureau of Plant Genetic Resources, Regional Station, Central Arid Zone Research Institute Campus, Jodhpur-342003, Rajasthan*

Between 1980 to May 2001, 68 major explorations comprising 48 crop/region specific and 20 multicrops, were carried besides 13 minor ones in the states – Gujarat, Haryana, Rajasthan and adjoining areas of Madhya Pradesh, Punjab and Uttar Pradesh (Chandel and Bhandari, 1989; Chopra and Bhandari, 1989; Dwivedi and Bhandari, 1995, 1996, 1999; Dwivedi *et al.*, 1994, 1997, 1998). Of these collection trips, 25 major explorations were jointly carried out with National/International Institutes

(Central Arid Zone Research Institute, Jodhpur; Central Institute for Jute and Allied Fibres, Barrackpore, W.B.; CCS Haryana Agricultural University, Hisar and its Agricultural Research Station, Bawal, Directorate of Pulse Research, Kanpur; ISCRISAT, Hyderabad; University of Hyderabad; Indian Institute of Horticulture Research, Bangalore; Gujarat Agricultural University, Main Rice Research Station Navagaon; Kheda, Wheat Research Station Vijapur, Mehsana; National Research Centre for Arid Horticulture, Bikaner and Rajasthan Agriculture University, Agriculture College, Jobner. Six

\*National Bureau of Plant Genetic Resources Regional Station, Niglat, Bhowali-263132, Nainital, Uttanchal

- Chauhan NS (1988) Ethnobotanical study of medicinal plants of Himachal Pradesh. In: P. Kaushik (ed.) *Indigenous Medicinal Plants*, Today and Tomorrow's Printers and Publishers, New Delhi, pp 198-205.
- Chauhan NS (1989) Herbal wealth of cold desert area of Himachal Pradesh. *Proceedings National Seminar-cum-Workshop on Cold Desert Area in India*, Govt. Press, Shimla, pp 65-68
- Chauhan NS (1989b) Potential of aromatic plants flora in Himachal Pradesh. *Indian Perfumer* 33: 118-122.
- Chauhan NS and Sanjeev Thakur (1995) Conservation of plant genetic resources of HP. *Indian J. For.* 18: 226-238.
- Chowdhery HJ and BM Wadhwa (1984b) *Flora of Himachal Pradesh, Analysis* Vols. 1-3. Botanical Survey of India, Calcutta.
- Collett H (1902) *Flora Simlensis*. Thacker Spink. & Co. Calcutta and Simla, Reprinted 1971, Bishen Singh Mahendra Pal, Dehra Dun.
- Hooker JD (Hook. f.) (ed.) (1872-1897) *The Flora of British India*. Vol. 1-7 L. Reeve and Co. London. Reprinted 1973, Dehra Dun and Periodical Experts, Delhi.
- Jain SK (ed.) (1989) *Methods and Approaches in Ethnobotany*. Soc. Ethnobot., Lucknow.
- Kachroo P, BL Sapru and U Dhar (1977) *Flora of Ladakh*, Dehra Dun.
- Kapahi BK (1990) Ethnobotanical investigations in Lahaul (Himachal Pradesh). *J. Econ. Tax. Bot.* 14: 49-55.
- Maheshwari JK (1984) Biosphere reserves in the Himalayas. In: G.S. Paliwal (ed.) *The Vegetational Wealth of Himalayas*, Puja Publishers, Delhi, pp 439-449.
- Maheshwari ML, KPS Chandel and MJ Chien (1988) The composition of essential oils from *Hyssopus officinalis* L. and *Cymbopogon jwarancusa* (Jones) Schult. collected in the cold desert of Himalaya. *Developments Food Sci.* 18: 171-176.
- Mani MS (1978) *Ecology and Phytogeography of High Altitude Plants of the North-West Himalaya*. Oxford and IBH Publishing Co., New Delhi.
- Nautiyal S (1991) Willow a multipurpose tree of cold desert of India. *Indian Forester* 117: 153-155.
- Nautiyal S, VK Pandita and HB Naithani (1994) Exploration and collection of fodder grasses and legumes germplasm from cold desert of India. *Ann. Forestry* 2: 77-79.
- Polunin P and A Stainton (1984) *Flowers of Himalayas*. Oxford University Press, Delhi. 580 p.
- Puri GS (1960) *Indian Forest Ecology*, Vols. 1-2. Oxford Book and Stationary Co., New Delhi and Calcutta.
- Rau MA (1961) A recent survey of medicinal plant resources of Lahaul Valley (Punjab, India). *Pakistan J. Sci. Ind. Res. Spl.* No. International Symposium 4: 202-205.
- Sarkar AK (1990) Endemic genera of Angiosperms and their species in India. In: BK Gupta (ed.) *Higher Plants of Indian Subcontinent* 1: 235-257. Bishen Singh Mahendra Pal Singh, Dehra Dun.
- Uniyal MR and NS Chauhan (1979) A preliminary study of the indigenous drugs used at the Tibetan medical Centre, Dharamsala (HP). *Nagarjun*, Vol. XXII 8: 190-193.
- Uniyal MR, AV Bhat and PN Chaturvedi (1982) Preliminary observation on the medicinal plants of Lahaul and Spiti Forest Division in Himachal Pradesh. *Bull. Medic-Ethnobotanical Res.* 3: 1-26.

## Collection of Plant Genetic Resources from Parts of Arid and Semi-Arid Regions in India

**NK Dwivedi, Neelam Bhatnagar and DC Bhandari\***

*National Bureau of Plant Genetic Resources, Regional Station, Central Arid Zone Research Institute Campus, Jodhpur-342003, Rajasthan*

Between 1980 to May 2001, 68 major explorations comprising 48 crop/region specific and 20 multicrops, were carried besides 13 minor ones in the states – Gujarat, Haryana, Rajasthan and adjoining areas of Madhya Pradesh, Punjab and Uttar Pradesh (Chandel and Bhandari, 1989; Chopra and Bhandari, 1989; Dwivedi and Bhandari, 1995, 1996, 1999; Dwivedi *et al.*, 1994, 1997, 1998). Of these collection trips, 25 major explorations were jointly carried out with National/International Institutes

(Central Arid Zone Research Institute, Jodhpur; Central Institute for Jute and Allied Fibres, Barrackpore, W.B.; CCS Haryana Agricultural University, Hisar and its Agricultural Research Station, Bawal, Directorate of Pulse Research, Kanpur; ISCRISAT, Hyderabad; University of Hyderabad; Indian Institute of Horticulture Research, Bangalore; Gujarat Agricultural University, Main Rice Research Station Navagaon; Kheda, Wheat Research Station Vijapur, Mehsana; National Research Centre for Arid Horticulture, Bikaner and Rajasthan Agriculture University, Agriculture College, Jobner. Six

\*National Bureau of Plant Genetic Resources Regional Station, Niglat, Bhowali-263132, Nainital, Uttanchal

crop specific explorations were undertaken for the collection of sesame, okra and eggplant under NBPGR/IPGRI Collaboration Programme from parts of Gujarat and Rajasthan. The sample were collected from farmers' field, threshing yards, farm store, kitchen gardens, weekly village market (cultivated form), waste lands, roadside, irrigated and rainfed farmers' fields, river banks, canal areas, annual and ephemeral ponds, terraces, slopes, valley and hilltops. Biased, random and bulk sampling procedures were followed for collecting of germplasm. Herbarium sheets were prepared. Passport data were recorded along with important plant characters. One set of collected seed material was sent to NBPGR Headquarter, New Delhi for conservation in National Genebank and getting accession numbers. Vegetative propagules were planted at this Regional Station for establishment.

A total of 12,884 collections comprising cultivated (12,365) and wild (519) accessions have been made (Tables 1 and 2) in various crops/economically important/rare plant group like cereals and millets (1,823), pulses and legumes (5,484), oilseeds (1,829), fibres (385), vegetables (1,464), fruits and minor fruits (905), medicinal and aromatic plants (117), halophytes (22), spices and condiments (167), fodder plants (153) wild relative and weedy forms (339) and miscellaneous (223) (Tables 1 and 2); (Dwivedi and Bhandari, 1996; Dwivedi *et al.*, 1998). An effort was made to collect maximum

**Table 1. Explorations undertaken and germplasm collected during 1980-May, 2001**

| Year    | Explorations undertaken |       |            | Samples Collected |        |
|---------|-------------------------|-------|------------|-------------------|--------|
|         | Major                   | Minor | Cultivated | Wild              | Total  |
| 1980    | 1                       | -     | 2,764      | 33                | 2,797  |
| 1981    | 1                       | -     | 1,547      | 29                | 1,576  |
| 1982    | -                       | 1     | 356        | -                 | 356    |
| 1983    | 1                       | -     | 176        | 2                 | 178    |
| 1984    | -                       | 1     | 60         | 0                 | 60     |
| 1985    | 1                       | -     | 1,018      | 5                 | 1,023  |
| 1986    | 6                       | 7     | 1,078      | 6                 | 1,084  |
| 1987    | 5                       | 2     | 550        | 3                 | 553    |
| 1988    | 7                       | -     | 608        | 1                 | 609    |
| 1989-90 | 8                       | -     | 1,226      | 2                 | 1,228  |
| 1990-91 | 4                       | -     | 568        | 139               | 707    |
| 1991-92 | 4                       | -     | 448        | 20                | 468    |
| 1992-93 | 6                       | -     | 486        | 13                | 499    |
| 1993-94 | 1                       | -     | 96         | 1                 | 97     |
| 1995-96 | 4                       | -     | 485        | -                 | 485    |
| 1996*   | 2                       | 1     | 82         | 85                | 167    |
| 1997    | 2                       | -     | 180        | -                 | 249    |
| 1998    | 3                       | 1     | 249        | -                 | 249    |
| 1999-00 | 1                       | -     | 61         | 15                | 76     |
| 2000-01 | 8                       | -     | 220        | 165               | 385    |
| 2001*   | 3                       | -     | 107        | -                 | 107    |
| Total   | 68                      | 13    | 12,365     | 519               | 12,884 |

\* upto May, 2001

**Table 2. Details of germplasm collected in different crops (1980 to May, 2001)**

| Crop Groups                | Important Crop Species                                                                                                                  |        |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|--------|
| Cereals and Millets        | Barley (129), Maize (308), Pearl millet (762), Sorghum (96), <i>Oryza sativa</i> (111), Wheat (337), Minor Millets (38) and others (42) | 1823   |
| Pulses and Legumes         | Chickpea (506), Cowpea (237), Guar (3044), Mothbean (640), Mungbean (766), Pigeonpea (138), Urdbean (121) and others (32)               | 5484   |
| Oilseeds                   | Castor (135), Groundnut (177), Mustard (250), Taramira (65), Til (1037), Tumba (161) and Others (4)                                     | 1829   |
| Fibres                     | <i>Corchorus olitorius</i> (76), Cotton (145), Kenaf (63) Sunn-hemp (52) and others (22)                                                | 358    |
| Vegetables                 | Brinjal (203), Chillies (299), <i>Cucumis</i> spp. (299), Garlic (44), Ker (140), Lasora (86), Okra (134), Pea (73) and Others (151)    | 1429   |
| Fruits and Minor fruits    | Ber (175), <i>Coria rothii</i> (24), Khejri (404), Matira (124), Muskmelon (105), Pomegranate (24) and Others (84).                     | 940    |
| Medicinal plants           |                                                                                                                                         | 117    |
| Halophytes                 | <i>Salicornia brachiata</i> (5), <i>Suaeda fruticosa</i> (8) and others (8)                                                             | 22     |
| Spices and Condiments      | Coriander (80), Cumin (36), and Methi (51)                                                                                              | 167    |
| Fodder Plants              | <i>Cenchrus</i> spp. (3), <i>Lasiurus indicus</i> (65), <i>Sesbania</i> spp. (43) and others (15)                                       | 153    |
| Wild relatives/Weedy forms | Okra (143), <i>Sesamum</i> sp. (100), <i>Solanum</i> spp. (32) and others (64)                                                          | 339    |
| Miscellaneous              | <i>Corchorus</i> spp. (133), <i>Tephrosia purpurea</i> (31), others (50)                                                                | 223    |
| Total                      |                                                                                                                                         | 12,884 |

The local landraces collected in different crop groups were:

|              |                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                    |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wheat        | <i>T. aestivum</i><br>Bodiya gehun<br>Contoli gehun<br>Deshi gehun<br>Deshi Lal gehun<br>Dhola gehun<br>Kotbajiya<br>Kharchiya gehun<br>Lal gehun<br>Moti<br>Nana gehun<br>Pili kanak<br>Desi Jov                                                                                                                                    | Safed kanak<br>Sachiya<br>Teria<br>Tukara<br>Vajya<br><br><i>T. dicoccum</i><br>Jau<br>Popatiya<br>Putadiya<br>Putragehun<br>Putrajau                                                                                                                                                                        | <i>T. durum</i><br>Arnej Gehun<br>Arnej Katha<br>Bansi<br>Bhatiya Desi<br>Daut Khani<br>Futel<br>katha<br>Kathiya<br>Poonagiri<br><i>T. sphaerococcum</i><br>Patoliya                                                                                                                                              |
| Barley       | Desi makki                                                                                                                                                                                                                                                                                                                           | Hatti Makki                                                                                                                                                                                                                                                                                                  | Malan Makki                                                                                                                                                                                                                                                                                                        |
| Maize        | Satti makki                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                    |
| Rice         | Akoli Bhat<br>Altiya<br>Ankalo<br>Ausi<br>Bangalo<br>Barihai<br>Batli Bhat<br>Bhujhavalia Bhat<br>Chawara<br>Chocolate<br>Cholli Desi<br>Dabla<br>Dabohal<br>Dabual<br>Dadrcolon<br>Dalaki<br>Dang Bhat<br>Dault Puri<br>Desi Bath<br>Desi Dangar<br>Desi Sathi<br>Dhauar<br>Dhanpari<br>Dholi Bhatt<br>Dholi Danger<br>Mahuda Bajra | Ekngare<br>Ekdaudi<br>Futiya<br>Geton<br>Gutniyao<br>Halaki<br>Kauchi<br>Hari Bangalo<br>Hathi,<br>Indrani<br>Jaware<br>Jhadaki<br>Jhini Sathi<br>Jodohallio<br>Kada<br>Kajal Hari<br>Kala Kundiya<br>Kali Dangar<br>Kalinga<br>Kansarvav Karojo<br>Kirali<br>Khadasi<br>Khadsia<br>Khasriva Dangar<br>Kolpi | Kosure<br>Lakshari<br>Lakshari Bhuri<br>Lakshari Sona<br>Lal Dangar<br>Markolin<br>Masuri<br>Nanisal<br>Panijal<br>Pejje<br>Podhari<br>Rata Chawal<br>Rodi Kawod<br>Ratiya Dangar<br>Saket, Sathi<br>Sativa Dangar<br>Sukhwel<br>Sutrasal<br>Taichun<br>Thumbati<br>Tulshya<br>Ubhi Dangar<br>Vardala<br>Vijalpuri |
| Pearl Millet |                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                    |
| Sorghum      | Deshi                                                                                                                                                                                                                                                                                                                                | Dhorki                                                                                                                                                                                                                                                                                                       | Gundri                                                                                                                                                                                                                                                                                                             |
| Sesame       | Bhanwari tilli                                                                                                                                                                                                                                                                                                                       | Dhili tilli                                                                                                                                                                                                                                                                                                  | Zhumak tilli                                                                                                                                                                                                                                                                                                       |
| Cotton       | Dhumad Kalvan<br>Vara                                                                                                                                                                                                                                                                                                                | Mathio<br>Waged                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                    |
| Ber          | Banarasi<br>Chhuahara<br>Chonchal<br>Dak<br>Daudan<br>Gola Kela<br>Kakrol<br>Ilaichi                                                                                                                                                                                                                                                 | Kaithali<br>Kalingada<br>Karava<br>Kara<br>Kathaphal<br>Sotai<br>Lasora                                                                                                                                                                                                                                      | Noki<br>Pathan<br>Porda<br>Rashmi<br>Sandhura Narnaul Seb<br>Umaran                                                                                                                                                                                                                                                |
| Lasora       | Desi Lesua                                                                                                                                                                                                                                                                                                                           | Lesu                                                                                                                                                                                                                                                                                                         | Pemali Lesua                                                                                                                                                                                                                                                                                                       |
| Cucumber     | Balam Kakadi                                                                                                                                                                                                                                                                                                                         | Balam Kheera                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                    |
| Chillies     | Bayana Local<br>Bilara Local<br>Ghumari Tikhi                                                                                                                                                                                                                                                                                        | Haripur Rati<br>Mathania Lambi<br>Mehasana Charkhun                                                                                                                                                                                                                                                          | Raipuri<br>Reshampatti<br>Tonkey Local                                                                                                                                                                                                                                                                             |
| Fenugreek    | Achar Maithidana<br>Dana Methi                                                                                                                                                                                                                                                                                                       | Nagouri Maithi                                                                                                                                                                                                                                                                                               | Nainaki Maithi                                                                                                                                                                                                                                                                                                     |

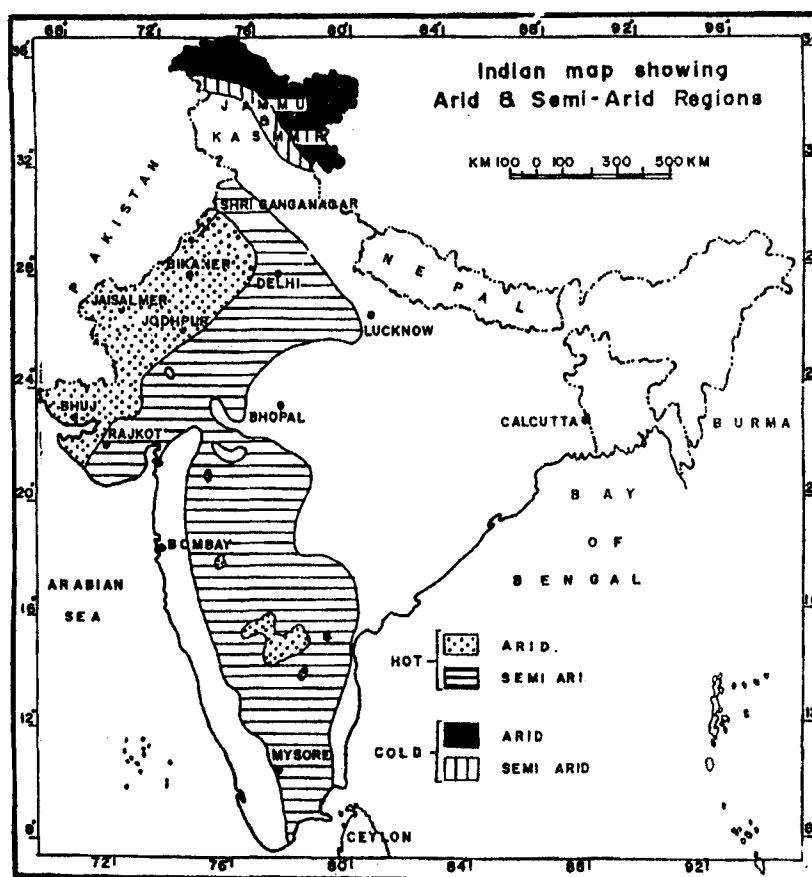


Fig. 1 Map of India showing arid and semi-arid regions

information on the samples collected. Local names, names of landraces, their uses, indigenous knowledge and role of women in the conservation of crop/plant species were also recorded. A wide range of variability has been recorded in the distribution, plant habit and type, canopy, earliness, bearing, size, shape and colour of leaves, flowers, fruits and seeds, weight of fruits and seeds etc. (Fig. 1).

**Wild relatives/wild species/weedy forms:** In all, 519 collections of various wild relatives/wild species/weedy forms were collected during these explorations and collection missions. Some of these are *Abelmoschus ficulneus*, *A. manihot*, *A. tetraphyllus*, *A. tuberculatus*, *Corchorus aestuans*, *C. depressus*, *C. fascicularis*, *C. tridens*, *C. trilocularis*, *C. urticaefolia*, *Cordia rothii*, *Crotolaria medicagenia*, *Cucumis callosus*, *C. hardwickii*, *C. hystrix*, *C. prophetarum*, *C. tridens*, *Diospyros montana*, *Luffa acutangula* var. *amara*, *L. hermaphrodita*, *Sesamum mulayanum*, *Solanum indicum*, *S. nigrum*, *S. saeforthianum*, *S. surattense*, *Tephrosia*

*purpuria*, *Vigna radiata* var. *sublobata*, *V. trilobata*, wild guar, wild pea etc.

Local/desi cultivars were preferred due to their desired traits/adaptability, nutritive value, better taste and higher fodder yield e.g. *Triticum durum*. *Cucurbits* viz.- *Citrullus vulgaris* var. *fistulosus*, *Cucumis callosus*, *C. melo* var. *argestris*, *C. melo* var. *momordica*, *C. hardwickii*, *C. sativus* and *Luffa hermaphrodita* are used as vegetables in various forms. Root extract of *C. prophetarum* for cure of earache and fruits to cows and buffaloes for conception. Taramira (*Eruca sativa*) makes soil poor and has allelopathic effects on subsequent crops. Its oil is edible and seed cakes are given to cattle for higher milk production. Dried flower of *Diospyros melanoxylon* are used to cure urinary and skin troubles, its fruits are edible. Seeds or seed cakes of *Hibiscus cannabinus* are mixed with guar, bajra etc. and fed to buffaloes for higher milk production and good quality ghee. Wild relatives/wild species of crop plant (*Corchorus* spp.; *Diospyros montana*, *Solanum*

*indicum*, *S. nigrum*, *S. saefortianum*, *S. surattense*, *Vigna radiata* var. *sublobata* etc.) have important role and value in the lives of village and tribal people (Dwivedi *et al.*, 1998). Ash of cow dung and neem leaves are in general used for storage besides keeping seeds intact (chick pea pods/maize cobs) or in straw (*Triticum* spp.) in air tight traditional vessels/containers.

The collected material with desirable traits may be used as a good source of breeding material to improve selected crops or may be used directly for human welfare.

### References

- Chandel KPS and DC Bhandari (1989) Collection of germplasm resources in northeastern Rajasthan. *Indian J. Plant Genet. Resour.* 2: 150-156.
- Chopra DP and DC Bhandari (1989) Plant Genetic Resources: Collection and promising introduction from arid and semi arid regions. *Indian J. Plant Genet. Resour.* 2: 60-63.
- Dwivedi NK and DC Bhandari (1995) Tumba (*Citrullus colocynthis* Schrad) variability in Rajasthan, India. *IPGRI Newslett. Asia, Pacific Oceania* 17: 14.
- Dwivedi NK and DC Bhandari (1996) Collecting cultivated and wild species of *Corchorus* in Gujarat, India. *Indian J. Plant Genet. Resour.* 9: 323-326.
- Dwivedi NK and DC Bhandari (1999) Collecting *Capsicum annum* L. germplasm in Rajasthan, India. *Plant Genetic Resources Newslett.* 119: 56-58.
- Dwivedi NK, DC Bhandari and TS Aghora (1994) Collecting pea germplasm from Rajasthan, India. *IPGRI Newslett. Asia, Pacific Oceania* 15:11.
- Dwivedi NK, DC Bhandari and SK Verma (1997) *Prosopis cineraria* (L.) Mac. Bride germplasm in western India. *IPGRI Newslett. Asia, Pacific Oceania* 22: 19.
- Dwivedi NK, DC Bhandari and Neelam Bhatnagar (1998) Collecting wild species of some crop plants from Aravalli hills, Rajasthan, India. *Indian J. Plant Genet. Resour.* 11: 41-48.

## Evaluation of Different Sucking Mango Strains Under Sub-Tropical Sub-Mountainous Tracts of Punjab

**WS Dhillon, RC Sharma\* and KS Bains\***

Department of Horticulture, Punjab Agricultural University, Ludhiana-141004, Punjab

**Key Words:** Mango, Evaluation, Fruit Variability, Juicy Mango

Apart from table purposes, mango is also known for sucking qualities. For sucking purposes, good proportion of juice content with favourable amount of TSS, acidity and fibre on the stone are the main criteria. Large variability exists in sucking mango varieties in India. Also in Punjab State, a great diversity in quality, shape and colour of sucking mangoes have been recorded. The quality as well as the flavour of the fruit varied greatly with the change in climatic and adaphic conditions. Some of the strains of sucking mangoes were evaluated for their performance under local conditions.

More than 60 strains of mango were collected from different sources and evaluated at Fruit Research Station, Gangian. The trees were of 21 years old and received uniform cultural practices. The stem girth and tree height was measured with the help of measuring tape. The

floral malformation was recorded in the month of April by counting the infected panicles and then the percentage was calculated from the total number of panicles on the tree. The fruit number was counted from the individual tree before the fruit harvest. The fruit yield was calculated by multiplying the fruit weight with the total number of fruits of the tree. The weight of the fruit, peel and stone was measured on pan balance. The peel and stone weight was subtracted from the total weight of the fruit to calculate the juice content. The fruits were analysed for TSS and acidity as per standard procedure of A.O.A.C. (1980).

The data presented in Table 1 revealed that the strain GN<sub>1</sub> was the most vigorous which recorded stem girth of 125 cm and tree height of 8.0 m. However, the maximum (128 cm) stem girth was noted in GN<sub>12</sub>. But, the lowest (94 cm) stem girth and tree height (5.5 m) was recorded in GN<sub>2</sub>. Ramasowamy (1989) also reported great variation in growth parameters in mango cultivars.

\*Regional Fruit Research Station, Gangian (Dasuya), Hoshiarpur, Punjab

*indicum*, *S. nigrum*, *S. saefortianum*, *S. surattense*, *Vigna radiata* var. *sublobata* etc.) have important role and value in the lives of village and tribal people (Dwivedi *et al.*, 1998). Ash of cow dung and neem leaves are in general used for storage besides keeping seeds intact (chick pea pods/maize cobs) or in straw (*Triticum* spp.) in air tight traditional vessels/containers.

The collected material with desirable traits may be used as a good source of breeding material to improve selected crops or may be used directly for human welfare.

### References

- Chandel KPS and DC Bhandari (1989) Collection of germplasm resources in northeastern Rajasthan. *Indian J. Plant Genet. Resour.* 2: 150-156.
- Chopra DP and DC Bhandari (1989) Plant Genetic Resources: Collection and promising introduction from arid and semi arid regions. *Indian J. Plant Genet. Resour.* 2: 60-63.
- Dwivedi NK and DC Bhandari (1995) Tumba (*Citrullus colocynthis* Schrad) variability in Rajasthan, India. *IPGRI Newslett. Asia, Pacific Oceania* 17: 14.
- Dwivedi NK and DC Bhandari (1996) Collecting cultivated and wild species of *Corchorus* in Gujarat, India. *Indian J. Plant Genet. Resour.* 9: 323-326.
- Dwivedi NK and DC Bhandari (1999) Collecting *Capsicum annum* L. germplasm in Rajasthan, India. *Plant Genetic Resources Newslett.* 119: 56-58.
- Dwivedi NK, DC Bhandari and TS Aghora (1994) Collecting pea germplasm from Rajasthan, India. *IPGRI Newslett. Asia, Pacific Oceania* 15:11.
- Dwivedi NK, DC Bhandari and SK Verma (1997) *Prosopis cineraria* (L.) Mac. Bride germplasm in western India. *IPGRI Newslett. Asia, Pacific Oceania* 22: 19.
- Dwivedi NK, DC Bhandari and Neelam Bhatnagar (1998) Collecting wild species of some crop plants from Aravalli hills, Rajasthan, India. *Indian J. Plant Genet. Resour.* 11: 41-48.

## Evaluation of Different Sucking Mango Strains Under Sub-Tropical Sub-Mountainous Tracts of Punjab

**WS Dhillon, RC Sharma\* and KS Bains\***

Department of Horticulture, Punjab Agricultural University, Ludhiana-141004, Punjab

**Key Words:** Mango, Evaluation, Fruit Variability, Juicy Mango

Apart from table purposes, mango is also known for sucking qualities. For sucking purposes, good proportion of juice content with favourable amount of TSS, acidity and fibre on the stone are the main criteria. Large variability exists in sucking mango varieties in India. Also in Punjab State, a great diversity in quality, shape and colour of sucking mangoes have been recorded. The quality as well as the flavour of the fruit varied greatly with the change in climatic and adaphic conditions. Some of the strains of sucking mangoes were evaluated for their performance under local conditions.

More than 60 strains of mango were collected from different sources and evaluated at Fruit Research Station, Gangian. The trees were of 21 years old and received uniform cultural practices. The stem girth and tree height was measured with the help of measuring tape. The

floral malformation was recorded in the month of April by counting the infected panicles and then the percentage was calculated from the total number of panicles on the tree. The fruit number was counted from the individual tree before the fruit harvest. The fruit yield was calculated by multiplying the fruit weight with the total number of fruits of the tree. The weight of the fruit, peel and stone was measured on pan balance. The peel and stone weight was subtracted from the total weight of the fruit to calculate the juice content. The fruits were analysed for TSS and acidity as per standard procedure of A.O.A.C. (1980).

The data presented in Table 1 revealed that the strain GN<sub>1</sub> was the most vigorous which recorded stem girth of 125 cm and tree height of 8.0 m. However, the maximum (128 cm) stem girth was noted in GN<sub>12</sub>. But, the lowest (94 cm) stem girth and tree height (5.5 m) was recorded in GN<sub>2</sub>. Ramasowamy (1989) also reported great variation in growth parameters in mango cultivars.

\*Regional Fruit Research Station, Gangian (Dasuya), Hoshiarpur, Punjab

The floral malformation in different strains was calculated between 3.0% in GN<sub>3</sub> to 38.0% in GN<sub>4</sub>. This shows that level of resistance exists in different mango strains against this disorder.

The GN<sub>3</sub> produced maximum (643) number of fruits/tree followed by 599 in GN<sub>19</sub> and 537 in GN<sub>1</sub>. The minimum (325) number of fruits were counted in GN<sub>2</sub>. However, the heaviest fruit of 203 g was weighed in GN<sub>6</sub> and minimum of 81 g in GN<sub>1</sub>. But, GN<sub>19</sub> was recorded to be the highest yielder with an average yield of 112.0 kg/tree followed by 109.2 kg in GN<sub>3</sub>. The GN<sub>2</sub> was the lowest (41.6 kg) yielder. The heaviest stone of 51.0 g was recorded in GN<sub>6</sub> followed by 43.5 g in GN<sub>19</sub>. The smallest stone with an average weight of 23.0 g, however, was recorded in GN<sub>1</sub>. The peel weight of the fruit was noted to be minimum (11.2 g) in GN<sub>1</sub> and maximum (45.0 g) in GN<sub>6</sub>. The juice content of the fruit ranged between 46.0 ml/fruit in GN<sub>1</sub> to 107.0 ml in GN<sub>6</sub>. The second highest juice content of 105.1 ml was recorded in GN<sub>12</sub> followed

by 103.0 ml in GN<sub>19</sub>. The high proportion of juice content in these strains attributed to lower peel and stone weight recorded in proportion to the total fruit weight.

The TSS of as high as 20.4% was recorded in GN<sub>12</sub> followed by GN<sub>3</sub> (20.2%) and GN<sub>19</sub> (19.5%). The lowest (14.8%) TSS was noted in GN<sub>6</sub>. The juice of GN<sub>6</sub> and GN<sub>2</sub> contained the highest (0.65%) and lowest (0.38%) acid content, respectively. The literature pertaining to physico-chemical characteristic variation in sucking mangoes is lacking but many workers have reported great variability in table mangoes (Deshmukh and Budrukhar, 1989 and Katrodia *et al.*, 1989). The GN<sub>19</sub> was the earliest (1<sup>st</sup> fortnight of July) and GN<sub>3</sub> was the last (end of August) to mature. The fibre on the stone was absent in GN<sub>1</sub> and GN<sub>5</sub>, while the others had medium to heavy fibre content. The fruit colour was green in GN<sub>1</sub>, sindhuri in GN<sub>2</sub>, light yellow in GN<sub>3</sub> and GN<sub>4</sub>, yellow with red blush in GN<sub>5</sub>, highly coloured in GN<sub>6</sub>, green yellow in GN<sub>7</sub>, yellowish green in GN<sub>12</sub> and sindhuri blush at shoulder with yellow base

**Table 1. Performance of some sucking mango selections**

| Characters              | Sucking mango selections |                    |                  |                    |                       |                     |                     |                     |                                             | C.D. at 5% |
|-------------------------|--------------------------|--------------------|------------------|--------------------|-----------------------|---------------------|---------------------|---------------------|---------------------------------------------|------------|
|                         | GN <sub>1</sub>          | GN <sub>2</sub>    | GN <sub>3</sub>  | GN <sub>4</sub>    | GN <sub>5</sub>       | GN <sub>6</sub>     | GN <sub>7</sub>     | GN <sub>12</sub>    | GN <sub>19</sub>                            |            |
| Stem girth (cm)         | 125                      | 90                 | 117              | 113                | 123                   | 120                 | 114                 | 128                 | 102                                         | 14.3       |
| Tree height (m)         | 8.0                      | 5.8                | 7.2              | 7.3                | 7.3                   | 7.2                 | 7.4                 | 7.6                 | 7.0                                         | N.S.       |
| Floral malformation (%) | 15.2                     | 38.0               | 3.0              | 38.0               | 19.3                  | 14.6                | 26.3                | 29.0                | 18.0                                        | 22.2       |
| Fruit number/tree       | 537                      | 325                | 643              | 389                | 503                   | 387                 | 338                 | 353                 | 599                                         | 33.3       |
| Fruit yield (kg/tree)   | 43.5                     | 41.6               | 109.2            | 65.0               | 61.9                  | 78.5                | 43.0                | 66.0                | 112.0                                       | 11.4       |
| Fruit weight (g)        | 81                       | 124                | 149              | 167                | 123                   | 203                 | 127                 | 170                 | 160                                         | 18.3       |
| Peel weight (g)         | 11.2                     | 20.4               | 19.3             | 27.1               | 19.6                  | 45.0                | 19.3                | 24.7                | 40.5                                        | 0.18       |
| Stone weight (g)        | 23.0                     | 27.0               | 34.0             | 37.0               | 30.5                  | 51.0                | 33.3                | 40.2                | 27.0                                        | 2.30       |
| Juice content (ml)      | 46.8                     | 76.6               | 95.7             | 102.9              | 72.9                  | 107.0               | 74.4                | 105.1               | 103.0                                       | 14.1       |
| TSS (%)                 | 18.3                     | 18.3               | 20.2             | 18.0               | 18.9                  | 14.8                | 19.5                | 18.7                | 20.4                                        | 1.59       |
| Acidity (%)             | 0.40                     | 0.38               | 0.43             | 0.60               | 0.50                  | 0.65                | 0.42                | 0.50                | 0.51                                        | N.S.       |
| Maturity time           | Second week of July      | Third week of July | End of August    | Third week of July | First week of August  | Second week of July | Second week of July | Fourth week of July | First fortnight of July                     | —          |
| Fibreless               | Absent                   | Fibrous all over   | Sparsely fibrous | Sparsely fibrous   | Absent                | Fibrous all over    | Fibrous             | Fibrous all over    | Medium                                      | —          |
| Fruit colour            | Green                    | Sindhuri           | Light yellow     | Light yellow       | Yellow with red blush | Highly coloured     | Green yellow        | Yellowish green     | Sindhuri blush at shoulder with yellow base | —          |
| Fruit shape             | Ovate                    | Oblong             | Ovate            | Ovate oblong       | Ovate                 | Oblong              | Oblong              | Oblong              | Ovate oblong                                | —          |
| Flavour                 | Good                     | Pleasant           | Pleasant         | Pleasant           | Pleasant              | Pleasant            | Good                | Pleasant            | Pleasant                                    | —          |

NS = Non significant

in GN<sub>19</sub>. The fruit shape was ovate in GN<sub>1</sub>, GN<sub>3</sub> and GN<sub>5</sub>, oblong in GN<sub>2</sub>, GN<sub>6</sub>, GN<sub>7</sub> and GN<sub>12</sub> and ovate oblong in GN<sub>4</sub> and GN<sub>19</sub>. The flavour of the fruit was good in GN<sub>1</sub> and GN<sub>7</sub> and pleasant in the remaining strains. Overall, GN<sub>3</sub>, GN<sub>5</sub>, GN<sub>12</sub> and GN<sub>19</sub> have shown promise under the local conditions.

### References

A.O.A.C. (1980) Official and tentative methods of analysis. 13<sup>th</sup> Ed. Washington, DC, USA.

Deshmukh PA and ND Budrukhar (1989) Promising mango selections from Himayat Bag. *Acta Horticulture* 231: 97-99.

Katrodia JS, HP Bhura and GL Patel (1989) Yield and quality performance of mango germplasm under South Gujarat conditions. *Acta Horticulturae* 231: 121-124.

Ramaswamy N (1989) Survey and isolation of plus trees of mango. *Acta Horticulturae* 231: 93-96.

## Evaluation of *Sesbania* Germplasm for Some Green Manuring Traits

**Vimal Prakash, Deepti Rai, Vandana Joshi, Hanuman Lal, S Sardana and GD Sharma**

National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012

**Key words:** *Sesbania*, Green Manuring, Nodules, Biomass

*Sesbania* popularly known as *dhaincha* is the most common green manuring crop in the tropical cropping system. It belongs to family Leguminosae and sub-family Papilionaceae. It is a large genus, comprises of about 24 species distributed all over the tropics of the world. *Sesbania aculeata* (*S. bispinosa*) is the most common among them in India. *Sesbania rostrata*, a species endemic to West Africa possesses nitrogen-fixing nodules on the stem in addition to root nodules. Potential of *Sesbania* as green manure crop has been demonstrated by many workers (Rinaudo *et al.*, 1983; Abrol and Palaniappan, 1988; Ramani *et al.*, 1990; Joshua *et al.*, 1992; Ladha *et al.*, 1993). There is a great need to develop suitable varieties of *Sesbania* which can fit well in different cropping system. Importance of germplasm in crop improvement is well recognized, therefore, present study has been undertaken to evaluate and characterize the 23 accessions of *Sesbania* germplasm for some green manuring traits.

A total of 23 accessions of *Sesbania* comprising nine accessions of *S. rostrata* and 14 accessions of *S. aculeata* were grown during *Kharif* season of 2000 at six locations viz. New Delhi, Hisar, Pantnagar, Faizabad, Modipuram, and Samastipur. The entries were sown in a randomized block design having three replications. Each plot consisted of 4 m<sup>2</sup> area with row to row spacing of 45 cm and plant to plant 15 cm. The recommended agronomic practices were followed to raise a good crop. The observations were recorded on green manuring traits like plant height, nodules/plant, weight of nodules/plant and green biomass at 45 days of sowing (45 DAS) and other agro-morphological traits like pods/plant, 100-seed weight and seed yield/plant.

Among two species studied, *S. rostrata* (EC178342, EC213472, EC-95553, EC218472, EC223312, 250626, EC331970 and EC331973) possessed nodules on the stem. Wide variability was recorded in number and size of aerial nodules. Highest number of nodules was

**Table 1. List of exotic and indigenous germplasm of *Sesbania***

| Place of collection/country of introduction                                                       | Accession numbers                                                                                                                                        |
|---------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| IRRI, Philippines                                                                                 | EC-331970, EC-331973, EC-95553 EC-218472, EC-223312, EC-250626, EC-178342, EC-213473, EC-213472A                                                         |
| India: Punjab, Himachal Pradesh, Uttaranchal, U.P., Haryana, Gujarat, Bihar, Karnataka, New Delhi | IC-75624, IC-277782, IC-277783 IC-277784, IC-277785, IC-277786, IC-277787, IC-277788, IC-277789, IC-277790, IC-277793 IC-277795 IC-277791, Pant sesbania |

in GN<sub>19</sub>. The fruit shape was ovate in GN<sub>1</sub>, GN<sub>3</sub> and GN<sub>5</sub>, oblong in GN<sub>2</sub>, GN<sub>6</sub>, GN<sub>7</sub> and GN<sub>12</sub> and ovate oblong in GN<sub>4</sub> and GN<sub>19</sub>. The flavour of the fruit was good in GN<sub>1</sub> and GN<sub>7</sub> and pleasant in the remaining strains. Overall, GN<sub>3</sub>, GN<sub>5</sub>, GN<sub>12</sub> and GN<sub>19</sub> have shown promise under the local conditions.

#### References

A.O.A.C. (1980) Official and tentative methods of analysis. 13<sup>th</sup> Ed. Washington, DC, USA.

Deshmukh PA and ND Budrukhar (1989) Promising mango selections from Himayat Bag. *Acta Horticulture* 231: 97-99.

Katrodia JS, HP Bhura and GL Patel (1989) Yield and quality performance of mango germplasm under South Gujarat conditions. *Acta Horticulturae* 231: 121-124.

Ramaswamy N (1989) Survey and isolation of plus trees of mango. *Acta Horticulturae* 231: 93-96.

## Evaluation of *Sesbania* Germplasm for Some Green Manuring Traits

**Vimal Prakash, Deepti Rai, Vandana Joshi, Hanuman Lal, S Sardana and GD Sharma**

National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012

**Key words:** *Sesbania*, Green Manuring, Nodules, Biomass

*Sesbania* popularly known as *dhaincha* is the most common green manuring crop in the tropical cropping system. It belongs to family Leguminosae and sub-family Papilionaceae. It is a large genus, comprises of about 24 species distributed all over the tropics of the world. *Sesbania aculeata* (*S. bispinosa*) is the most common among them in India. *Sesbania rostrata*, a species endemic to West Africa possesses nitrogen-fixing nodules on the stem in addition to root nodules. Potential of *Sesbania* as green manure crop has been demonstrated by many workers (Rinaudo *et al.*, 1983; Abrol and Palaniappan, 1988; Ramani *et al.*, 1990; Joshua *et al.*, 1992; Ladha *et al.*, 1993). There is a great need to develop suitable varieties of *Sesbania* which can fit well in different cropping system. Importance of germplasm in crop improvement is well recognized, therefore, present study has been undertaken to evaluate and characterize the 23 accessions of *Sesbania* germplasm for some green manuring traits.

A total of 23 accessions of *Sesbania* comprising nine accessions of *S. rostrata* and 14 accessions of *S. aculeata* were grown during *Kharif* season of 2000 at six locations viz. New Delhi, Hisar, Pantnagar, Faizabad, Modipuram, and Samastipur. The entries were sown in a randomized block design having three replications. Each plot consisted of 4 m<sup>2</sup> area with row to row spacing of 45 cm and plant to plant 15 cm. The recommended agronomic practices were followed to raise a good crop. The observations were recorded on green manuring traits like plant height, nodules/plant, weight of nodules/plant and green biomass at 45 days of sowing (45 DAS) and other agro-morphological traits like pods/plant, 100-seed weight and seed yield/plant.

Among two species studied, *S. rostrata* (EC178342, EC213472, EC-95553, EC218472, EC223312, 250626, EC331970 and EC331973) possessed nodules on the stem. Wide variability was recorded in number and size of aerial nodules. Highest number of nodules was

**Table 1. List of exotic and indigenous germplasm of *Sesbania***

| Place of collection/country of introduction                                                       | Accession numbers                                                                                                                                        |
|---------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| IRRI, Philippines                                                                                 | EC-331970, EC-331973, EC-95553 EC-218472, EC-223312, EC-250626, EC-178342, EC-213473, EC-213472A                                                         |
| India: Punjab, Himachal Pradesh, Uttaranchal, U.P., Haryana, Gujarat, Bihar, Karnataka, New Delhi | IC-75624, IC-277782, IC-277783 IC-277784, IC-277785, IC-277786, IC-277787, IC-277788, IC-277789, IC-277790, IC-277793 IC-277795 IC-277791, Pant sesbania |

observed in EC-178342 closely followed by EC-218472. Plants having stem nodules had a lower number of root nodules.

Wide range and high coefficient of variability in number of root nodules/plant (24.07-73.82) and weight of root nodules/plant (137.50-266.90 mg/plant) indicated that further selection could improve the genotypes for these traits. IC-277787 possessed the highest number of nodules/plant while green biomass was maximum in IC-277782 followed by IC-277783.

Plant vigour and fresh weight are direct indicator of biomass accumulation. Moderate coefficient of variability was observed in plant height and green biomass, which suggested that there is scope for improvement of these traits. High plant vigour coupled with high plant height at 45 DAS was observed in EC-213472A and highest weight of nodules/plant was found in IC-277788.

**Table 2. Mean, range and coefficient of variation (CV%) for some green manuring traits in *Sesbania***

| Characters                              | Mean   | Range         | CV%   |
|-----------------------------------------|--------|---------------|-------|
| No. of nodules/plant at 45 DAS*         | 47.22  | 24.07-73.82   | 29.78 |
| Weight of nodules (mg/plant) at 45 DAS* | 814.15 | 137.50-266.90 | 71.33 |
| Plant height (cm) at 45 DAS             | 79.93  | 58.17-102.60  | 18.37 |
| Green weight/plant (g) (45 DAS)*        | 68.08  | 43.75-102.00  | 23.02 |
| No. of pods/plant                       | 99.55  | 62.00-140.47  | 23.25 |
| Seed yield/plant (g)                    | 38.82  | 23.51-59.86   | 22.00 |
| 100-Seed weight (g)                     | 1.88   | 1.57-2.20     | 10.28 |

\* DAS – Days after sowing

Green biomass at 45 DAS showed high variability (58.17-102.60 g/plant). Yield and yield contributing traits like number of pods/plant (62.00-140.47), 100 seed weight (1.57-2.20g) and yield per plant (23.51-59.86g) showed medium to high co-efficient of variability, indicated that there is some scope for selection of these characters. High number of pods and seed yield/plant was found in IC-277787 and 100-seed weight in IC-277795.

In the present study, high to moderate variation was observed for number and weight of nodules, green biomass and yield contributing characters and thus further selections may be made to improve these traits. The accessions possessing desirable green manuring traits may be utilized for developing varieties through direct selection or through breeding programmes.

## References

- Rinaudo G, B Dreyfus and YR Dommergues (1983) Influence of *Sesbania rostrata* green manure on the nitrogen content of rice crop and soil. *Soil* 15: 111-113.
- Abrol IP and SP Palaniappan (1988) Green manure crops in irrigated and rainfed lowland rice based cropping system in South Asia. In: *Sustainable Agriculture-Green manure in Rice Farming*, Intl. Rice Res. Inst., Manila, Philippines, pp 71-82.
- Ramani Saradha, MS Shaikh. and DC Joshua (1990) Nodulation, biomass and nitrogen content in *Sesbania* species. *Plant and Soil* 128: 221-223.
- Joshua DC, S Ramani, E Suareg and MS Shaikh (1992) Growth, stem nodulation and nitrogen content of *Sesbania rostrata* plants treated with different rates of urea. *J. Plant Nutr.* 15: 1353-1358.
- Ladha JK, Padre Tiral, K Reddy and W Ventura (1993) Prospects and problems of biological nitrogen fixation in rice production. In: R Palacios (ed.) *New Horizons in Nitrogen Fixation*, Kluwer Academic Publ., The Netherlands, pp 677-682.

## Genetic Variability in Asiatic Radish

**B Singh, Sudhakar Pandey, G Kalloo and MK Banerjee**

Indian Institute of Vegetable Research, 1, Gandhinagar Naira PB 5002, Varanasi-221005, Uttar Pradesh

**Key Words:** Genetic Variability, *Raphanus sativus*, Asiatic Radish

Radish (*Raphanus sativus* L.) is an important root vegetable grown for its enlarged fleshy roots and tender foliage. Due to high yielding and early maturing nature, it can be easily fit in different cropping systems to get higher returns/unit area. A wide range of variability is available for root and shoot growth characters in radish, which may be utilized for its genetic improvement. Genetic improvement of crop is largely depending on the magnitude of genetic variability and the extent to which desirable traits are heritable. Broad base genetic diversity in the materials has more chances to obtain desired gene, which is great importance to the plant breeders. Earlier workers Lal and Shrivastava (1975) reported high phenotypic and genotypic variability, heritability and genetic advance by utilizing few lines. The success of phenotypic selection depends upon the nature of genetic diversity present in the population. Further partitioning of this variability into heritable and non-heritable component enables to know the effectiveness of selection. Therefore, an attempt was made in the present investigation to estimate the extent of variability, heritability and genetic advance by utilizing fifty-five divergent lines of tropical radish.

The experiment was carried out at the experimental farm, IIVR, Varanasi during *kharif* and *rabi* season, 1998-99. Fifty-five divergent genotypes (lines) were grown in randomized block design with three replication in *kharif* and *rabi* season. All the cultural practices and

fertilizers were given as per recommendation for proper growth and stand of the crop as and when required. The observations were recorded on five randomly selected plants on different characters viz.- plant height (cm), number of leaves/plant, leaf weight/plant (g), leaf length (cm), root length (cm), root diameter (cm), root weight (g) and root: leaf weight ratio. Data were statistically analyzed as suggested by Panse and Sukhatme (1967).

Statistical analysis revealed highly significant differences among the lines for all the characters in both seasons. EC 339790 and local land races were found promising during *kharif* and NIC-7215 and IIVR-1 during *rabi* season for most of the leaf and root growth parameters (Table 1). Root length was found highest in C-2 (22.67cm) followed by IIVR-1 (22.07cm) during *kharif* season and Mooli Early (32.27 cm) followed by IIVR-1 (32.53cm) during *rabi* season. Root: leaf weight ratio was noticed maximum in RH-7 (2.61) followed by NKD-19 (2.14) during *kharif* season and in Sungro Chetki (2.96) followed by Pusa Chetki (152) during *rabi* season. Genotypic and phenotypic coefficient of variation were maximum in leaf weight (36.67 and 45.58g) followed by root weight (34.67 and 38.38g) and root: leaf weight ratio (30.50 and 38.21) during *kharif* season, whereas, root: leaf weight ratio was found to be maximum (30.71 and 40.07) followed by leaf weight (28.82 and 34.30g) and root weight (26.58 and 32.47g) during *rabi* season, respectively. Some of the

**Table 1. Promising accessions identified in Asiatic radish**

| Characters              | Promising accessions                   |                                                        |
|-------------------------|----------------------------------------|--------------------------------------------------------|
|                         | <i>Kharif</i>                          | <i>Rabi</i>                                            |
| Plant height (cm)       | EC-339790, IIVR-1, C-2                 | NIC-7215, Ambala Local, IIVR-1                         |
| No. of leaves/plant     | RH-16, RH-17, Khari Local              | NKD-19, IIVR-3, NIC-72                                 |
| Leaf weight/plant (g)   | EC-339790, R.L. Local, Local-6         | NIC-7215, Local Collection-4, NKD-19                   |
| Leaf length (cm)        | EC-339790, Local-2, Local Collection-5 | NIC-7215, Jaunpuri Local, IIVR-1                       |
| Root length (cm)        | C-2, IIVR-1, EC-11705                  | Mooli Early, IIVR-1, SN-737                            |
| Root diameter (cm)      | Chinese Pink, EC-339790, Local-6       | Local Collection-4, Local Collection-3, Ambala Local-2 |
| Root weight (g)         | Local-6, R.L. Local, EC-339790         | Punjab Safed, NIC-7215, NKD-19                         |
| Root: leaf weight ratio | RH-7, NKD-119, Mooli Lal Bombay        | Sungro Chetki, SN-327, Pusa Chetki                     |

**Table 2. Mean performance and genetic parameters for quantitative characters**

| Characters              | Season | Statistical parameter |        |        |       |                     |                            |                          |            |
|-------------------------|--------|-----------------------|--------|--------|-------|---------------------|----------------------------|--------------------------|------------|
|                         |        | Mean                  | Max.   | Min.   | ± SE  | Genetic advance (%) | Heritability (broad sense) | Coefficient of variation |            |
|                         |        |                       |        |        |       |                     |                            | Genotypic                | Phenotypic |
| Plant height (cm)       | Kharif | 49.77                 | 68.80  | 32.67  | 2.68  | 16.75               | 87.50                      | 17.47                    | 18.68      |
|                         | Rabi   | 71.19                 | 82.27  | 54.93  | 2.53  | 11.05               | 79.10                      | 8.47                     | 9.53       |
| Number of leaves/plant  | Kharif | 13.22                 | 20.80  | 10.47  | 1.86  | 2.04                | 34.90                      | 12.65                    | 21.41      |
|                         | Rabi   | 13.08                 | 16.20  | 9.73   | 1.23  | 1.22                | 32.30                      | 8.00                     | 14.00      |
| Leaf weight/plant (g)   | Kharif | 105.53                | 223.33 | 32.67  | 14.95 | 71.89               | 81.60                      | 36.67                    | 40.58      |
|                         | Rabi   | 205.21                | 328.33 | 93.33  | 31.17 | 102.32              | 70.60                      | 28.82                    | 34.30      |
| Leaf length (cm)        | Kharif | 34.17                 | 50.07  | 20.00  | 3.16  | 10.03               | 69.80                      | 17.05                    | 20.42      |
|                         | Rabi   | 49.29                 | 53.27  | 28.13  | 2.46  | 9.80                | 76.50                      | 12.56                    | 14.36      |
| Root length (cm)        | Kharif | 15.54                 | 22.67  | 9.93   | 2.07  | 4.13                | 53.20                      | 17.60                    | 24.01      |
|                         | Rabi   | 22.84                 | 34.27  | 21.80  | 2.40  | 2.53                | 33.90                      | 7.58                     | 13.02      |
| Root diameter (cm)      | Kharif | 2.98                  | 4.32   | 2.31   | 0.33  | 0.55                | 47.20                      | 12.93                    | 18.81      |
|                         | Rabi   | 3.81                  | 4.61   | 3.05   | 0.33  | 0.41                | 38.40                      | 8.42                     | 13.58      |
| Root weight (g)         | Kharif | 109.09                | 223.67 | 50.33  | 14.75 | 70.30               | 81.40                      | 34.67                    | 38.38      |
|                         | Rabi   | 232.64                | 370.00 | 128.00 | 35.69 | 103.50              | 66.50                      | 26.48                    | 32.47      |
| Root: leaf weight ratio | Kharif | 1.12                  | 2.61   | 0.61   | 0.21  | 0.56                | 63.80                      | 30.50                    | 38.21      |
|                         | Rabi   | 1.21                  | 2.96   | 0.75   | 0.25  | 0.59                | 58.70                      | 30.71                    | 40.07      |

characters namely, number of leaves, root length, and root diameter were found to be more influenced by environmental factors. The characters such as leaf weight, root weight and root: leaf weight ratio has shown wider range of variability and high co-variance, therefore, indicating an ample scope for effective improvement in these characters. Other characters with low coefficient of variation are indication of less scope of selection. Similar results were reported by Pandey *et al.*, (1981). The estimate of heritability (broad sense) expected genetic advance as percent of mean have been presented in Table 2. The high heritability was recorded for plant height (87.50 and 79.10 cm) followed by leaf weight (81.60 and 70.60 g), root weight (81.40 and 66.50 g) and root: leaf weight ratio (63.80 and 58.70) and lowest for number of leaves (34.90 and 32.30) in both the season. The character which exhibited high heritability suggested that the selection will be more effective, whereas the character showing low heritability, indicated that the selection will be difficult as the expression of genotypes will be affected by the environmental factors (Arumugam and Muth Krishnan, 1975). High heritability estimates in conjunction with high genetic advance is

more useful than heritability alone in predicting the results and for selecting the best individual. Leaf weight and root weight exhibited high genetic advance as percent of mean (>70%) along with high heritability. This situation might have occurred due to additive gene action. The remaining characters suggested that it might not be possible to bring about a considerable improvement in such character through selection. These results are in agreement with the findings of Sirohi and Kutty (2000).

## References

- Arumugam R and Muthu Krishnan CR (1975) Genetic variability in some quantitative characters of radish *Indian J. Hortic.* **32**: 179-181.
- Lal S and Srivastava JP (1975) Heritability and genetic advance for root and fruit characters in radish. *Indian J. Hortic.* **32**: 99-93.
- Panse VG and Sukhatme PV (1967) *Statistical Method for Agricultural Research Workers*. ICAR, New Delhi.
- Pandey SC Pandita ML and Dixit J (1981) Genetics of yield and yield contributing characters in radish. *Haryana Agric. Univ. J. Res.* **11**: 384-388.
- Sirohi PS and Kutty C Narayanan (2000) Genetic analysis of yield and its components in radish. *Veg. Sci.* **27**: 142-144.

## *In vitro* Multiplication and Conservation of Wild *Arachis* Germplasm

K Chandran, K Rajgopal, T Radhakrishnan and HB Lalwani

National Research Centre for Groundnut, PO Box 5, Junagadh-362001, Gujrat

**Key Words:** *Arachis*, Conservation, Tissue culture, Wild species

With the receding genetic barriers among species because of biotechnological developments the possibilities of utilizing genes from wild alien species of a crop has become much higher. In groundnut, wild species of *Arachis* are potential sources of resistance to various pest and diseases and are being utilized in crop improvement programmes. Maintenance of germplasm of wild relative in groundnut is difficult because they produce either a few or no seeds (Stalker and Simpson, 1995). Sometimes poor seed viability under storage condition is a major problem in maintenance of an accession. Further, many species are perennials and as such the field gene banks are continuously exposed to the vagaries of environment including diseases. Micropropagation in these species will have the advantages of fast multiplication without genetic contamination, freedom from seed-borne diseases and ease in transportability and exchange. *In vitro* conservation of these propagules can be an alternative method of preservation of these germplasms. The prerequisite for *in vitro* conservation is standardization of *in vitro* regeneration system without callus formation and standardization of culture media with prolonged sub-culturing intervals. Micropropagation in cultivated groundnut using various explants and a few wild species has been reported (Radhakrishnan *et al.* 2000, Rani and Reddy, 1996, Venkatachalam *et al.* 1999). Most of the regeneration studies with the wild species have been through indirect method from immature leaf and embryo axes and cotyledonary segments (Still *et al.*, 1987, Mansur *et al.*, 1993) which is believed to induce somaclonal variation and cannot be used for multiplication and conservation of germplasm lines. Recently Gagliardi *et al.* (2000) has reported direct regeneration from different explants of wild species of the section *extranervosae* to tackle the problem of seed viability under storage. The present study reports the *in vitro* regeneration potential of *Arachis* species through direct multiple shoot induction from de-embryonated cotyledons and protocols for slow growth *in vitro* conservation.

Sixteen accessions belonging to nine of *Arachis* species of the sections *Arachis*, and *erectoides* were

studied. The procedure for surface sterilization of seeds and dissection of explants was followed as reported earlier (Radhakrishnan *et al.* 2000). The de-embryonated cotyledons cultured in MS medium with vitamins of B<sub>5</sub> medium. The basal medium was supplemented with one of the three level of BA viz.- 5 mg/l (MS1), 10 mg/l (MS2) and 15 mg/l (MS3). Magenta boxes were used as culture vessels. Fifty ml of culture media was dispensed in three boxes constituted each replication. Two explants were cultured in each box in two replications for each treatment. The number of responding cultures and number of shoots/explants were recorded after 30 days in culture under 4000 lux illumination and 26 ± 1°C. For further multiplication of shoots the portion of the explants bearing the shoots were dissected and cultured in the respective media at an interval of 21 days. The individual shoots were subcultured the basal medium for reducing the effect of cytokinin on to for 1 week and rooted in basal medium containing 1mg/l NAA and 1g/l activated charcoal.

Multiple shoots induced from the de-embryonated cotyledons of *A. monticola*, *A. duranensis*, *A. correntina* and *A. kempff-mercadoi* from the earlier experiment were used for *in vitro* conservation studies. Shoots were cultured on different media listed below:

1. MS+ 5mg/l BA + 30 g/l Sucrose
2. MS+ 5mg/l BA + 30 g/l Sucrose + 2 mg/l ABA
3. MS+ 5mg/l BA + 30 g/l Sucrose + 2% (w/v) Mannitol
4. MS+ 5mg/l BA + 30 g/l Sucrose + 2% (w/v) Mannitol + 2 mg/l ABA
5. MS+ 5mg/l BA + 30 g/l Sucrose + 4% (w/v) Mannitol
6. MS+ 5mg/l BA + 30 g/l Sucrose + 4% (w/v) Mannitol + 2 mg/l ABA

Culturing was done in test-tubes with 15 ml medium and incubated at 4000 lux illumination and 26 ± 0°C of 16 hrs photoperiod. Two to three shoots were

cultured in each of 20 tubes, which constitute one treatment. All experiments replicated twice. Shoots from three tubes/replication were harvested at an interval of 20 days and shoot length, fresh weight and dry weight were recorded until the shoots started drying.

Cotyledons were enlarged and turned green in culture and multiple shoots were mostly emerged from the proximal ends of the cotyledons without callus formation as reported earlier for cultivated species (Radhakrishnan *et al.* 2000). Though Gagliardi *et al.* (2000) reported the regeneration of shoots from several regions of the cotyledons, in our study callusing was associated with the shoot buds regenerating from the parts of the cotyledons other than the proximal ends. Significant variability was observed among the three media in multiple shoot induction ( $P=0.05$ ). All the accessions produced multiple shoots in MS1 and the response ranged from 10% (ICG 8201 and ICG 8198) to 82% (ICG 8205). Only 11 accessions responded in MS 2 with response ranging from 17% (ICG 8208) to 68% (ICG 8918). In MS3 medium only 12 accessions responded with a range of response of only 11 to 50%. The variability among genotypes for response to induction was also significant ( $P=0.01$ ). However, the interaction between genotypes and media combinations was not significant. Variation of shoots/responsive explant was significant among the genotypes but variation among three media was not significant. The interaction between the genotype and media was significant. The maximum number 10.5 shoots/explant was in *A. oteroi*. *A. oteroi* showed the maximum number of shoots/explant followed by *A. duranensis* and *A. kempff-mercadoi*. Though, the number of shoots in the induction phase is very low compared to the cultivated species of *A. hypogaea* the shoot-inducing portion of the explants on further subculturing produced approximately 1:20 multiplication in each subculture of three weeks interval. The requirement of growth hormone was also four times less in wild species compared to cultivated species. The shoots after hardening in the basal media, about 50% was induced rooting in the rooting medium with an average of 2 or 3 roots/shoot.

Among the six treatments tested for conservation, the control (without mannitol and ABA) had the maximum elongation of shoots followed by the treatment with

2 mg/l ABA. The variation in shoot growth was significant among media combinations and among genotypes ( $P=0.01$ ). The culture media supplemented with 2% mannitol alone could show uniformly retarded growth with healthy shoots. In some of the treatments, though the growth was retarded the shoots were not healthy and started wilting after 60 days from culture and would be unsuitable for maintaining the culture.

It is confirmed from the studies that the wild species of *Arachis* have the potential of *vitro* regeneration with a reasonable rate of multiplication on basal medium supplemented with 5 mg/l of BA and rooting could be obtained on MS medium supplemented with NAA and charcoal in the medium. The medium supplemented with 2% mannitol found suitable for prolonging the subculturing for more than 60 days. Hence, *in vitro* multiplication can be employed in multiplication exchange and storage of the valuable germplasm. However, the genetic integrity needs to be ascertained during prolonged storage as stress is induced for achieving slow growth.

## References

- Gagliardi RF, GP Pacheco, SP Coculilo and JFM Valls (2000) *In vitro* plant regeneration from seed explants of wild groundnut species (Genus *Arachis*, Section *Extranervosae*). *Biodiversity and Conservation* 9: 943-951.
- Mansur E, C Lacorte, ACG Rabello and AR Cordeiro (1993) *In vitro* regeneration of *Arachis villosulicarpa* Hoehne from cotyledon segments, leaves suspension. *Pesq. Agropec. Bras.* 28: 1143-1146.
- Radhakrishnan T, TGK Murthy, K Chandran and A Bandyopadhyay (2000) Micropropagation in peanut (*Arachis hypogaea* L.) *Biol. Plant.* 43: 447-450.
- Rani AS and GM Reddy (1996) Multiple shoot regeneration from de-embryonated cotyledons of cultivated and wild species of *Arachis*. *J. Gen. Breed.* 50:351-355.
- Stalker HT and CE Simpson (1995) Germplasm resources in *Arachis*. In *Advances in Peanut Science* (Eds. Pattee HA and Stalker HT) American Peanut Research and Education Society Stillwater, OK 74078, USA.
- Still PE, MT Plata, RJ Campsell, LC Bueno, EA Chichester and CL Niblet (1987) Regeneration of fertile *Arachis paraguariensis* from callus and suspension culture. *Plant Cell. Tiss. Org. Cult.* 9: 37-43.
- Venkatachalam P, N Geetha, A Khandelwal, MS Shaila and GL Sita (1999) Induction of direct somatic embryogenesis and plant regeneration from mature cotyledons explants of *Arachis hypogaea* L. *Curr. Sci.* 77: 269-273.

## Application of Economic Criteria in Prioritization of Conservation Methods and Valuation of Plant Genetic Resources

**M Sudha and PE Rajasekharan**

*Division of Plant Genetic Resources, Indian Institute of Horticultural Research, Bangalore-560089, Karnataka*

**Key Words:** Biodiversity, Conservation, Economic perspectives

Biological diversity has been identified as a primary factor of production essential for sustenance and enhancement of crop improvement. Plant breeders' efforts towards crop improvement by way of identification and incorporation of traits from within the available gene pool has been estimated at 8 % per annum in case of rice. Nearly 70 % of the new varieties of hybrids that were developed in crops like wheat, had specific contributions from their wild/local ancestors. So are the cases of crop reinstatement in case of epidemic spell of diseases. This not only highlights the significance of landraces and local varieties, but also stresses the need for effective conservation of genetic resources for posterity. Multilateral Transfer Agreements (MTAs) were the main instrument of accountability for all the transfers involving plant genetic material till very recently. A series of international undertakings, conventions and counter actions starting from the 1983 Rome Convention to CBD have successfully paved the way towards new dimensions to the global use of Plant Genetic Resources (PGR).

Though CBD, through the exclusivity clause (articles 15 and 16) assigns ownership of all biological resources to the state, it is often considered to be the beginning of an end of the global free flow of PGR. It has also opened the way for more dynamic modes of knowledge sharing between the public and private research efforts. The future being focussed towards more frequent interaction leading to the value added products and the need for assigning value for the existing stock gains utmost significance. This preempts the application of economic principles of valuation at various stages of conservation of PGR. Estimates show that huge volume of genetic material from the south has already been transferred to the north block of nations over the last few decades through the free flow of genetic material. Added to this, the future technology transaction costs could be much higher in favour of the north block nations. The only recourse thereby for the south, is to assign value to the existing stock of genetic material, which

has been placed outside the preview of any form of intellectual property protection measures, through the DUS criteria prescribed by WTO and TRIPS. Conservation is a common phenomenon in developing nations, but an economic perspective of the same is not yet a reality. This study attempts at an application of economic criteria for selection of suitable method for conservation as well as evaluation of conserved germplasm.

*Economic Valuation of Genetic Resources:* Economic principles of evaluation can be applied at various stages of conservation. First of all, the basic need for conservation of a specific resource or a species itself is debatable and is a subject for economic decision analysis. The methods of economic analysis, such as the hedonic pricing models or contingent valuation methods, which use subjective valuation of qualitative parameters, are of specific use for such evaluation. The mounting threat of extinction of species is yet another case for conservation. Due to their sheer existence value, conservation is opted as a preventive measure against species extinction.

Economic principle can be applied in the selection of a method as well as in deciding the appropriateness of a specific conservation method selected (Arora and Pandey, 1996). The need for such an analysis arises mainly due to the 'Limited capital' situations that are applicable to R and D expenditure. For example, decision on option between *in situ* vs *ex situ* conservation methods, selecting a specific method for a given species, or a habitat are subjects appropriate for economic as well as other factors while selecting and prioritizing research agenda on conservation of plant genetic resources. Economic criteria using 'directional scoring', fixing range and simple costs and return analysis have been adopted for judging the desirability of a specific method of conservation for PGR.

The economic criteria have been applied for selecting an appropriate method of conservation under the R & D conditions. The various *in situ* and *ex situ* conservation methods and their specific features have been presented

in Table 1. Factors such as the applicability, extent and time of preservation may be important while choosing a specific method, while the cost of conservation and the associated level of risk and its quantification will form the parameters for economic analysis while selecting a method.

Based on the nature of the specific character in question and its quantification, appropriate method of judgment, such as a specific 'range' or a 'scale' have been assigned to that feature with an associated rank of 1, 2 or 3 *etc.* The method of ranking is 'directional' in the sense that the specific feature, which is most desirable, gets the highest rank and the next best the second and so on. The total of ranks irrespective of the priority of the factor considered, forms the decision criteria. The least total sum of all ranks is the most desirable followed by the next. To illustrate, among the various *in situ* and *ex situ* conservation methods under consideration, (Table 1) all the *in situ* methods and some of the *ex situ* methods have wider applicability and can conserve species for a longer period and hence are more desirable. Other *ex situ* methods such as the pollen storage and *in vitro* may provide conservation for a limited period

of time and hence get a lower rank. Resource requirement in terms of manpower skill required for initiating and maintaining *ex situ* methods such as *in vitro*, pollen bank or cryopreservation may be high as compared to the *in situ* methods such as the botanical garden *etc.* In terms of initial capital out lay, the *in situ* conservation methods may be more demanding both from the point of availability of space and capital, depending on the geographic location and the economic status of the organisation in question.

In terms of global and local priority, the *in situ* conservation methods may be less in preference to the more modern methods. However, the most important of all factors is the ease of reinstatement for the conserved species. The *ex situ* methods of *in vitro*, pollen and cryopreservation provide an almost immediate access of the conserved material for future use, as against the time lag for bringing back or re-establishment for most of the *in situ* or traditional *ex situ* methods of conservation. Therefore, keeping in view, the preference for a specific feature, a score/rank of '1' is given to the most desirable feature and '2' or '3' for the others in that order of preference. The other important factor is the risk involved.

Table 1. Economic criteria for selecting conservation method

| Criteria/Methods                           | <i>In situ</i>    |                |             |                  | <i>Ex situ</i>  |                  |                      |                         |                      |
|--------------------------------------------|-------------------|----------------|-------------|------------------|-----------------|------------------|----------------------|-------------------------|----------------------|
|                                            | Biosphere Reserve | Gene sanctuary | On farm     | Botanical garden | Field gene Bank | Seed storage     | Pollen               | <i>In vitro</i> storage | Cryo                 |
| Applicability                              | Wide (1)          | Wide (1)       | Wide (2)    | Restricted (2)   | Res.            | Res (2)          | Res (2)              | Res (2)                 | Res (2)              |
| Extent and time of preservation            | Unlimited (1)     | Unlimited (1)  | Limited (2) | Un limited (1)   | Limited (2)     | Limited (2)      | Limited (2)          | Limited (2)             | Infinite (1)         |
| Resources needed                           |                   |                |             |                  |                 |                  |                      |                         |                      |
| i) Manpower                                | Low (1)           | Low (1)        | Low (1)     | Low (1)          | Medium          | M (2)            | Medium (2)           | Medium (2)              | Medium (2)           |
| ii) Initial capital                        | High (3)          | High (3)       | Low (1)     | High (3)         | Low (1)         | M (2)            | Medium (2)           | Medium (2)              | Medium (20)          |
| iii) Recurring contingencies               | Low (1)           | Low (1) (2)    | Medium      | Medium (2)       | Low (1) (2)     | M (2) (2)        | Medium (2)           | Medium                  | Medium               |
| Future access of conserved material        | Takes time (20)   | Takes time (2) | Takes       | Takes time (2)   | Takes           | Immediate access | Immediate access (1) | immediate access (1)    | Immediate access (1) |
| Risk                                       |                   |                |             |                  |                 |                  |                      |                         |                      |
| i) Cost hike due to failure in maintenance | Low (1)           | Low (1)        | Low (1)     | Low (1)          | Low (1)         | High (3)         | High (3) (20)        | High (3)                | medium               |
| ii) Change in conserved germplasm          | High (3)          | High (3)       | High (3)    | High (3)         | Low (1)         | Low (1)          | Low (1)              | Low (1)                 | Low (1)              |
| iii) Success rate in                       | Low (3)           | Low (3)        | Low (3)     | Low (3)          | M (2)           | M (2)            | High (1)             | High (1)                | High (1)             |
| iv) Risk due to high cost                  | Medium (2)        | Medium (2)     | Low (1)     | Low (1)          | Low (1)         | Low (1) (20)     | Medium (2)           | Medium                  | High (3)             |
| Total score                                | 18                | 18             | 17          | 19               |                 | 15               | 18                   | 18                      | 18 17                |
| Mean score                                 | 1.8               | 1.8            | 1.7         | 1.9              | 1.51            | 1.8              | 1.8                  | 1.8                     | 1.7                  |
| Preference ranking                         |                   |                | II          |                  |                 | I                |                      |                         | II                   |

Risk of cost hike due to failure of maintenance is very high for some of these methods; risk of getting back the conserved material true to type after a time lag in conservation, risk of loss or inability to reinstate the conserved material, risk of high costs involved in the process of conservation have also been ranked as 'low', medium and high and scored based on the desirability of that feature.

The total of the scores indicated that *ex situ* methods were more preferable than the *in situ* methods due to the wider option available for selection. Among the various *ex situ* methods, the field genebank stood first followed by the on farm and the cryopreservation methods getting similar scores. However, they indicate distinct variations. The on farm conservation method provides limited period conservation, cryopreservation offers for infinite time period. The reinstatement of conserved

germplasm requires time in on farm while it is almost instantaneous in cryopreservation. The reinstated material is 100% true to type in cryo, which may not be so in on farm method. These features weigh in favour of modern method such as cryopreservation. Further, the other features such as the land and infrastructure availability and the current priority of a specific method of preservation in terms of global vs local priority also need to be considered while selecting a method. An exercise of this nature would be of great significance in judging the appropriateness of specific methods of conservation. Based on the nature of the product developed, the actual valuation can be done for estimating the cost involved in its development.

#### References

Arora RK and Anjula Pandey (1996) *Wild Edible Plants of India; Diversity, Conservation and Use*. National Bureau of Plant Genetic Resources, New Delhi.

## Do Moisture and Temperature Play an Interactive Role on Seed Longevity?

**RL Sapra and BB Singh**

*Division of Genetics, Indian Agricultural Research Institute, New Delhi-110012*

**Key Words:** Moisture, Temperature, Seed longevity, Turkey's theorem

Do moisture and temperature exert independent effects on seed longevity? A question which seed biologists or genebank managers would like to have an answer. A correspondence published in Seed Science Research (Ellis *et al.* 1991) says "There is no interaction between the effects of temperature and moisture on seed longevity when these relations are quantified by the seed viability equations (e.g. Ellis and Roberts, 1980a,b; Ellis *et al.* 1982; Kraak and Vos, 1987), i.e. there is no evidence that the relative effect of moisture content on longevity varies with temperature." On the other hand, Vertucci *et al.* (1994) concluded the analysis of their experiment on pea seeds that moisture content and temperature do not exert independent effects on seed longevity.

In light of the abovesaid comments, this paper re-examines and makes an in-depth study of the already published data on *Lupinus polyphyllus* (Dickie *et al.* 1985). It also explains the role of log transformation

used in the longevity models in relation to predictive capabilities of the model as well as with respect to the interactive behaviour of the effects of moisture and temperature on seed longevity.

The physical meaning of interaction is that the two factors are said to interact if the effect of one factor changes as the level of other factors changes, and their interaction effect can be measured only if the said factors are tested together in the same experiment. In other words, if we plot the seed longevity (days) against the moisture at various levels of temperature (or against the temperature at various levels of moisture) curves should not be parallel. When data in Table 1 was plotted, the curves at three temperatures levels were found to be non-parallel indicating that the effects of moisture and temperature are non-additive in nature. Whether this non-additivity is significant or not, can be tested through Tukey's non-additivity theorem.

Risk of cost hike due to failure of maintenance is very high for some of these methods; risk of getting back the conserved material true to type after a time lag in conservation, risk of loss or inability to reinstate the conserved material, risk of high costs involved in the process of conservation have also been ranked as 'low', medium and high and scored based on the desirability of that feature.

The total of the scores indicated that *ex situ* methods were more preferable than the *in situ* methods due to the wider option available for selection. Among the various *ex situ* methods, the field genebank stood first followed by the on farm and the cryopreservation methods getting similar scores. However, they indicate distinct variations. The on farm conservation method provides limited period conservation, cryopreservation offers for infinite time period. The reinstatement of conserved

germplasm requires time in on farm while it is almost instantaneous in cryopreservation. The reinstated material is 100% true to type in cryo, which may not be so in on farm method. These features weigh in favour of modern method such as cryopreservation. Further, the other features such as the land and infrastructure availability and the current priority of a specific method of preservation in terms of global vs local priority also need to be considered while selecting a method. An exercise of this nature would be of great significance in judging the appropriateness of specific methods of conservation. Based on the nature of the product developed, the actual valuation can be done for estimating the cost involved in its development.

#### References

Arora RK and Anjula Pandey (1996) *Wild Edible Plants of India; Diversity, Conservation and Use*. National Bureau of Plant Genetic Resources, New Delhi.

## Do Moisture and Temperature Play an Interactive Role on Seed Longevity?

**RL Sapra and BB Singh**

*Division of Genetics, Indian Agricultural Research Institute, New Delhi-110012*

**Key Words:** Moisture, Temperature, Seed longevity, Turkey's theorem

Do moisture and temperature exert independent effects on seed longevity? A question which seed biologists or genebank managers would like to have an answer. A correspondence published in Seed Science Research (Ellis *et al.* 1991) says "There is no interaction between the effects of temperature and moisture on seed longevity when these relations are quantified by the seed viability equations (e.g. Ellis and Roberts, 1980a,b; Ellis *et al.* 1982; Kraak and Vos, 1987), i.e. there is no evidence that the relative effect of moisture content on longevity varies with temperature." On the other hand, Vertucci *et al.* (1994) concluded the analysis of their experiment on pea seeds that moisture content and temperature do not exert independent effects on seed longevity.

In light of the abovesaid comments, this paper re-examines and makes an in-depth study of the already published data on *Lupinus polyphyllus* (Dickie *et al.* 1985). It also explains the role of log transformation

used in the longevity models in relation to predictive capabilities of the model as well as with respect to the interactive behaviour of the effects of moisture and temperature on seed longevity.

The physical meaning of interaction is that the two factors are said to interact if the effect of one factor changes as the level of other factors changes, and their interaction effect can be measured only if the said factors are tested together in the same experiment. In other words, if we plot the seed longevity (days) against the moisture at various levels of temperature (or against the temperature at various levels of moisture) curves should not be parallel. When data in Table 1 was plotted, the curves at three temperatures levels were found to be non-parallel indicating that the effects of moisture and temperature are non-additive in nature. Whether this non-additivity is significant or not, can be tested through Tukey's non-additivity theorem.

**Table 1. Data/results reproduced from Dickie *et al.* (1985) of viability decline curves of *Lupinus polyphyllus* seeds stored at various moisture contents and temperatures**

| Storage temp.           | Mean seed mc           | Slope (1/L) | Longevity (L) | Log L |
|-------------------------|------------------------|-------------|---------------|-------|
| 21° C (T <sub>1</sub> ) | 7.91 (M <sub>1</sub> ) | -0.0019     | 526.32        | 2.715 |
|                         | 11.73(M <sub>2</sub> ) | -0.0056     | 178.57        | 2.254 |
|                         | 14.11(M <sub>3</sub> ) | -0.0059     | 169.49        | 2.231 |
| 42° C (T <sub>2</sub> ) | 7.92(M <sub>1</sub> )  | -0.0118     | 84.75         | 1.926 |
|                         | 11.58(M <sub>2</sub> ) | -0.0789     | 12.67         | 1.102 |
|                         | 13.35(M <sub>3</sub> ) | -0.2876     | 3.48          | 0.541 |
| 62° C (T <sub>3</sub> ) | 8.13(M <sub>1</sub> )  | -0.3027     | 3.30          | 0.526 |
|                         | 11.93(M <sub>2</sub> ) | -0.4378     | 2.28          | 0.359 |
|                         | 14.32(M <sub>3</sub> ) | -0.5185     | 1.93          | 0.285 |

If data on the longevity is available for more than one replication, then we can analyze the data using the two factor factorial experiment analysis and can test the interaction mean squares against the residual mean squares for accepting or rejecting the null hypothesis of 'no interaction'. However, when one observation per cell is available, we can test the assumption of additivity for the two-way layout using Tukey's theorem which partitions the usual error sum of squares into two components  $SS_G$  and  $SS_{res}$ . The test assumes the following model with usual anova assumptions:

$$L_{ij} = \mu + t_i + m_j + (tm)_{ij} + e_{ij}$$

$$\text{Null hypothesis} \quad H_0: (tm)_{ij} = 0,$$

$$\text{Alternative hypothesis} \quad H_1: (tm)_{ij} \neq 0,$$

where  $L_{ij}$  is the longevity for the  $i^{\text{th}}$  temperature and  $j^{\text{th}}$  moisture,  $t_i$  is the effect of  $i^{\text{th}}$  temperature,  $m_j$  is the effect of  $j^{\text{th}}$  moisture,  $(tm)_{ij}$  is the interaction effect of  $i^{\text{th}}$  temperature and  $j^{\text{th}}$  moisture and  $e_{ij}$  is the error term for  $ij^{\text{th}}$  cell.

The test for interactions, yielded by the theorem, consists in testing  $SS_G$  against  $SS_{res}$ . This is done with the statistics,

$$(TM-TM) SS_G/SS_{res},$$

which has a central F-distribution with 1 and TM-TM degrees of freedom. T is the number of temperature levels and M is the number of moisture levels in a two way table. We worked out the above said F statistics for the data shown in Table 1. Three levels of temperature

are  $T_1=21^\circ\text{C}$ ,  $T_2=42^\circ\text{C}$  and  $T_3=62^\circ\text{C}$ ; and three levels of moisture are taken as  $M_1=(7.9-8.2)$ ,  $M_2=(11.5-12.0)$  and  $M_3=(13.3-14.4)$ . When the computed F statistics ( $F=238.6$ ) is compared with the tabulated F value, the hypothesis of 'no interaction' is rejected indicating the presence of non additivity or interactions in the data.

In the above said Tukey's test, both the moisture and temperature have been dealt qualitatively. However, it would be more appropriate to deal them quantitatively and to study the individual effects as well as their joint effects through multiple linear regression analysis approach. For studying these effects, we normally fit a response surface to the data and test the corresponding estimated regression coefficients with the help of Student t-test. The interaction terms in a response surface are products of two or more predictor variables. They are useful when it is believed that the effect of a predictor variable on the response depends on the values of other predictor variables. However, the interaction terms in the regression model repeat information provided by the predictor variables and if the redundancy induced by the interaction terms is too strong, coefficient estimates for the individual predictor variables can be distorted (Gunst and Mason, 1980). We tried to examine the issue of interaction on four scales *viz.* -original, inverse, log and 1.9<sup>th</sup> root (special scale closer to the square root scale) by fitting response surface to the data and using the stepwise regression analysis. The results of the various fitted models with significant regression coefficients are summarized as follows:

The parameters of the modified viability equations (Ellis and Roberts, 1980a) are estimated statistically in two stages: (i) firstly, estimating the seed longevity L (inverse of the slope of the seed survival curve) for each set of environment (moisture and temperature) using probit analysis between the viability (v) and the period (p) in days, (ii) secondly, after estimating L a linear model is fitted between log L; and log of moisture (m), temperature(t) and quadratic temperature ( $t^2$ ). The second relationship has been established after the application of a linearizing transformation (log) to the seed longevity (L). Modified viability equations (Ellis and Roberts, 1980a) defining longevity are as follows:

**Model I. (Original Scale):**  $L = K_E - C_w m - C_H t - C_I m.t - C_Q t^2 + e$   
 $R^2 = 0.94499$

| Parameter | Estimate | S.E    | T     | Sig. T |
|-----------|----------|--------|-------|--------|
| $K_E$     | 1792.00  | 271.41 | 6.602 | 0.0027 |
| $C_w$     | 87.91    | 20.12  | 4.369 | 0.0120 |
| $C_H$     | 46.86    | 9.427  | 4.971 | 0.0076 |
| $C_I$     | -1.48    | 0.446  | 3.316 | 0.0295 |
| $C_Q$     | -0.28    | 0.096  | 2.888 | 0.0447 |

**Model II. (Inverse scale):**  $1/L = K_E - C_I m.t + e$   
 $R^2 = 0.90072$

| Parameter | Estimate    | S.E        | T     | Sig. T |
|-----------|-------------|------------|-------|--------|
| $K_E$     | -0.203267   | 0.053739   | 3.782 | 0.0069 |
| $C_I$     | 8.24666E-04 | 1.0348E-04 | 7.969 | 0.0001 |

**Model III. (log scale):**  $\log L = K_E - C_I \log m.t + e$   
 $R^2 = 0.90395$

| Parameter | Estimate | S.E     | T      | Sig. T |
|-----------|----------|---------|--------|--------|
| $K_E$     | 3.368815 | 0.27303 | 12.343 | 0.0000 |
| $C_I$     | -0.04716 | 0.00581 | 8.117  | 0.0001 |

**Model IV. (Special scale):**  $L^{1/3} = K_E - C_w \log m - C_H t - C_I \log m.t - C_Q t^2 + e$   
 $R^2 = 0.98391$

| Parameter | Estimate  | S.E      | T     | Sig. T |
|-----------|-----------|----------|-------|--------|
| $K_E$     | 126.9939  | 14.96438 | 8.486 | 0.0011 |
| $C_w$     | 80.07609  | 13.81944 | 5.794 | 0.0044 |
| $C_H$     | 2.68035   | 0.389262 | 6.886 | 0.0023 |
| $C_I$     | -1.202638 | 0.308854 | 3.894 | 0.0176 |
| $C_Q$     | -0.012116 | 0.002714 | 4.465 | 0.0111 |

$$v = K_I - (1/L)p \quad (1)$$

$$K_E - C_w \log m - C_H t - C_Q t^2 \quad (2)$$

$$L = 10$$

$$v = K_I - p/L \quad (3)$$

where  $K_E$ ,  $C_w$ ,  $C_H$  and  $C_Q$  are the viability constants and  $K_I$  is the initial viability;  $v$  is the viability on a probit scale and  $L$  is the longevity *i.e.* number of days required to loose a unit probit of viability. The longevity coefficients of model (2) are estimated using the multiple linear regression analysis to the following model:

$$\log L = K_E - C_w \log m - C_H t - C_Q t^2 + e, \quad (4)$$

where  $e$  is an error term which is assumed to be independently, identically and normally distributed with constant variance ( $\sigma^2$ ) *i.e.*

$$e \sim \text{i.i.d } N(0, \sigma^2). \quad (5)$$

Though, a log linearization transformation has been used practically in all the viability models helping in converting a non linear model to a linear one and thereby making the effects additive in model (4). The required linearization transformation depends upon the parameter  $\lambda$ . A useful family of transformation on the (necessarily positive) response variable  $Y$  is given by the power transformation (Box and Cox, 1964)

$$W = (Y^\lambda - 1)/\lambda \quad \text{for } \lambda \neq 0 \quad (6)$$

$$= \log Y \quad \text{for } \lambda = 0$$

This continuous family depends on a single parameter  $\lambda$ . We will now use the data (Table-1) to estimate this parameter as well as the regression parameter  $\beta$  in the model to be fitted

$$W = X\beta + \varepsilon, \quad (7)$$

where  $W$  is a transformed response and  $\varepsilon$  is an error term. Here  $W$ ,  $Y$ ,  $\beta$  and  $\varepsilon$  are in the matrix notation. There are two main ways to estimate  $\lambda$  as suggested by Box and Cox (1964). However, we have used the maximum likelihood method for estimating the parameter  $\lambda$ . The corresponding values of likelihood function  $L_{\max}(\lambda)$  for several values of  $\lambda$  in the selected range  $(-1, 1)$  were obtained. The values of  $L_{\max}(\lambda)$  were plotted against  $\lambda$ . The value of  $\lambda$  which maximizes  $L_{\max}(\lambda)$  was approximately equal to zero, suggesting again a log transformation for achieving the required additivity. Thus, after the application of the desired transformation, the seed longevity ( $L$ ) can be linearly related to moisture and temperature in the following form:

$$\log L = f(m, t, \theta) + e, \quad (8)$$

where  $\theta$  is a parameter vector to be estimated.

When we take  $\log(m)$  and  $t$  as the only explanatory variables and regress them on  $\log(L)$  we get a model  $V$  with the following details:

Model V. (log scale):  $\log L = K_E - C_w \log m - C_H t + e$   
 $R^2 = 0.92975$

| Parameter | Estimate | S.E      | T     | Sig. T |
|-----------|----------|----------|-------|--------|
| $K_E$     | 6.223945 | 1.026285 | 6.065 | 0.0009 |
| $C_w$     | 2.765399 | 0.963299 | 2.871 | 0.0284 |
| $C_H$     | 0.048609 | 0.005832 | 8.335 | 0.0002 |

Model V was also obtained by Dickie *et al.* (1985). The quadratic temperature term being insignificant is dropped from the model.

Let us examine critically all the curves, Tukey's theorem and the fitted models in terms of interpretation of effects and their predictive behaviour. Intersecting nature of curves at three levels of temperature clearly indicated the differential response of seed longevity as the level of temperature varies. Temperature and moisture do not exert independent effects is also indicated by the Tukey's theorem which rejects the null hypothesis of "no interaction".

The effect of interaction can be seen on all the scales (Models I to IV). However, the interaction has been more sensitively expressed through model II and III as compared to I and IV. Surprisingly, in these two models (II & III), regression parameters corresponding to temperature as well as moisture are missing. Should we conclude from these models that the seed longevity or the rate of dying of seeds is not at all affected by the temperature or moisture, and it is the interactive effect which is primarily responsible for deterioration of seeds? The reason for this is quite simple. The interaction term ( $\log m.t$  or  $m.t$ ) in these models is highly correlated with the response variable ( $\log L$  or  $1/L$ ) and thus, explains the maximum variation in the response variable. Due to this reason, the other main effect terms become almost redundant and do not find significant place in these models. Out of all these five models, model IV explains the maximum variation (98.4%) in the longevity and has been iteratively obtained and appears to approach the true deterministic model. However, this particular model IV fitted on a special scale and other models I, II and III suffer from a severe drawback of simplicity of interpretation of effects, and conclusions drawn from these models are

very complicated and messy. These models may behave well under interpolated conditions, but under extrapolated conditions may give even negative estimates of longevity. The only best alternative choice here seems to be model V which does not contain interaction term and has a simplicity in the expression of results. It also behaves well under the extrapolated conditions. We should here clearly differentiate the construction of regression models for prediction purposes from the formulation of theoretical models. Model IV is approaching towards a theoretical model (true relationship), whereas model V has been formulated for the prediction purposes. It is worth noting here that in the model V the log transformation has eliminated the need for second order terms (quadratic and interaction) in the regression equation. Thus, if we are interested in whether there is interaction between temperature and moisture we should not simply use this additive effects model (V) for making conclusions about the presence or absence of interaction as this model has been selected with minimum sample interactions. We should look for a properly formulated model or a model on a reasonable scale on which the effect of interaction could be tested.

Box and Cox (1964) maximum likelihood method when applied to the data suggested a log linearizing transformation to achieve the additivity of effects. While discussing the issue of interaction and transformation we refer to the paper on 'An analysis of transformations' by Box and Cox (1964). In analysis of variance and multiple regression problems we are concerned not merely with finding a transformation which will justify anova assumptions but rather to find, where possible, a metric in terms of which our findings may be succinctly expressed. Thus, we look for a scale on which the effects are additive, *i.e.* to see whether interactions are removable by a transformation. Of course, only a particular type of interaction is removable. Having chosen a suitable candidate from a parameteric family of transformations, we should make the detailed estimation and interpretation of effects on this transformed scale. In longevity models a log scale has been chosen to estimate and interpret moisture and temperature effects. Model III and model V both have been fitted on log transformed data. Though,

model III explains a slightly less variation (2.5%) when compared to model V yet, it estimates the interaction parameter with more sensitivity and has only one explanatory variable *i.e.* the interaction component. Longevity parameters ( $K_E$  and  $C_W$ ) estimated through model V have high standard errors and thus, have poor reliability. However, we will prefer selecting and using the model V as interaction(s) are missing in the said model which may cause unnecessary nuisance in the prediction of longevity.

The possible reason, perhaps, for the difference of opinions made in respect of the interactive behaviour of moisture and temperature on seed longevity is the analysis of the data with altogether different objectives. Vertucci *et al.* (1994) analyzed peas experimental data on the original scale and concluded that the temperature and moisture do not exert independent effects, whereas Ellis *et al.* (1991) tried to prove the absence of interaction on the basis of longevity models - models developed with minimum sample interactions.

Logarithmic transformation has been used practically in all the modified viability models to estimate, express, and to predict the effects of moisture and temperature on the seed longevity. We believe this transformation has performed the task of removing the interactions in the additive type of the models suggested by Ellis and Roberts (1980a) and hence there is a need to re-examine these interactions on valid scales through properly formulated models. The purpose of log transformation used in the viability models is to avoid the undesirable interactions to appear in the model which otherwise would have led to messy conclusions. The objective of transformation should not be mistaken here as 'only a mathematical relationship'. It has its own statistical significance. In addition to the reduction in interactions,

transformations also reduce non-normality, but most frequently reduce inequality of variance in the data (Scheffe, 1949).

The longevity models should not be used for drawing inferences about the presence or absence of interactions between moisture and temperature as they have been developed for simplicity and for better expression of the effects by avoiding undesired interactions to appear in these models. Thus, we disagree with the statement given by Ellis *et al.* (1991) in reference to the interactive behaviour of moisture and temperature on seed longevity.

### References

- Box GEP and DR Cox (1964) An analysis of transformations. *J. Roy. Statist. Soc. B-26*: 211-243.
- Dickie JB, McGrath and SH Linington (1985) Estimation of provisional seed viability constants for *Lupinus polyphyllus* Lindley. *Ann. Bot.* **55**: 147-151.
- Ellis RH, TD Hong and EH Roberts (1991) Seed moisture content, storage, viability and vigour. *Seed Sci. Res.* **1**: 275-279.
- Ellis RH and EH Roberts (1980a) Improved equations for the prediction of seed longevity. *Ann. Bot.* **45**: 13-30
- Ellis RH and EH Roberts (1980b) The influence of temperature and moisture on seed viability in barley. *Ann. Bot.* **45**: 31-37
- Ellis RH, K Osei-Bonsu and EH Roberts (1982) The influence of genotype, temperature and moisture on seed longevity in sesame seeds. *Ann. Bot.* **50**: 69-82.
- Kraak HL and J Vos (1987) Seed viability constants for lettuce. *Ann. Bot.* **59**: 343-349.
- Gunst RF and RL Mason (1980) Regression analysis and its application- a data oriented approach. Marcel Dekker Inc. New York and Basel. p 38.
- Scheffe H (1949) The analysis of variance. John Wiley and Sons, Inc. 473 p.
- Vertucci CW, EE Roos and J Crane (1994) Theoretical basis for seed storage III. Optimum moisture contents for pea seeds stored at different temperatures. *Ann. Bot.* **74**: 531-540.

## Seed Germplasm Conservation with Modified Atmosphere Storage in Amaranth (*Amaranthus* spp.)

**SD Doijode**

*Division of Plant Genetic Resources, Indian Institute of Horticultural Research, Hessaraghatta Lake PO, Bangalore-560089, Karnataka*

**Key Words:** Amaranth, Modified Atmosphere, Seed Longevity, Seed Germination

Amaranth is a popular leafy vegetable in the tropics. It is grown for edible leaves and cooked as vegetable. Seeds are also used for grain purposes. Wide genetic diversity of amaranth occurs in India and the crop is mainly propagated through the seeds. Amaranth seeds are short-lived under ambient conditions (Aufhammer *et al.*, 1998) and seed viability is largely dependent on storage conditions (Popovska *et al.*, 1981). Seed storage under unfavourable conditions affects the seedling growth and reduces the yield. Normally seed deteriorates faster at higher storage temperature, high seed moisture or in presence of high oxygen contents (Bass, 1980). High oxygen contents during storage reduce the seed longevity (Roberts and Abdalla, 1968). Further, replacement of air with inert gases such as nitrogen or carbon dioxide in storage container greatly reduces the deterioration and retains high viability and vigour (Bass and Stanwood, 1978). The experiment was conducted with the view to explore possibilities of modified atmosphere storage of seed conservation of amaranth germplasm.

Seeds of amaranth cvs CO-1 and CO-2 were extracted from mature spikes and dried to 10% moisture content. Later seeds were packed in laminated aluminium foil pouches along with nitrogen ( $N_2$ ), carbon dioxide ( $CO_2$ ) or in partial vacuum by PAC-vacuum (vac) and gas sealing machine and stored at ambient conditions (Ch) (16-35°C; 25-90% RH) for 10 years. Seeds were tested periodically for viability and vigour. Seed viability was expressed in terms of percentage of germination. One hundred seeds each in three replications were sown in Petri plates containing moist germination paper at alternate temperature of 20 and 30°C for 16 and 8 h respectively in Clelands' seed germinator. Seedling characteristics such as shoot and root length, seedling dry weight were recorded after 7 d of sowing and final count was taken after 14 d of sowing. Dry weight was recorded on seedlings dried at 65°C for 48 h. Vigour was compared by means of seedling characters (Mugnisjah and Nakamura, 1986).

Seed viability and vigour were significantly

influenced by the modified atmosphere storage in amaranth. About 83-92% of seeds germinated in cv CO-1 after 5 years of storage when stored in modified atmosphere as compared to none in control. Likewise, high seed viability was maintained for 7 years in cv CO-2. Amongst different gaseous environment used seeds stored with nitrogen exhibited fairly high percentage of germination (92%) in both the cultivars CO-1 and CO-2 (Fig.1).

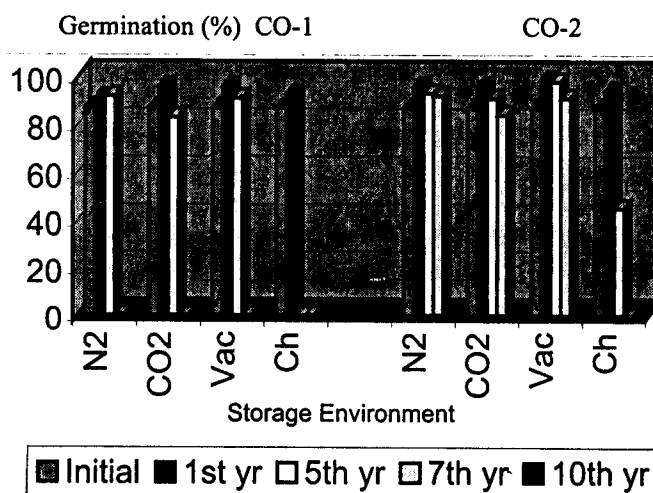


Fig. 1: Seed viability under modified atmosphere storage in amaranth

Seedling vigour was compared by means of seedling characters. In both the cultivars shoot length, root length, dry weight and vigour were relatively higher for seeds stored in nitrogen atmosphere (Table 1 and 2).

Amaranth seeds are viable for fairly long period. Aufhammer *et al.* (1998) reported that seed viability reduces after one year of storage under ambient conditions. Loss of viability was greater in improper storage conditions and it is more in open than sealed storage. Seed longevity was significantly extended to 7 years by modified atmosphere especially with nitrogen under ambient conditions. Also stored seeds showed high vigour. Presence of high oxygen in storage containers reduces the germination percentage (Roberts and Abdalla, 1968). Similarly cabbage seeds showed high viability under

Table 1. Seedling characters during storage of amaranth cv CO-1 seeds under modified atmosphere storage

| Storage period (years) | Storage environment | Coefficient of germination | Shoot length (cm) | Root length (cm) | Dry weight (mg) | Vigour |
|------------------------|---------------------|----------------------------|-------------------|------------------|-----------------|--------|
| 0                      |                     | 28.4                       | 1.9               | 1.8              | 0.12            | 30.2   |
| 1                      | Nitrogen            | 25.1                       | 2.4               | 0.2              | 0.23            | 29.3   |
|                        | Carbon dioxide      | 29.1                       | 2.2               | 0.4              | 0.26            | 35.3   |
|                        | Vacuum              | 26.9                       | 2.2               | 0.5              | 0.20            | 32.9   |
|                        | Check               | 19.7                       | 2.2               | 0.3              | 0.10            | 20.4   |
| 5                      | Nitrogen            | 30.8                       | 2.8               | 0.9              | 0.23            | 29.9   |
|                        | Carbon Dioxide      | 23.5                       | 2.5               | 0.8              | 0.19            | 20.8   |
|                        | Vacuum              | 27.7                       | 2.6               | 1.1              | 0.23            | 28.9   |
|                        | Check               | —                          | —                 | —                | —               | —      |
|                        | CD at 5%            | 4.8                        | NS                | 0.34             | NS              | 4.9    |

Table 2. Seedling characters during storage of amaranth seeds cv CO-2 under modified atmosphere storage

| Storage period (years) | Storage environment | Coefficient of germination | Shoot length (cm) | Root length (cm) | Dry weight (mg) | Vigour |
|------------------------|---------------------|----------------------------|-------------------|------------------|-----------------|--------|
| 0                      |                     | 41.3                       | 1.8               | 2.4              | 0.53            | 37.9   |
| 1                      | Nitrogen            | 31.7                       | 2.6               | 1.7              | 0.50            | 40.6   |
|                        | Carbon dioxide      | 42.4                       | 2.9               | 1.8              | 0.50            | 42.8   |
|                        | Vacuum              | 39.6                       | 3.1               | 2.2              | 0.50            | 46.0   |
|                        | Check               | 39.4                       | 2.9               | 2.0              | 0.40            | 42.8   |
| 5                      | Nitrogen            | 34.9                       | 3.4               | 1.7              | 0.31            | 38.9   |
|                        | Carbon dioxide      | 41.5                       | 3.5               | 2.2              | 0.37            | 41.8   |
|                        | Vacuum              | 42.2                       | 2.9               | 1.9              | 0.38            | 44.5   |
|                        | Check               | 38.9                       | 3.3               | 1.2              | 0.31            | 21.1   |
| 7                      | Nitrogen            | 33.9                       | 2.8               | 1.5              | 0.38            | 38.0   |
|                        | Carbon dioxide      | 19.1                       | 2.3               | 1.4              | 0.34            | 35.7   |
|                        | Vacuum              | 28.7                       | 3.2               | 1.7              | 0.36            | 30.0   |
|                        | Check               | —                          | —                 | —                | —               | —      |
| CD at 5%               |                     | 5.5                        | 0.7               | NS               | 0.10            | 4.4    |

partial vacuum storage (Isely and Bass, 1960). Therefore, it is advantageous to preserve well-dried seeds in modified atmosphere for maintaining high viability and vigour. Amaranth seed storage with nitrogen in laminated aluminium foil pouches maintained the viability and vigour for 7 years under ambient storage. The process is effective, practicable and economic in maintaining seed germplasm for medium-term storage and also useful under non-availability of cold storage facility.

## References

- Aufhammer W, D Czuczorova, HP Kaul and M Kruse (1998) Germination of grain amaranth effects of seed quality by temperature, light and pesticides. *European J. Agron.* 8: 127-135
- Bass LN (1980) Seed viability during long-term storage. *Hort Rev.* 2: 117-141.
- Bass LN and PC Stanwood (1978) Long-term preservation of sorghum seeds as affected by seed moisture, temperature and atmosphere environment. *Crop Sci.* 18: 575-577.
- Isely D and LN Bass (1960) Seeds and packaging material. *Proc. 14<sup>th</sup> Hybrid Corn Indust. Res. Conf.* 101-110.
- Mugnisjah WQ and S Nakamura (1986) Methanol and ethanol stress for seed vigour evaluation in soybean. *Seed Sci. Technol.* 14: 95-103.
- Popvoska HP, M Mihajlovski and M Skopje (1981) The influence of packing over germination of pepper and tomato seeds. *Acta Hort* 111: 281-290.
- Roberts EH and FH Abdalla (1968) The influence of temperature, moisture and oxygen on period of seed viability in barley, broad bean and peas. *Ann. Bot.* 32: 97-117.

## Seed Conservation – An Effective Method for Preservation of Genetic Variability in French Bean (*Phaseolus vulgaris* L.)

**SD Doijode**

*Division of Plant Genetic Resources, Indian Institute of Horticultural Research, Hessaraghatta Lake PO, Bangalore-560089, Karnataka*

**Key Words: French Bean, Seed Conservation, Longevity, Viability, Vigour, Laminated Aluminium Foil Pouches, Storage Temperature**

French bean is an important pod vegetable cultivated for edible tender pods in temperate, sub-tropic and tropics. Seed is also rich in protein contents. Plants show wide variations for growth habit, flowering and pod characters, nutrient contents and resistant to various biotic and abiotic stresses. Germplasm can be conserved by different means, amongst them seed conservation appears to be promising since it exhibits genetic stability on long-term conservation, easy to handle, practicable and cost effective. French bean seeds are short-lived under ambient conditions and longevity is further affected by improper storage conditions (Justice and Bass, 1978). Seed quality in terms of high viability and vigour is affected by high storage temperature and high relative humidity (Bass, 1980). The cool and dry climatic conditions are favourable for preservation of seed germplasm. The experiment was conducted with the view to study performance of seed germplasm on long-term conservation under controlled climatic conditions.

Seeds of four genotypes namely Sel-2, Sel-5, Arka Komal and Burpee's Stringless were used for long-term conservation. Seeds were dried to 6.5% moisture and packed in moisture permeable, semi-permeable and impermeable containers and stored at low (5°C), sub-zero (-20°C) and ambient temperatures (16-35°C) for 15 years. Seed viability was expressed in terms of percentage of germination and determined periodically. One hundred seeds each in three replications were sown in moist kraft paper at alternate temperatures of 20 and

30°C for 16 and 8 h respectively in Clelands' seed germinator. The percentage of germination was expressed in terms of normal seedling, wherein root and shoot systems are properly developed. Shoot and root length were recorded for one-week-old seedling. Dry weight was recorded for seedlings dried at 65°C for 48 h. The data were statistically analyzed for variance and means and compared by using protected least significant differences test at 0.05 probability level.

High seed viability and vigour maintained for 15 years in different French bean genotypes. Seed longevity was significantly affected by the storage temperatures. Initially seeds were viable for 2 years under ambient conditions and high percentage of germination was recorded in seeds stored in glass and laminated aluminum foil pouches (Doijode, 1988). Seed germination varied from 71 to 100% after 15 years of storage (Table 1).

Comparatively seeds of Arka Komal exhibited high viability followed by seeds of Sel-2, Sel-5 and Burpee's Seedless during storage. Likewise, seeds stored at sub-zero (-20°C) temperature had greater potential for germination than seeds stored at 5°C. Fonseca *et al.* (1980) reported that seeds stored at high temperature deteriorate faster and show lower germination and seedling vigour. The process of seed deterioration is slower at cooler temperature (Harrington, 1972). At low temperature (5°C) storage the percentage of germination was more in seeds stored in glass and laminated aluminium

**Table 1. Seed viability in different French bean genotypes after 15 years of storage under different packaging and temperatures**

| Genotype            | Kraft paper |       | Glass container |       | Polyethylene bag |       | Aluminium foil pouches |       |
|---------------------|-------------|-------|-----------------|-------|------------------|-------|------------------------|-------|
|                     | 5°C         | -20°C | 5°C             | -20°C | 5°C              | -20°C | 5°C                    | -20°C |
| Sel-2               | 93          | 76    | 90              | 82    | 93               | 90    | 94                     | 89    |
| Sel-5               | 86          | 81    | 91              | 90    | 90               | 88    | 93                     | 92    |
| Arka Komal          | 86          | 92    | 100             | 93    | 79               | 97    | 92                     | 95    |
| Burpee's Stringless | 71          | 73    | 82              | 92    | 88               | 88    | 86                     | 89    |

CD at 5% = 5.0

Contd.

foil pouches. Even seeds stored in kraft paper bags retained high viability both at 5°C and -20°C indicating thereby that kraft paper bags are equally good for storage of French bean seeds. About 90% of seeds were viable at -20°C storage after 15 years of storage. Seeds stored in glass and laminated aluminium foil pouches showed high viability. Further, plants raised from stored seeds were normal and healthy and gave appreciable pod quality and yield, showing thereby maintenance of genetic and horticultural traits on long-term conservation. Seedling characters such as shoot and root length and dry weight were greater for seeds stored in moisture impermeable containers than seeds stored in kraft paper bags (Table 2). Similarly seedling vigour was greater for seeds stored in glass and laminated aluminium foil pouches at 5°C and seeds stored in polyethylene, glass and laminated aluminium foil pouches at -20°C.

The results reveal that high storage temperature reduces the seed longevity in French bean. Conservation either at 5°C or -20°C retains high viability and seedling vigour for 15 years. Seed conservation was better in moisture proof containers such as glass and laminated aluminium foil pouches

both at 5°C and -20°C storage. High humidity promotes seed deterioration especially in moisture permeable containers (Bass and Clark, 1974). French bean seeds have poor survival under ambient conditions and sometimes it is for only 90 days (Borges *et al.*, 1991). Seed longevity could be extended to 15 years with low temperature storage. Laminated aluminium foil pouches are ideal for germplasm conservation both at 5 and -20°C. However, polyethylene bags are also equally usable at 5°C and they are readily available and cheaper. Selection of packaging and temperature depends on duration and storage requirements. The polyethylene bags are as good as laminated aluminium foil pouches in dry conditions (Villareal *et al.*, 1972). However, for long-term conservation, it is advantageous to pack well-dried seeds in laminated aluminium foil pouches and store at sub-zero (-20°C) temperature.

## References

- Bass LN (1980) Seed viability during long-term storage. *Hortic. Rev* 2: 117-141.
- Bass LN and DC Clark (1974) Effect of storage conditions, packing material and seed moisture content on longevity of safflower seeds. *Proc. Assoc. Seed Analyst* 64: 120-128.

**Table 2. Seedling characters during storage of French bean genotypes under different packaging and temperatures after 15 years of storage**

| Storage containers               | Genotypes  | Coefficient of germination |       | Shoot length (cm) |       | Root length (cm) |       | Dry wt. (mg) |       | Vigour |       |
|----------------------------------|------------|----------------------------|-------|-------------------|-------|------------------|-------|--------------|-------|--------|-------|
|                                  |            | 5°C                        | -20°C | 5°C               | -20°C | 5°C              | -20°C | 5°C          | -20°C | 5°C    | -20°C |
| Kraft paper                      | Sel-2      | 23.3                       | 19.9  | 7.9               | 9.9   | 8.1              | 6.8   | 48.7         | 52.5  | 26.4   | 24.4  |
|                                  | Sel-5      | 24.6                       | 24.5  | 9.9               | 12.6  | 7.5              | 9.3   | 55.2         | 61.3  | 30.5   | 27.6  |
|                                  | Arka Komal | 19.8                       | 26.3  | 6.5               | 12.7  | 5.5              | 10.9  | 46.1         | 47.4  | 27.3   | 33.6  |
|                                  | Burpee's   | 23.9                       | 32.3  | 6.8               | 6.5   | 4.1              | 5.0   | 38.9         | 41.2  | 26.4   | 28.6  |
|                                  | Stringless |                            |       |                   |       |                  |       |              |       |        |       |
| Glass container                  | Sel-2      | 46.9                       | 44.1  | 10.3              | 13.1  | 8.8              | 9.2   | 48.4         | 60.9  | 43.3   | 39.9  |
|                                  | Sel-5      | 41.7                       | 35.5  | 13.1              | 14.5  | 11.3             | 10.3  | 48.2         | 65.5  | 43.1   | 40.1  |
|                                  | Arka Komal | 42.4                       | 49.4  | 11.6              | 15.5  | 12.5             | 9.6   | 98.4         | 84.3  | 48.0   | 47.1  |
|                                  | Burpee's   | 27.2                       | 22.9  | 10.7              | 13.5  | 9.3              | 9.4   | 64.4         | 58.1  | 27.7   | 24.3  |
|                                  | Stringless |                            |       |                   |       |                  |       |              |       |        |       |
| Polyethylene bags                | Sel-2      | 23.4                       | 33.1  | 10.5              | 13.9  | 9.8              | 10.1  | 48.6         | 60.4  | 29.0   | 39.9  |
|                                  | Sel-5      | 40.2                       | 36.5  | 11.8              | 13.5  | 10.9             | 10.3  | 82.2         | 62.3  | 42.2   | 40.3  |
|                                  | Arka Komal | 23.4                       | 49.6  | 11.5              | 12.0  | 12.9             | 12.0  | 98.2         | 81.3  | 26.6   | 49.1  |
|                                  | Burpee's   | 33.9                       | 40.4  | 15.3              | 14.1  | 12.4             | 10.5  | 90.7         | 61.6  | 30.9   | 41.5  |
|                                  | Stringless |                            |       |                   |       |                  |       |              |       |        |       |
| Laminated Aluminium foil pouches | Sel-2      | 46.3                       | 31.0  | 9.6               | 12.2  | 10.1             | 9.4   | 50.5         | 59.3  | 43.7   | 40.0  |
|                                  | Sel-5      | 37.0                       | 32.9  | 10.5              | 13.5  | 9.8              | 10.3  | 89.7         | 62.4  | 41.2   | 39.7  |
|                                  | Arka Komal | 41.5                       | 46.3  | 10.7              | 10.9  | 11.9             | 10.8  | 93.0         | 77.8  | 44.9   | 47.7  |
|                                  | Burpee's   | 40.0                       | 41.7  | 13.5              | 13.6  | 12.2             | 9.8   | 73.8         | 67.3  | 34.5   | 41.9  |
|                                  | Stringless |                            |       |                   |       |                  |       |              |       |        |       |
| CD at 5%                         |            | 3.8                        |       | 1.6               |       | 1.5              |       | 6.6          |       | 3.1    |       |

- Borges JWM, EA Moraes and MGG Vieira (1991) Effect of processing on seed viability of stored beans. *Phaseolus vulgaris*. *Revista Brasileira de Sementes* 13: 135-138.
- Doijode SD (1988) Comparison of storage containers for storage of French bean seeds under ambient conditions. *Seed Res.* 16: 245-247.
- Fonseca JR, A De Freire, MS Freire and FJP Zimmerman (1980) Conservation of bean seeds under three methods of storage. *Revista Brasileira de Sementes* 2: 19-27.
- Harrington JF (1972) Seed storage and longevity. In: TT Kozlowski (ed.) *Seed Biology* Academic Press, New York, Vol III pp 145-245.
- Justice, OL and LN Bass (1978) *Principles and practices of seed storage*. USDA ARS Washington DC.
- Villareal RL, JB Balagedan and AD Castro (1972) The effect of packing materials and storage conditions on the vigour and viability of squash (*Cucurbita maxima*), patola (*Luffa acutangula*) and upo (*Lagenaria siceria*) seeds. *Philippine Agriculturist* 56: 59-76.

## Conservation of Banana Diversity in Bay Islands—An Approach to Prevent Genetic Erosion

**T Damodaran, RP Medhi, Sujatha A Nair and MA Suryanarayana**

*Central Agricultural Research Institute, Port Blair (Andmans and Nicobar Islands)*

**Key Words:** Banana, Conservation, Germplasm, Wild Species

Banana is one of the oldest fruits known to mankind. South-East Asia is considered the place of origin for *Musa acuminata* and *Musa balbisiana*, which are the ancestral species of banana. The Andaman and Nicobar group of Islands which are situated 1200 km away from mainland of India in the Bay of Bengal forms an arched string of about 572 islands and isles, stretching from Burma in the North to Sumatra in the south between 6° and 14° N latitudes and 92° and 94° E longitudes. The total land area of these islands amounts to only about 8249 sq km of which about 86% is covered by lush green tropical rain forests. The islands receive an average rainfall of 3100 mm distributed over 8 months. The location of these islands suggests that the Andaman group of islands may have cultivars of Burma origin and Nicobar group of islands may have cultivars of Indonesian origin. The unexploited fragile ecosystem offers lot of scope for banana diversity. Currently banana production in the globe is threatened by biotic pressures, which have increased in the past two decades. Pathogenic form of fungal diseases like Sigatoka leaf spot and *Fusarium* wilt have spread to all banana growing states in our country. Banana streak virus infects Poovan, a leading commercial cultivar, grown all over the country. Hill banana, which are famous in Tamil Nadu, are in the danger of extinction due to banana bunchy top virus. *M. acuminata* sub sp. *burmannica*, which is considered one of the resistant sources for nematode breeding is on the brink of extinction. Thus,

conservation of banana germplasm by any means has to be taken in an intensive manner. At present Bay Islands have recorded nearly 20 cultivated types and six wild types of banana.

An exploration tour was undertaken in North and South Andaman. Places of collection were divided into two types (i) primary sources like forest areas and (ii) secondary centres like farmers and markets etc. The selected plants were characterized morphologically and genetically using Simmonds and Sheperds (1952) scoring technique and IPGRI descriptors. Conservation of the collected germplasm was carried out in field gene banks, *in situ* and village seed banks.

Since the Island consists of people drawn from all the states of India, the flora has been subjected to long period of natural and human introduction and selection. Wild banana dominates the forest flora in certain pockets. The highly endangered wild types like *M. acuminata* var. *andamanica*; *M. acuminata* sub. sp. *burmannica*, *M. acuminata* sub. sp. *malacansis* were collected, characterized and conserved. Clearing of the natural vegetation for settlements and agriculture has almost wiped out the forest trees and natural variability available in the forests. The conservation of banana germplasm along with endangered medicinal plants has been impeded due to lack of awareness about its availability, distribution, reproduction biology and breeding systems. To prevent further erosion of these population both *in situ* and *ex*

- Borges JWM, EA Moraes and MGG Vieira (1991) Effect of processing on seed viability of stored beans. *Phaseolus vulgaris*. *Revista Brasileira de Sementes* 13: 135-138.
- Doijode SD (1988) Comparison of storage containers for storage of French bean seeds under ambient conditions. *Seed Res.* 16: 245-247.
- Fonseca JR, A De Freire, MS Freire and FJP Zimmerman (1980) Conservation of bean seeds under three methods of storage. *Revista Brasileira de Sementes* 2: 19-27.
- Harrington JF (1972) Seed storage and longevity. In: TT Kozlowski (ed.) *Seed Biology* Academic Press, New York, Vol III pp 145-245.
- Justice, OL and LN Bass (1978) *Principles and practices of seed storage*. USDA ARS Washington DC.
- Villareal RL, JB Balagedan and AD Castro (1972) The effect of packing materials and storage conditions on the vigour and viability of squash (*Cucurbita maxima*), patola (*Luffa acutangula*) and upo (*Lagenaria siceria*) seeds. *Philippine Agriculturist* 56: 59-76.

## Conservation of Banana Diversity in Bay Islands—An Approach to Prevent Genetic Erosion

**T Damodaran, RP Medhi, Sujatha A Nair and MA Suryanarayana**

*Central Agricultural Research Institute, Port Blair (Andmans and Nicobar Islands)*

**Key Words:** Banana, Conservation, Germplasm, Wild Species

Banana is one of the oldest fruits known to mankind. South-East Asia is considered the place of origin for *Musa acuminata* and *Musa balbisiana*, which are the ancestral species of banana. The Andaman and Nicobar group of Islands which are situated 1200 km away from mainland of India in the Bay of Bengal forms an arched string of about 572 islands and isles, stretching from Burma in the North to Sumatra in the south between 6° and 14° N latitudes and 92° and 94° E longitudes. The total land area of these islands amounts to only about 8249 sq km of which about 86% is covered by lush green tropical rain forests. The islands receive an average rainfall of 3100 mm distributed over 8 months. The location of these islands suggests that the Andaman group of islands may have cultivars of Burma origin and Nicobar group of islands may have cultivars of Indonesian origin. The unexploited fragile ecosystem offers lot of scope for banana diversity. Currently banana production in the globe is threatened by biotic pressures, which have increased in the past two decades. Pathogenic form of fungal diseases like Sigatoka leaf spot and *Fusarium* wilt have spread to all banana growing states in our country. Banana streak virus infects Poovan, a leading commercial cultivar, grown all over the country. Hill banana, which are famous in Tamil Nadu, are in the danger of extinction due to banana bunchy top virus. *M. acuminata* sub sp. *burmannica*, which is considered one of the resistant sources for nematode breeding is on the brink of extinction. Thus,

conservation of banana germplasm by any means has to be taken in an intensive manner. At present Bay Islands have recorded nearly 20 cultivated types and six wild types of banana.

An exploration tour was undertaken in North and South Andaman. Places of collection were divided into two types (i) primary sources like forest areas and (ii) secondary centres like farmers and markets etc. The selected plants were characterized morphologically and genetically using Simmonds and Sheperds (1952) scoring technique and IPGRI descriptors. Conservation of the collected germplasm was carried out in field gene banks, *in situ* and village seed banks.

Since the Island consists of people drawn from all the states of India, the flora has been subjected to long period of natural and human introduction and selection. Wild banana dominates the forest flora in certain pockets. The highly endangered wild types like *M. acuminata* var. *andamanica*; *M. acuminata* sub. sp. *burmannica*, *M. acuminata* sub. sp. *malacansis* were collected, characterized and conserved. Clearing of the natural vegetation for settlements and agriculture has almost wiped out the forest trees and natural variability available in the forests. The conservation of banana germplasm along with endangered medicinal plants has been impeded due to lack of awareness about its availability, distribution, reproduction biology and breeding systems. To prevent further erosion of these population both *in situ* and *ex*

*situ* methods of conservation is the need of the hour.

*In situ* conservation is the best for richer specific endemic species, through identification and demarcation of areas of representative populations as "preservation plots". The diversity of banana in the Andaman is being mapped for both wild and cultivated types. Due to the proximity of Andaman Islands to Burma, ecotypes of Burma origin are found in the forests of South Andaman. One such type is *M. acuminata* var. *burmannica* (Ac. No. 30106). This type is being maintained under *in situ* condition with constant monitoring and evaluation. Due to constraints such as local encroachment, maintenance of germplasm under *in situ* conditions is under threat. The next alternative for conservation is through field gene bank.

Gene banks are the reservoirs of genetic variability as they provide desirable traits for the breeders to develop superior genotypes. CARI has developed a field gene bank for banana consisting of 20 cultivated types and 4 wild types. All the varieties in the gene bank are collected from the island alone (Table 1).

The important functions of gene banks are:

- i. To assemble the genetic resources of the banana from all over the Andaman and Nicobar Islands.

- ii. To propagate and conserve the collected genetic resources under proper cultural and phytosanitary conditions.
- iii. To carry out preliminary evaluation for the genetic resources by recording important qualitative and quantitative traits.
- iv. To maintain liaison with NBPGR and NRC (Banana) for technical expertise and documentation.

The concept of village gene banks wherein the concerned farmers' fields are used as gene banks. The village gene bank are being maintained by farmers in their fields.

With the currently debated issues of IPR, benefit sharing, biosafety, documentation and conservation of the existing banana diversity is of great importance. Due to the isolated nature of these islands from the mainland dreadful diseases like banana bunchy top, bract mosaic virus are totally absent. This factor along with optimum environment for banana growing suggests that these islands can be effectively used in conserving the banana germplasm that is threatened in other parts of the country.

#### References

- Simmonds NW and Sheperds (1954) The taxonomy and origin of cultivated bananas. *J. Linn. Soc. (Botany)* 55: 302-12.

**Table 1. Germplasms at field gene bank at CARI, Port Blair**

| Wild banana/clones                            | Synonyms                             | Genomic group |
|-----------------------------------------------|--------------------------------------|---------------|
| Katta champa (1)                              | Poovan, Mysore, Palayankodan, Champa | AAB           |
| Katta champa (2)                              | Pisang kempu                         | AAB           |
| Meeta champa (1)                              | Sugandhi                             | AAB           |
| Meeta champa (2)                              | Thalla chakkarakeli                  | AAA           |
| Lal kela                                      | Red banana, Chenkadali               | AAA           |
| Rathalu                                       | Venkadali, Gren red                  | AAA           |
| Raja Bale                                     | Raja vazhai                          | AAA           |
| Dwarf Cavendish                               | Basrai, Jahaji, Vamanakeli           | AAA           |
| Nendran                                       | Rajeli                               | AAB           |
| Korangi                                       | Pisang kelat                         | AAB           |
| Cheena kela (1)                               | Karpooravalli                        | ABB           |
| Cheena kela (2)                               | Kanthali                             | ABB           |
| Monthan (1)                                   | Bluggoe                              | ABB           |
| Monthan (2)                                   | Sambarani Monthan                    | ABB           |
| <i>M. balbisiana</i> var. <i>andamanica</i>   | —                                    | ABB           |
| <i>M. balbisiana</i> var. from Nicobar        | —                                    | ABB           |
| <i>M. acuminata</i> sub sp. <i>burmannica</i> | —                                    | AA            |
| <i>M. acuminata</i> sub sp. <i>malacansis</i> | —                                    | AA            |
| Ney Poovan                                    | —                                    | AB            |

## Pollen Cryopreservation in Vegetable and Ornamental Species: Retrospects and Prospects

**PE Rajasekharan and S Ganeshan**

*Pollen Storage Laboratory, Plant Genetic Resources Division, Indian Institute of Horticultural Research, Hessaraghatta Lake PO, Bangalore-560089, Karnataka*

**Key Words:** Cryopreservation, Pollen, Nuclear Genetic Diversity

Conservation of nuclear genetic diversity (NGD) using pollen is desirable in horticultural species for a variety of reasons. Cryopreserved pollen can be a major access point for pre-breeding germplasm lines, hybrid seed production, biotechnological and other basic studies. In case of tree species, germplasm can be easily received and exchanged through pollen, eliminating a long juvenile phase. The objective of a useful pollen cryostorage protocol is to collect mature pollen from plant and treat it so as to retain its normal function, ultimately assessed by its ability to germinate *in vivo* and effect normal fertilization (Hanna and Towill, 1995). Hoekstra (1995) has assessed the merits and demerits of pollen as genetic resource. Ganeshan and Rajasekharan (1995) reviewed work on ornamental crop pollen storage. Recently Barnabas and Kovacs (1997) and Berthoud (1997) stressed the importance and need for pollen conservation. Response to cryopreservation experiments obtained with pollen conservation are presented in Table 1. In some of the recently cryostored pollen only feasibility tests were carried out. In most species, protocols are optimized for establishing pollen cryobanks. Besides the already existing role of pollen banks in breeding, there are many promising applications which has come to focus with the recent advances in allied bioscientific areas.

The protocols for pollen collection, viability assessment (pre- and post-storage), processing for cryopreservation, retrieval and fertility assessment followed at IIHR for vegetable (Rajasekharan and Ganeshan, 1994) and ornamental crops (Ganeshan and Rajasekharan, 1995) are described in detail.

Status of cryopreservation of pollen of various species is presented in Table 1. Extended availability of nuclear gene pool through application of cryogenic technology can help redesign crop breeding strategies, integrating conventional and biotechnological techniques for crop improvement. Exchange of dry pollen as germplasm pose relatively less quarantine problems and

provides a 'snap shot' of nuclear genetic diversity of the species in question for a given ecosystem. A 'Pollen Cryobank' has been established at IIHR, maintaining more than 600 tropical pollen accessions collected during different seasons and years, kept under constant cryogenic conditions, through periodical replenishment of the cryogen (liquid nitrogen) over the past 18 years.

Crossing of desirable genotypes involves multiple and staggered plantings in order to synchronize flowering. This can be avoided when cryopreserved viable pollen is available, facilitating hybrids between genera, species and genotypes. This could effectively conserve field and greenhouse space. A pollen cryobank for a given crop can provide constant supply of viable and fertile pollen and can also allow supplementary pollination for improving seed set. The variability due to daily pollen collection can be nullified (Barnabas and Kovacs, 1997). Male sterile populations can be perpetuated by cryostored maintainer pollen, thus avoiding frequent planting of maintainer line. Large scale consolidation of potential pollen from male parents will ensure uninterrupted supply of the male gametophyte for hybrid seed production at a given location and pollen can be transported to different locations where seed parents are grown for crossing (Ganeshan and Rajasekharan, 1995). Cryogenic technology applied to pollen conservation facilitates integration of conventional breeding methods with modern biotechnological practices.

The international transfer of germplasm in the form of dry pollen is not generally restricted (Hoekstra, 1995). Moreover, this will eliminate the need of growing plant populations to produce pollen. Pollen is subjected to less stringent quarantine restrictions. So, it can be easily shipped and used. Through exchange of pollen, desired crosses can be made directly on the seed parent, allowing introgression of characters at a much faster rate. This would find favour especially in breeding of tree species with long juvenile phase. Conservation and management

Table 1. Response to pollen cryopreservation of different plant species

| Species/Cultivars              | Family     | Pollen Longevity<br>(Kozaki, 1975) | Longevity (CYP)<br>(Year) | PSVFP<br># Accessions | Current status | Cryofeasibility |
|--------------------------------|------------|------------------------------------|---------------------------|-----------------------|----------------|-----------------|
| <i>Gladiolus</i> sp.           | Iridaceae  | Medium                             | 11                        | V-7, F-7              | 20             |                 |
| <i>G. callianthus</i>          |            |                                    |                           | Under study           |                |                 |
| <i>Allium cepa</i>             | Liliaceae  | Medium                             | 13                        | V-7, F-7              | 27             |                 |
| <i>A. fistulosum</i>           |            |                                    |                           | Under study           |                |                 |
| <i>Rosa</i> sp.                | Punicaceae | Not reported                       | 13                        | Under study           | 10             | Good            |
| <i>R. indica</i>               | Rosaceae   | Long                               | 1-2                       | V-5, F-6              | 40             | Good            |
| <i>R. multiflora</i>           |            |                                    |                           | Under study           |                |                 |
| <i>Capsicum annuum</i>         | Solanaceae | Medium                             | 6-9                       | V-5, F-6              |                |                 |
| <i>C. baccatum</i>             |            |                                    |                           | V-6, F-6              |                |                 |
| <i>C. frutescens</i>           |            |                                    |                           | Under study           |                |                 |
| <i>C. praertermisum</i>        |            |                                    |                           | Under study           |                |                 |
| <i>Lycopersicon esculentum</i> |            |                                    |                           |                       |                |                 |
| <i>L. hisutum</i>              |            |                                    | 9-10                      | V-9, F-9              | Under study    | Good            |
| <i>L. peruvianum</i>           |            |                                    |                           | Under study           |                |                 |
| <i>L. pimpinellifolium</i>     |            |                                    |                           | V-9, F-9              |                |                 |
| <i>Solanum erianthum</i>       |            |                                    |                           |                       |                |                 |
| <i>S. indicum</i>              |            |                                    |                           | Under study           |                |                 |
| <i>S. insanum</i>              |            |                                    |                           | 2 V-7, F-7            | 91             | Good            |
| <i>S. integrifolium</i>        |            |                                    |                           | 2 V-7, F-7            |                |                 |
| <i>S. macrocarpum</i>          |            |                                    |                           | 2 V-7, F-7            |                |                 |
| <i>S. melongena</i>            |            |                                    |                           | 2 V-7, F-7            |                |                 |
| <i>S. sisymbirifolium</i>      |            |                                    | 9-10                      | V-7, F-7              |                |                 |
| <i>S. torvum</i>               |            |                                    |                           | 2 V-7, F-7            |                |                 |
| <i>S. viarum</i>               |            |                                    |                           | 2 V-7, F-7            |                |                 |
| <i>S. xanthocarpum</i>         |            |                                    |                           | 2 V-7, F-7            |                |                 |
| Viability and fertility scale  |            |                                    |                           | 10-11                 | V-8, F-8       |                 |

1 very low, 2 very low to low 3 low 4 low to intermediate 5 intermediate 6 intermediate to high 7 high 8 high to very high 9 very high

PSVFP: Post Storage Viability and Fertility Profile, CYP: Cryopreservation

of NGD in plant species calls for constant cryobiological inputs in terms of material needed. These include cryobiological containers, constant supply of liquid nitrogen, its periodical replenishment, minimizing loss under ambience and above all, secure personnel safety. Stacking pollen samples in cryobiological systems needs to be done in sealed laminated poly-pouches, either in gelatin capsules or in butter paper packets. It is important to maintain a proper inventory of pollen samples under cryopreservation. Improper pouch sealing may lead to bursting of the sample packet, leading to loss of pollen. Unless and otherwise known periodical viability checks need to be carried out. It is preferable to cryopreserve sample with a high initial viability profile (Ganeshan, 1998).

The availability of pollen of quality in a pollen cryobank will provide constant supply of the same for extended durations. Pollen in such a state can be termed

value added by virtue of its potential extended life, since it can be kept viable and fertile for extended duration to perform its natural function of fertilization, leading to formation of fruit and seed set *e.g.* pollen used in hybrid seed production. The process of genetic characterization further enhances the value of pollen, especially when it is established that it contains specific DNA sequences which are attributable to specific traits *e.g.* pollen with marker genes (Ganeshan and Rajasekharan, 1995).

#### References

- Barnabas B and G Kovacs (1997) Storage of pollen. In: KR Shivanna and VK Sawney (ed.) *Pollen Biotechnology for Crop Production and Improvement* Cambridge University Press. U.K. pp 293-314.
- Berthoud J (1997) Strategies for conservation of genetic resources in relation to their utilization. *Euphytica* **96**: 1-12.
- Ganeshan S and PE Rajasekharan (1995) Genetic conservation through pollen storage in ornamental crops. In: KL Chadha

- and SK Bhattacharjee (ed.) *Advances in Horticulture Part-I Ornamental Crops*, Malhotra Publishing House, New Delhi pp 87-108.
- Ganeshan S (1998) Pollen storage in tropical fruits. In: RK Arora and VR Rao (ed.) *Tropical Fruits in Asia Diversity, Maintenance, Conservation and Use*. Proceedings of the IPGRI-ICAR-UTFANET Regional Training Course on the Conservation and Use of Germplasm of Tropical Fruits in Asia, IIHR Bangalore 18-31 May 1997 pp120-126.
- Ganeshan S and PE Rajasekharan (2000) Current Status of Pollen Cryopreservation Research: Relevance to Tropical Horticulture. In: F Engelmann and H Takagi (ed.) *Cryopreservation of Tropical Plant Germplasm-Current Research Progress and Application*, IPGRI (Rome) and JIRCAS (Japan). IPGRI, Rome, pp 360-365.
- Hanna WW and LE Towill (1995) Long-term pollen storage. In: J Janick (ed.) *Plant Breeding Reviews* John Wiley and Sons, Chester, USA, pp 179-207.
- Hoekstra FA (1995) Collecting Plant Genetic Diversity. In: L Guarino, V Ramanatha Rao and R Reid (ed.) *Technical guidelines*, CAB International Walling Ford U.K.
- Rajasekharan PE and S Ganeshan (1994) Pollen Cryopreservation in Vegetables as a Possible Aid to Heterosis Breeding. In: *Proceeding of 8<sup>th</sup> Kerala Science Congress* 27-29 January 1994. Thiruvananthapuram, pp 185-186.

## Conservation of Endangered Medicinal Plants: Challenges and Options

**PE Rajasekharan, S Ganeshan and Sunitha Bhaskaran**

*Division of Plant Genetic Resources, Indian Institute of Horticultural Research, Hessaraghatta Lake PO, Bangalore-560089, Karnataka*

**Key Words:** Endangered Species, *In Vitro*, Micropropagation, Hardening

India has about 8000 species of known medicinal plants. Using the current global rates of species extinction around 10 to 12% of the plants *i.e.*, around 800–1000 species are likely to be threatened. For developing conservation strategies it is essential to study their extent of occurrence (geographic range, endemism), assess their degree of threat based on International Union for the Conservation of Nature (IUCN) categories *viz.* - vulnerable, endangered, critically endangered *etc.*, harvesting practices, habitat specificity and growth forms (Mali and Ved, 1999). More of shrubs and less of herbs, which is expected from a random distribution among natural flora, appear to be among the rare/endangered (RE) group (Lokesha and Vasudeva, 1997). This suggests that shrubs have a higher risk of becoming endangered than herbs. Data on mode of dispersal suggest that a greater fraction of species that disperse their propagules through biotic agents than through wind, water or by passive means are likely to become RE. It may be important to use these syndromes as indications to identify the RE species and concentrate conservation efforts on these species. As a concept, rarity is a phenomenon in time as well as space (Harper, 1986).

Criteria used to assess the threat status of plant species as the class of rarity vary. Correct definition is important for formulating conservation policies

especially for countries like India with 11% of world's floral diversity.

Plant tissue culture techniques are now being used globally for the multiplication of medicinally important plant species and monitoring of their secondary metabolites. The application of micropropagation techniques for medicinal plants gives many benefits to the breeders as it enables to increase the rate of rapid multiplication of plants which in a particular climate do not provide seeds or where seeds have low germination, the availability of plants throughout the year, producing uniform clones from highly heterozygous plants, production of plants with changed genotypes, conservation of genetic resources of species and threatened plant and improvement by regeneration technique (Srivastava and Pande, 1998). Successful *in vitro* regeneration of medicinal plants could be made possible with varied explants such as leaf and stem segments, shoot buds, hypocotyls, cotyledons, roots, and seedlings.

Micropropagation holds promise as a major component in medicinal plant breeding. Its benefits derive from *in vitro* culture and multiplication of axenic shoots excluding callus formation and association problems (Constabel, 1990). Axenic shoot (tip) cultures can be employed not only for multiplication, but also for storage.

- and SK Bhattacharjee (ed.) *Advances in Horticulture Part-I Ornamental Crops*, Malhotra Publishing House, New Delhi pp 87-108.
- Ganeshan S (1998) Pollen storage in tropical fruits. In: RK Arora and VR Rao (ed.) *Tropical Fruits in Asia Diversity, Maintenance, Conservation and Use*. Proceedings of the IPGRI-ICAR-UTFANET Regional Training Course on the Conservation and Use of Germplasm of Tropical Fruits in Asia, IIHR Bangalore 18-31 May 1997 pp120-126.
- Ganeshan S and PE Rajasekharan (2000) Current Status of Pollen Cryopreservation Research: Relevance to Tropical Horticulture. In: F Engelmann and H Takagi (ed.) *Cryopreservation of Tropical Plant Germplasm-Current Research Progress and Application*, IPGRI (Rome) and JIRCAS (Japan). IPGRI, Rome, pp 360-365.
- Hanna WW and LE Towill (1995) Long-term pollen storage. In: J Janick (ed.) *Plant Breeding Reviews* John Wiley and Sons, Chester, USA, pp 179-207.
- Hoekstra FA (1995) Collecting Plant Genetic Diversity. In: L Guarino, V Ramanatha Rao and R Reid (ed.) *Technical guidelines*, CAB International Walling Ford U.K.
- Rajasekharan PE and S Ganeshan (1994) Pollen Cryopreservation in Vegetables as a Possible Aid to Heterosis Breeding. In: *Proceeding of 8<sup>th</sup> Kerala Science Congress* 27-29 January 1994. Thiruvananthapuram, pp 185-186.

## Conservation of Endangered Medicinal Plants: Challenges and Options

**PE Rajasekharan, S Ganeshan and Sunitha Bhaskaran**

*Division of Plant Genetic Resources, Indian Institute of Horticultural Research, Hessaraghatta Lake PO, Bangalore-560089, Karnataka*

**Key Words:** Endangered Species, *In Vitro*, Micropropagation, Hardening

India has about 8000 species of known medicinal plants. Using the current global rates of species extinction around 10 to 12% of the plants *i.e.*, around 800–1000 species are likely to be threatened. For developing conservation strategies it is essential to study their extent of occurrence (geographic range, endemism), assess their degree of threat based on International Union for the Conservation of Nature (IUCN) categories *viz.* - vulnerable, endangered, critically endangered *etc.*, harvesting practices, habitat specificity and growth forms (Mali and Ved, 1999). More of shrubs and less of herbs, which is expected from a random distribution among natural flora, appear to be among the rare/endangered (RE) group (Lokesha and Vasudeva, 1997). This suggests that shrubs have a higher risk of becoming endangered than herbs. Data on mode of dispersal suggest that a greater fraction of species that disperse their propagules through biotic agents than through wind, water or by passive means are likely to become RE. It may be important to use these syndromes as indications to identify the RE species and concentrate conservation efforts on these species. As a concept, rarity is a phenomenon in time as well as space (Harper, 1986).

Criteria used to assess the threat status of plant species as the class of rarity vary. Correct definition is important for formulating conservation policies

especially for countries like India with 11% of world's floral diversity.

Plant tissue culture techniques are now being used globally for the multiplication of medicinally important plant species and monitoring of their secondary metabolites. The application of micropropagation techniques for medicinal plants gives many benefits to the breeders as it enables to increase the rate of rapid multiplication of plants which in a particular climate do not provide seeds or where seeds have low germination, the availability of plants throughout the year, producing uniform clones from highly heterozygous plants, production of plants with changed genotypes, conservation of genetic resources of species and threatened plant and improvement by regeneration technique (Srivastava and Pande, 1998). Successful *in vitro* regeneration of medicinal plants could be made possible with varied explants such as leaf and stem segments, shoot buds, hypocotyls, cotyledons, roots, and seedlings.

Micropropagation holds promise as a major component in medicinal plant breeding. Its benefits derive from *in vitro* culture and multiplication of axenic shoots excluding callus formation and association problems (Constabel, 1990). Axenic shoot (tip) cultures can be employed not only for multiplication, but also for storage.

Development of efficient plant regeneration protocols for threatened plants of medicinal and aromatic value is a recent phenomenon. The methods for the micropropagation include stimulation of axillary bud, proliferation from shoot tip and nodal explants, induction of somatic embryogenesis using explants.

Plant materials were collected from the Western Ghats of Kerala and Karnataka and relocated in the *ex situ* conditions in Bangalore for the establishment of Field Gene Bank (FGB).

Shoot tips and single nodal cuttings of *ex situ* established plants were taken and surface sterilized using 0.1% HgCl<sub>2</sub> for 5 min in *Rauvolfia* and *Tylophora*, 7 min in *Aristolochia*, *Curculigo* and *Gloriosa* and for 10 min in *Kaempferia*. Inoculations were done in MS medium (Table 1).

Rooted shoots were taken out, washed and transferred to polybags containing soilrite and kept in a hardening chamber for four week. After this the plants were ready for planting in the field. Cultures were transferred to 10°C or 15°C with dim light for storage studies.

Thus, protocols were optimized for micropropagation of above mentioned threatened species of medicinal importance. Species response to *in vitro* culture was varied. In all cases, MS medium gave good response. The micropropagated plants were successfully planted out in pots with over 90% survival. Once the protocols for propagation are optimized *in vitro* raised conservation also attempted by shifting the *in vitro* plants to low temperatures like 10°C or 15°C with low light. Most of the *in vitro* plants survived the low temperature treatment.

**Table 1. *In vitro* multiplication of different threatened medicinal plant species**

| Species                     | Medium                               | No. of weeks for first response | No. of shoots in 3 months | Rooting                                 | No. of months for <i>in vitro</i> plant |
|-----------------------------|--------------------------------------|---------------------------------|---------------------------|-----------------------------------------|-----------------------------------------|
| <i>A. tagala</i>            | ½ MS, MS                             | 2 weeks                         | 2-5                       | Simultaneous                            | 1 month                                 |
| <i>Curculigo orchiodes</i>  | ½ MS                                 | 15 days                         | 3.5                       | Simultaneous                            | 1 month                                 |
|                             | MS                                   |                                 | 5                         |                                         |                                         |
|                             | ½ MS+ 5 mg/IBAP                      |                                 | 3                         |                                         |                                         |
|                             | WPM                                  |                                 | 3                         |                                         |                                         |
| <i>Gloriosa superba</i>     | MS                                   | 1.5 months                      | 3                         | Simultaneous                            | 1.5 month                               |
| <i>Kaempferia galanga</i>   | ½ MS + 8.87 µM BAP                   | 4 weeks                         | 10                        | Simultaneous                            | 2 months                                |
| <i>Rauvolfia serpentina</i> | ½ MS+ 8.87 µM BAP +0.54 µM NAA       | 3 weeks                         | 10                        | Simultaneous with shoot regeneration    | 3 months                                |
| <i>Tylophora indica</i>     | ½ MS+ 4.44 µM NAA BAP ++ 0.54 µM NAA | 2 weeks                         | 7                         | Simultaneous with shooting regeneration | 1 month                                 |

## References

- Constabel (1990) Medicinal Plant Biotechnology. *Planta Medica* 56: 421-425.
- Srivastava and Pande (1998) *In vitro* propagation and conservation of medicinal plants. In: *Plant Tissue Culture and Molecular Biology; Application and Prospects*. Narosa Publishing House, New Delhi, pp 254-281.
- Harper JH (1986) The meaning of rarity. In: ME Soule, (ed.) *Conservation Biology the Science of Scarcity and Diversity* Sinauer Sunderland, pp 189-203.
- Lokesha R and Vasudeva R (1997) Patterns of life history traits among rare/endangered plants of South India. *Curr. Sci.* 171-172.
- Mali S and DK Ved (1999) Medicinal plant conservation: number does matter. *Amruth* 3: 15-18.

## Clonal Propagation and *In Vitro* Conservation of Jojoba [*Simmondsia chinensis* (Link) Schneider]

**RK Tyagi and S Prakash**

*Tissue Culture and Cryopreservation Unit, National Bureau of Plant Genetic Resources, New Delhi-110012*

**Key Words:** Clonal Propagation, Conservation, Jojoba, Tissue Culture

*Simmondsia chinensis* (Link) Schneider, popularly known as 'jojoba' or 'hohoba', is an evergreen, dioecious desert shrub, belonging to the family Simmondsiaceae. The plant is valued for its seeds, which store liquid wax (50% dry wt.). The properties of jojoba oil are similar to that of spermaceti and it is widely used as lubricant for heavy machinery, in cosmetic, pharmaceuticals and plastic industries (Benzioni, 1995). The vegetative propagation of jojoba via conventional stem cuttings did not prove effective due to lengthy procedure and slow growth (Lee *et al.*, 1985; Benzioni, 1995). Therefore, vegetative propagation of jojoba through tissue culture-raised plants becomes the obvious choice. The conservation of germplasm is imperative for the breeding programmes, as the diversity in the crop harbours genes for various important traits. Amongst the various approaches for *ex situ* conservation, tissue culture is potential technique for conservation of those plants where either seeds are not set or heterozygosity is prevalent among seeds. *S. chinensis* is dioecious in nature and cross-pollinated (Gentry, 1958). Therefore, *in vitro* conservation is the best alternative to maintain the true-to-type plants for such crops. Development of micropropagation protocol is a pre-requisite for *in vitro* conservation. Though some attempts have been made earlier to obtain the plants of jojoba clonally from sexually known plants using tissue culture (Chaturvedi and Sharma, 1989; Llorente and Apostolo, 1998) but none of these reports mention the differential responses of male and female explants. The present study aimed to investigate the twin objectives (a) clonal propagation via tissue culture and (b) *in vitro* conservation of male and female accession of *S. chinensis*.

Healthy twigs (20-30 cm long) were excised from 20-year-old female and male plants of *S. chinensis* (EC 99691 Ex-USA) growing at NBPGR Regional Research Station, Jodhpur, Rajasthan. The twigs were thoroughly washed under running tap water for 30 min. After defoliating, 20 nodal segments (1-2 cm) from each male and female plants were excised, surface sterilized with

freshly prepared 0.2%  $\text{HgCl}_2$  for 10 min and finally rinsed 4 or 5 times with sterile distilled water in laminar flow cabinet. The cut ends of the explants which had turned brown were trimmed prior to culture for their establishment in the medium. The pH of the media was adjusted to 5.8 with 1N HCl or 1N NaOH. The culture vessels (25 x 150 cm; Borosil) containing media (20 ml) enclosed with polypropylene caps were autoclaved at 121°C and 15 psi pressure for 15 min. All the cultures were incubated in a culture room at  $25 \pm 2^\circ\text{C}$  under photo period 16 h provided by cool white fluorescent tubes (40 W, Philips, India) with 40 mmol/m<sup>2</sup>/s illumination. Further experiments were carried out using the nodal segments (*ca.* 1 cm) excised from the shoots obtained from mature explants in cultures. Murashige and Skoog's (hereafterward referred to as MS) medium (1962) was used as basal medium and served as control. The nodal explants were cultured on MS supplemented with various concentrations (2, 5, 10  $\mu\text{M}$ ) of N<sup>6</sup>-benzyladenine (BA). The *in vitro* regenerated shoots were given a pulse treatment of 50  $\mu\text{M}$  indole-3-butyric acid (IBA) for 1-20 min. and implanted on semi-solid MS + 10  $\mu\text{M}$  IBA + 0.5% activated charcoal (AC) for induction of roots. Shoots with small roots; more aptly plantlets, were transferred to MS liquid medium (devoid of iron) supplemented with 5  $\mu\text{M}$  BA and containing cotton as support matrix in the culture tubes for elongation. Shoot cultures obtained on control and MS + 2-10  $\mu\text{M}$  BA were maintained as such (without subculture) and studied for conservation on their respective culture media.

Data were recorded for number of shoots/culture, shoot length (cm), % of rooting cultures, number of roots/shoot and root length (cm) after a periodic interval of 30 days. Conservation period was computed when the 50% shoots of a culture died and the remaining shoots were further subcultured on defined media. All the experiments replicated thrice; each replicate comprised 10 cultures. Infected cultures are not counted for computing the mean values. Therefore, data are based on 25-30 cultures for each treatment.

Following the surface sterilization described earlier, 20% in male and 52% in female explants established in cultures. Among the various concentrations of cytokinin tested, 10  $\mu$ M BA supported shoot regeneration in nodal explants excised from both male and female plants that were used for initial establishment of cultures. Two or three shoots/explant regenerated in 10% of male and 25% of female explants during 3 months on MS + 10  $\mu$ M BA. For further experiments, the nodal explants derived from these shoots were used. Direct shoot regeneration occurred on all the media tested in cultures of both types of explants (male and female). Within 1 week, the shoot (0.3-0.5 cm long) regeneration was observed in all the cultures. Male nodal explants elicited the best response *i.e.* 4.1 shoots/culture, as obtained on MS + 5  $\mu$ M BA in 60 d from culture. In 90-d-old cultures, the shoot propensity increased to 5.5 shoots/culture with 2.0 cm length on the same medium (Table 1). In female nodal explants, MS + 10  $\mu$ M BA was found optimal for shoot regeneration (6.7 shoots/culture) in 60 days and subsequently 8.7 shoots/culture with 1.7 cm length were obtained in 90 d from culture on the same medium (Table 1). Direct shoot regeneration was obtained from axils of node of the explants, however, callus formation was observed from the basal cut ends. The effectiveness of BA for micropropagation of jojoba has already been documented (Llorente and Apostolo, 1998; Roussos *et al.*, 1999). However, Chaturvedi and

Sharma (1989) reported 5-8 shoots/nodal explants of jojoba on Schenk and Hildebrandt (1972) supplemented with BA in combination with indole-3-acetic acid (IAA).

The shoots (1-2 cm) were excised and initially given a pulse treatment of 50  $\mu$ M IBA for different duration (1-20 min) for *in vitro* rhizogenesis. The pulse treated-shoots were vertically implanted on MS + 10  $\mu$ M IBA + 0.5% AC. For both the male and female shoots 50  $\mu$ M IBA for 20 min proved to be the best as 53% of male shoots and 67% of female shoots developed roots within 30 d (Table 2). To facilitate elongation of roots, the shoots (1-2 cm) with small roots (2-3 cm) were transferred to MS liquid medium (devoid of iron) containing 5  $\mu$ M BA and cotton as support matrix. Shoots as well as roots elongated to 4-5 cm each in 2 months on the same medium. The plantlets are ready for hardening treatment.

On the basis of survey of literature, to the best knowledge of the authors, no report is available on the conservation of *S. chinensis*. During storage in both the male and female cultures, the development of new shoot was accompanied by the senescence of existing shoots on MS (control) as well as on MS supplemented with BA. During the period of conservation, *ca.* 15% cultures contaminated. A significant difference was recorded for the conservation period, between the shoot cultures of male and female. In comparison to control, the conservation

**Table 1. Clonal propagation and conservation period of male and female *S. chinensis***

| Medium<br>MS+BA ( $\mu$ M) | Male                      |                       |                               | Female                     |                       |                               |
|----------------------------|---------------------------|-----------------------|-------------------------------|----------------------------|-----------------------|-------------------------------|
|                            | No. of shoots/<br>culture | Shoot length*<br>(cm) | Conservation<br>period (days) | No. of shoots/<br>culture* | Shoot length*<br>(cm) | Conservation<br>period (days) |
| 0<br>(control)             | 1.7                       | 1.2                   | 150                           | 2.4                        | 1.4                   | 210                           |
| 2                          | 4.6                       | 1.5                   | 240                           | 3.4                        | 1.7                   | 210                           |
| 5                          | 5.5                       | 2.0                   | 240                           | 5.0                        | 1.8                   | 240                           |
| 10                         | 3.0                       | 1.5                   | 270                           | 8.7                        | 1.7                   | 360                           |

\* Data were recorded after 90 d from culture

**Table 2. Effect of pulse treatment of IBA (50  $\mu$ M) on the root induction of *S. chinensis* (Culture age: 30 d from transfer on rooting medium)**

| Time of pulse<br>treatment (min) | Male                   |                        |                     | Female                 |                        |                     |
|----------------------------------|------------------------|------------------------|---------------------|------------------------|------------------------|---------------------|
|                                  | Rooting<br>culture (%) | No. of roots/<br>shoot | Root<br>length (cm) | Rooting<br>culture (%) | No. of roots/<br>shoot | Root length<br>(cm) |
| 0 (control)                      | 0                      | 0                      | 0                   | 0                      | 0                      | 0                   |
| 2                                | 25                     | 1.5                    | 0.7                 | 25                     | 1.6                    | 1.9                 |
| 10                               | 27                     | 2.7                    | 0.8                 | 42                     | 3.0                    | 2.6                 |
| 20                               | 53                     | 3.0                    | 1.5                 | 67                     | 5.0                    | 2.7                 |

period of male shoot cultures increased significantly with the increased concentration of BA and recorded maximum as 270 days on MS + 10  $\mu$ M BA. The female shoot cultures were found better storer than the male counterparts; as the cultures could survive up to 360 days on the same medium (Table 1).

On the basis of the responsive cultures, 3 shoots/nodal-explants regenerated in 30 days and each shoot bore 3 nodes. On extrapolation of the available data, an average of 1,06,819 female and 84,498 male plantlets can be obtained on MS medium supplemented with 10  $\mu$ M and 5  $\mu$ M BA, respectively. Female plants not only produced more number of plantlets than the male ones but also could be conserved for longer duration. The present study describes the simple protocols for clonal propagation and medium-term conservation of jojoba. For long-term conservation, the experiments are in progress to standardize the cryopreservation protocols using encapsulation and dehydration methods.

**Acknowledgements:** The authors are grateful to Director, National Bureau of Plant Genetic Resources (NBPGR), New Delhi, for providing the facilities. The authors are also thankful to Office-in-Charge, NBPGR, Regional Station Jodhpur, for providing the plant materials. The

financial support from Department of Biotechnology, Government of India, is also gratefully acknowledged.

## References

- Benzioni A (1995) Jojoba domestication and commercialization in Israel. *Hortic. Rev.* 17: 233-266.
- Chaturvedi HC and M Sharma (1989) *In vitro* production of cloned plants of jojoba (*Simmondsia chinensis* (Link) Schneider) through shoot proliferation in long term culture. *Plant Sci.* 63: 199-207.
- Gentry HS (1958) The natural history of jojoba (*Simmondsia chinensis*) and its cultural aspects. *Econ. Bot.* 12: 261-295.
- Lee ECW, JC Thomas and SL Buchmann (1985) Factors affecting *in vitro* germination and storage of jojoba pollen. *J. Amer. Soc. Hortic. Sci.* 110: 671-677.
- Llorente B and NM Apostolo (1998) Effect of different growth regulators and genotype on *in vitro* propagation of jojoba. *New Zealand J. Crop Hortic. Sci.* 26: 55-62.
- Murashige T and F Skoog (1962) A revised medium for rapid growth and bio assays with tobacco tissue cultures. *Physiol. Plant.* 15: 473-497.
- Roussos PA, A Tolia-Marioli, CA Pontikis and D Kotsias (1999) Rapid multiplication of jojoba seedlings by *in vitro* culture. *Plant Cell Tiss. Org. Cult.* 57: 133-137.
- Schenk RU and AC Hildebrandt (1972) Medium and techniques for induction and growth of monocotyledonous and dicotyledonous plant cell cultures. *Can. J. Bot.* 50: 199-204.

## Effects of Polyamines on *In Vitro* Conservation of *Vanilla planifolia* (Salisb.) Ames

**RK Tyagi, A Yusuf, P Jeyaprakash\* and Poonam Dua**

*Tissue Culture and Cryopreservation Unit, National Bureau of Plant Genetic Resources, New Delhi-110012*

**Key words:** *In Vitro* Conservation, Putrescine, Spermidine, *Vanilla*

*Vanilla planifolia*, a tropical orchid, belongs to the family Orchidaceae. It is grown for its fruits that yield vanilla flavour used in food, beverages and ice creams etc. Although, seed setting occurs in *Vanilla* but the seed viability is very low, therefore, it is propagated vegetatively through cuttings. Plantlet regeneration *via* callus (Davidonis and Knorr, 1991; Philip and Nainar, 1986) and without callus in *V. planifolia* has been reported

(George and Ravishankar, 1997). Polyamines are a group of ubiquitous, polycationic substances found in the prokaryotic and eukaryotic cells, that influence the cellular and developmental processes (Dey *et al.*, 1998). Embryogenesis, senescence and flowering are reported to be influenced by polyamines in cucumber (Tassoni *et al.*, 1996) and higher catabolism of polyamines in the organogenesis from leaf disc was reported in *Chrysanthemum* (Aribaud *et al.*, 1999). With the assumption that exogenous supply of polyamines will influence the senescence in shoot cultures of *V. planifolia*,

\*Agricultural Research Station, Tamil Nadu Agricultural University, Paramakudi, Tamil Nadu-623707

period of male shoot cultures increased significantly with the increased concentration of BA and recorded maximum as 270 days on MS + 10  $\mu$ M BA. The female shoot cultures were found better storer than the male counterparts; as the cultures could survive up to 360 days on the same medium (Table 1).

On the basis of the responsive cultures, 3 shoots/nodal-explants regenerated in 30 days and each shoot bore 3 nodes. On extrapolation of the available data, an average of 1,06,819 female and 84,498 male plantlets can be obtained on MS medium supplemented with 10  $\mu$ M and 5  $\mu$ M BA, respectively. Female plants not only produced more number of plantlets than the male ones but also could be conserved for longer duration. The present study describes the simple protocols for clonal propagation and medium-term conservation of jojoba. For long-term conservation, the experiments are in progress to standardize the cryopreservation protocols using encapsulation and dehydration methods.

**Acknowledgements:** The authors are grateful to Director, National Bureau of Plant Genetic Resources (NBPGR), New Delhi, for providing the facilities. The authors are also thankful to Office-in-Charge, NBPGR, Regional Station Jodhpur, for providing the plant materials. The

financial support from Department of Biotechnology, Government of India, is also gratefully acknowledged.

## References

- Benzioni A (1995) Jojoba domestication and commercialization in Israel. *Hortic. Rev.* 17: 233-266.
- Chaturvedi HC and M Sharma (1989) *In vitro* production of cloned plants of jojoba (*Simmondsia chinensis* (Link) Schneider) through shoot proliferation in long term culture. *Plant Sci.* 63: 199-207.
- Gentry HS (1958) The natural history of jojoba (*Simmondsia chinensis*) and its cultural aspects. *Econ. Bot.* 12: 261-295.
- Lee ECW, JC Thomas and SL Buchmann (1985) Factors affecting *in vitro* germination and storage of jojoba pollen. *J. Amer. Soc. Hortic. Sci.* 110: 671-677.
- Llorente B and NM Apostolo (1998) Effect of different growth regulators and genotype on *in vitro* propagation of jojoba. *New Zealand J. Crop Hortic. Sci.* 26: 55-62.
- Murashige T and F Skoog (1962) A revised medium for rapid growth and bio assays with tobacco tissue cultures. *Physiol. Plant.* 15: 473-497.
- Roussos PA, A Tolia-Marioli, CA Pontikis and D Kotsias (1999) Rapid multiplication of jojoba seedlings by *in vitro* culture. *Plant Cell Tiss. Org. Cult.* 57: 133-137.
- Schenk RU and AC Hildebrandt (1972) Medium and techniques for induction and growth of monocotyledonous and dicotyledonous plant cell cultures. *Can. J. Bot.* 50: 199-204.

## Effects of Polyamines on *In Vitro* Conservation of *Vanilla planifolia* (Salisb.) Ames

**RK Tyagi, A Yusuf, P Jeyaprakash\* and Poonam Dua**

*Tissue Culture and Cryopreservation Unit, National Bureau of Plant Genetic Resources, New Delhi-110012*

**Key words:** *In Vitro* Conservation, Putrescine, Spermidine, *Vanilla*

*Vanilla planifolia*, a tropical orchid, belongs to the family Orchidaceae. It is grown for its fruits that yield vanilla flavour used in food, beverages and ice creams etc. Although, seed setting occurs in *Vanilla* but the seed viability is very low, therefore, it is propagated vegetatively through cuttings. Plantlet regeneration *via* callus (Davidonis and Knorr, 1991; Philip and Nainar, 1986) and without callus in *V. planifolia* has been reported

(George and Ravishankar, 1997). Polyamines are a group of ubiquitous, polycationic substances found in the prokaryotic and eukaryotic cells, that influence the cellular and developmental processes (Dey *et al.*, 1998). Embryogenesis, senescence and flowering are reported to be influenced by polyamines in cucumber (Tassoni *et al.*, 1996) and higher catabolism of polyamines in the organogenesis from leaf disc was reported in *Chrysanthemum* (Aribaud *et al.*, 1999). With the assumption that exogenous supply of polyamines will influence the senescence in shoot cultures of *V. planifolia*,

\*Agricultural Research Station, Tamil Nadu Agricultural University, Paramakudi, Tamil Nadu-623707

the effects of two polyamines—putrescine and spermidine were studied and presented in this paper.

*In vitro* cultures of *V. planifolia*, obtained from Indian Institute of Spices Research, Kozhikode, Kerala, were used for the present study. These cultures were maintained on Murashige and Skoog's (1962) medium (hereafterward referred to as MS) supplemented with 0.5 mg/l IBA and 1.0 mg/l BA. MS medium was used as basal medium and served as control. In addition to MS + 0.5 mg/l IBA + 1.0 mg/l BA (regeneration medium), two polyamines (putrescine and spermidine) were tested to study their effects on regeneration and conservation of *V. planifolia*.

Four concentrations of each spermidine and putrescine (0.25, 0.5, 0.75 and 1.0 mg/l) were incorporated into MS medium. Nodal segments (*ca.* 2-3 cm), internodes (*ca.* 3-4 cm), leaf segments (*ca.* 2-3 cm) and roots (*ca.* 3-4 cm) were excised and cultured onto the defined media. The media were solidified with 0.7% (w/v) agar-agar (Qualigens, India). The pH of all the media were adjusted to 5.7 prior to autoclaving at 121°C and 1.06 Kg/cm<sup>2</sup> for 20 min. All cultures were raised in culture tubes (25x150 mm; Borosil) containing 20 ml of the medium. Each culture tube received one explant. The cultures were incubated at 25 ± 2°C and 16 h photoperiod with 40 mmolm<sup>-2</sup>s<sup>-1</sup> photon flux density provided by the white fluorescent tubes (Phillips, India). All the chemicals and growth substances used were of analytical grade (Qualigens, Hi-Media and Sigma). All the treatments comprised 12 cultures and replicated twice. Thus, the mean values were computed on the basis of 24 cultures for each treatment. Observations were recorded at a periodic interval of 15 d for number of shoots/culture, shoot length and callus regeneration. Survival of shoot cultures was considered up to the stage that 50% shoots of a culture are green and healthy and subcultured on fresh medium; the period was considered as conservation period.

Nodal segments swelled in all the treatments of putrescine and spermidine within a week period. In 15-d-old cultures, one or two shoots were observed in all the cultures including that on MS and other treatments (Table 1). No further increment in the number of shoots was observed in any of the cultures. Although, observations were recorded at 15 d interval but explant did not show any remarkable change at this short interval, therefore, the data of number of shoots and shoot length are not presented at different intervals in Table 1 but for 15

d. To increase the conservation period, it is desirable to develop a protocol that supports the slow growth of shoots in tissue cultures. Polyamines tested in the present study showed the positive influence on conservation period. Of the four concentrations of putrescine and spermidine tested, the lowest concentration of putrescine was found better for the conservation of shoot cultures obtained from nodal segments. On MS + 0.25 mg/l putrescine, the shoot cultures of *V. planifolia* could be conserved for 290 d without subculture or replacement of fresh medium which is significantly higher than that on MS (110 d). It is to be noted that no callus was observed in shoot cultures on 0.25 mg/l putrescine supplemented medium. With the increase in the concentration of putrescine, generally conservation period did not increase significantly, however, the number of shoots increased significantly on MS + 1.0 mg/l putrescine with decreased length of shoots (Table 1). Wound callus formed in about 80% of the cultures at the cut ends of the explants cultured on > 0.25 mg/l putrescine supplemented media, however, the shoots were healthy and equivalent to that obtained on 0.25 mg/l putrescine. Unlike putrescine, conservation period increased with increased concentrations of spermidine. It was recorded maximally as 320 d for the shoot cultures obtained from nodal segments cultured on MS + 1.0 mg/l spermidine (Table 1). All the cultures raised on spermidine supplemented media, showed white callus at the cut ends of the explants which later turned to green and

**Table 1.** Effects of polyamines on *in vitro* conservation of *V. planifolia* (explant: nodal segment)

| Treatment                       | No. of shoots/culture | Shoot length (cm) | Conservation period (days) | Callus intensity |
|---------------------------------|-----------------------|-------------------|----------------------------|------------------|
| MS (control)                    | 1.1                   | 1.9               | 110                        | -                |
| MS + 0.5 mg/l IBA + 1.0 mg/l BA | 2.0                   | 1.7               | 150                        | -                |
| MS + putrescine (mg/l)          |                       |                   |                            |                  |
| 0.25                            | 1.4                   | 1.8               | 290                        | -                |
| 0.50                            | 2.2                   | 1.4               | 280                        | +                |
| 0.75                            | 2.8                   | 1.0               | 295                        | +                |
| 1.00                            | 3.2                   | 0.5               | 290                        | ++               |
| MS + spermidine (mg/l)          |                       |                   |                            |                  |
| 0.25                            | 3.0                   | 1.5               | 295                        | +                |
| 0.50                            | 1.5                   | 1.1               | 290                        | +                |
| 0.75                            | 1.3                   | 1.1               | 310                        | +                |
| 1.00                            | 1.3                   | 0.5               | 320                        | +                |

– no callus; + little callus; ++ moderate callus

produced hairy roots on the surface of the callus. Callus formation has been observed due to high accumulation of polyamines in *Chrysanthemum morifolium* (Aribaud *et al.*, 1999). Although culture could be conserved for 320 d in spermidine-supplemented medium, but due to callus formation, spermidine can not be recommended for conservation as it may induce genetic instability during prolonged period of conservation.

Root explants produced green callus from the whole surface of the explant at 0.5 mg/l of putrescine and spermidine. The callus turned regenerative after 60 d from culture and produced small shoot buds, but did not elongate. Lower concentration of putrescine (0.25 mg/l) supported yellowish callus at the cut ends of the roots and proliferated into a callus mass, which turned brown within 40 d and discarded. On higher concentrations of putrescine (0.75 and 1.0 mg/l) supplemented media, root explants produced hard white callus from the whole surface of the explant and developed into white globular structures. These structures remained quiescent (for 2-3 months) and later turned brown.

Leaf and internodal explants did not elicit any regenerative response on media supplemented with polyamines up to 90 d. In 120-d-old cultures, the leaves cultured on 1.0 mg/l putrescine, produced white globular embryogenic mass from the surface which was in contact with the medium. These cultures are under observation. The remaining cultures raised from leaf and internodal segments at lower concentrations of putrescine and spermidine (0.25-0.75 mg/l) turned brown within 120 d from culture.

To maintain genetic stability, direct regeneration (without callus) is a pre-requisite to develop the protocol for conservation in tissue culture. To conserve the shoot

cultures of *V. planifolia*, MS + 0.25 mg/l putrescine was adjudged the best amongst the tested media as it did not induce callus and the cultures could be conserved up to 290 days. The protocol is simple and reproducible. The efficacy of this protocol is being tested for *in vitro* conservation of other genotypes of *V. planifolia* at NBPGR.

**Acknowledgments:** The authors are thankful to the Director, National Bureau of Plant Genetic Resources, New Delhi for providing facilities. Financial assistance by Department of Biotechnology, Government of India, is gratefully acknowledged. P Jeyaprakash is thankful to Tamil Nadu State Council for Science and Technology, Chennai, for award of Young Scientists Fellowship.

### References

- Aribaud M, C Kevers, MJ Tanguy and T Gaspar (1999) Low activity of amino-oxidases and accumulation of conjugated polyamines in disfavoured of organogenic programs in *Chrysanthemum* leaf disc explants. *Plant Cell Tiss. Org. Cult.* **55**: 85-94.
- Davidonis G and D Knorr (1991) Callus formation and shoot regeneration in *Vanilla planifolia*. *Food Biotechnol.* **5**: 59-66.
- Dey M, S Kalia, S Gosh, S Guha-Mukherjee, S Kalia and S Gosh (1998) Biochemical and molecular basis of differentiation in plant tissue culture. *Curr. Sci.* **74**: 591-596.
- George PS and GA Ravishankar (1997) *In vitro* multiplication of *Vanilla planifolia* using axillary bud explants. *Plant Cell Rep.* **16**: 490-494.
- Murashige T and F Skoog (1962) A revised medium for rapid growth and bioassays with tobacco tissue culture. *Physiol. Plant.* **15**: 473-497.
- Philip VJ and SAZ Nainar (1986) Clonal propagation of *Vanilla planifolia* (Salisb.) Ames using tissue culture. *J. Plant physiol.* **122**: 211-215.
- Tassoni A, F Antognoni and N Bagni (1996) Polyamine binding to plasma membrane vesicles isolated from Zucchini hypocotyls. *Plant. Physiol.* **110**: 817-824.

## Handling of Indigenous Plant Genetic Resources at NBPGR

**Sanjeev Saxena, Neeru Jain, Rajeev Koppar, Amitabh B Chaudhary and Devander Chauhan**

*National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012*

**Key Words:** Accessioning, Conservation, Germplasm

Plants play an indispensable role in the sustenance of life on this planet, being the source of food, fodder, fuel wood and minor forest products. India is one of 12 mega biodiversity regions of the world, harbouring two (Western Ghats and North Eastern Himalayas), out of the 18 'hot spot' regions of the world.

National Bureau of Plant Genetic Resources (NBPGR) is actively involved in collection and conservation of genetic resources in India, since its inception. However, to further strengthen these activities, National Agriculture Technology Project (NATP) on Plant Biodiversity (PB) was formulated. It aims at systematic collection, evaluation, conservation and utilization of agro-biodiversity of India.

Indian sub-continent harbours a wide spectrum of agro climatic conditions. Therefore to achieve the goals of NATP-PB, India has been divided into 10 regions, viz.- Arid Region (Zone I), South West Coastal Region and A & N Islands (Zone II), Humid/Moist Tropical East Coastal Region (Zone III), North Eastern Region (Zone IV), Central West Himalayas (Zone V), North West Sub-Himalayan and High altitude Himalayan Region (Zone VI), North Western Plains (Zone VII), Subtropical/Subhumid Region (Zone VIII), Central Plains (Zone IX) and South East Coastal Region (Zone X).

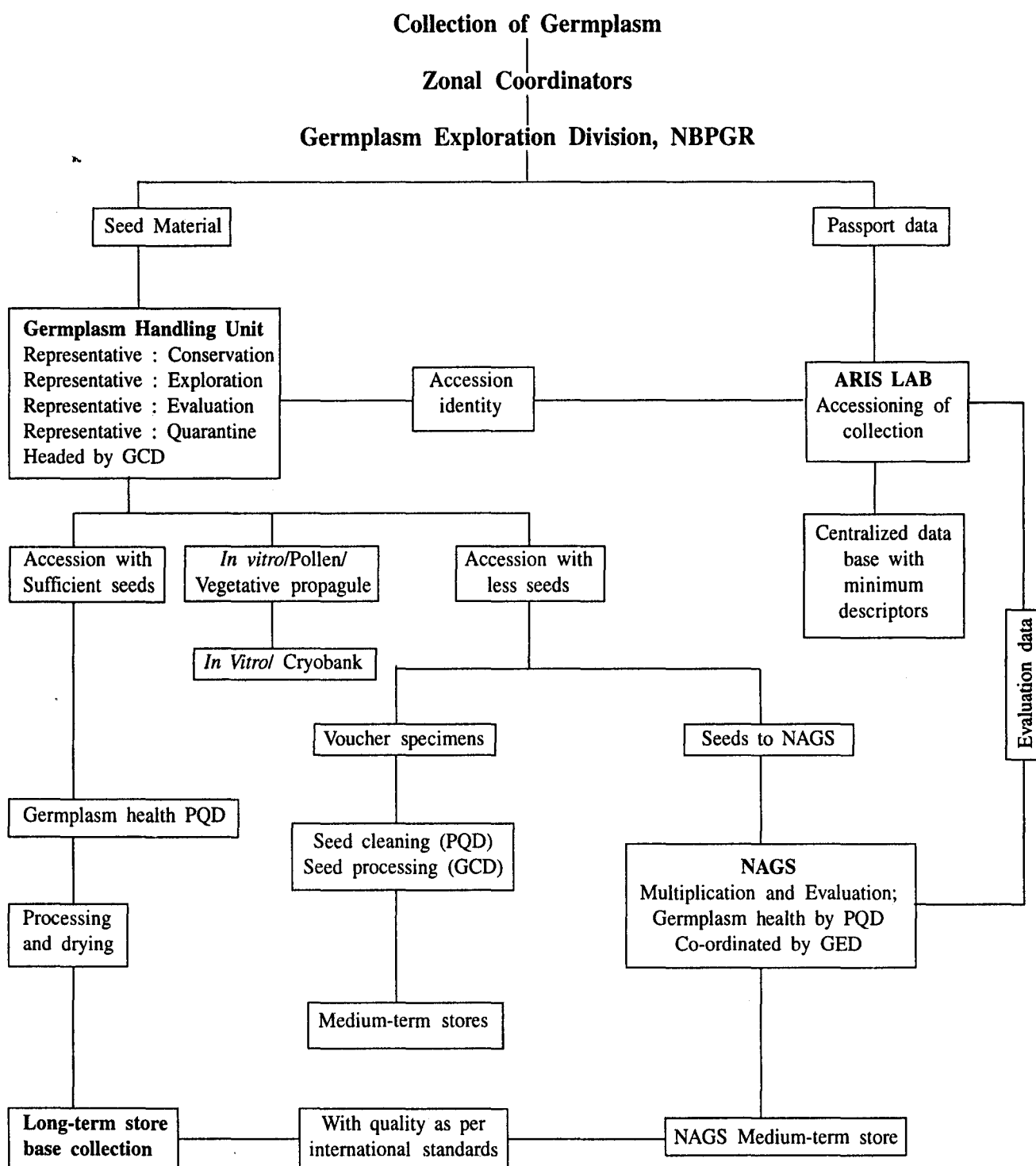
The Germplasm Handling Unit (GHU) was constituted at the headquarters of NBPGR to streamline the conservation activities of the germplasm collected under NATP (Fig.1). The activities of GHU were initiated in April 2000 and has scientific representation from all the divisions of the Bureau.

The collector divides the collected germplasm in three sets. One set is retained by the collector, one is sent to the zonal leader and the third set to CCPI, Exploration Division at headquarters. All the collected germplasm is handed over to GHU by CCPI, Germplasm Exploration. The germplasm received by the GHU is being maintained as voucher specimens in medium-term storage (MTS). The

information is sent to the Agricultural Research Information System (ARIS) cell for allotment of IC (indigenous collection) number to the collected germplasm, which is validated by GHU. So far germplasm collected from 380 explorations have been handed over to GHU. Before keeping the germplasm in MTS, all the received accessions are physically examined to remove the infested/infected accessions. These infected accessions are handed over to Plant Quarantine Division (PQD) for salvaging. So far 345 accessions have been salvaged by PQD and have been handed over to GHU for maintenance in MTS modules. The vegetative propagules of the crops are either handed over for *in vitro* conservation or to the PI (Principal Investigator) for maintenance in the field gene bank, depending on the availability of the regeneration protocols. The propagules of 29 accessions of vegetatively propagated plants such as ginger, turmeric, garlic *etc.* are being maintained *in vitro* storage conditions.

The seeds with recalcitrant behaviour, where the moisture content can not be reduced beyond a certain level, are conserved through the technique of cryopreservation. So far 322 accessions have been handed over for cryopreservation. Apart from recalcitrant seeds, 175 such accessions of core collections have also been conserved employing this approach. While, the orthodox seeds, where the moisture content can be reduced up to 3-5% without losing the viability, are conserved in the gene bank (MTS). Such accessions are arranged serially in the basket according to the allotted IC number. In the MTS more than 24,800 accessions are being conserved (Table 1). The information is maintained in the database providing the details regarding the explorations carried out, quality and quantity of germplasm and storage place in the gene bank. The collected germplasm elicits a wide range of diversity both within the genera as well as within species. The details of the germplasm of different crop group clearly indicates the extent of variability being collected and conserved so far (Table 2).

## FLOW OF MATERIAL COLLECTED UNDER NATP



GCD = Germplasm Conservation Division; PQD = Plant Quarantine Division; GED = Germplasm Evaluation Division;  
ARIS = Agricultural Research Information Services; NAGS = National Active Germplasm Sites

Fig. 1. Flow of material collected under NATP

Table 1. Summary report of all 10 zones

| No. of explorations |     | Status of germplasm |       |          |       |               |       | Maintenance of received germplasm |      |      |                       |     |      | Status of VP/LP not received |      |      |
|---------------------|-----|---------------------|-------|----------|-------|---------------|-------|-----------------------------------|------|------|-----------------------|-----|------|------------------------------|------|------|
|                     |     | Collected           |       | Received |       | Not available |       | Seeds                             |      |      | Vegetative Propagules |     |      | FGB                          | Her. | NI   |
|                     |     | Seeds               | VP/LP | Seeds    | VP/LP | Seeds         | VP/LP | MTS                               | Cryo | Rej. | In vitro              | FGB | Rej. |                              |      |      |
| Zone I              | 66  | 1865                | 184   | 1856     | 0     | 9             | 184   | 1845                              | 10   | 1    | 0                     | 0   | 0    | 0                            | 0    | 184  |
| Zone II             | 47  | 2243                | 195   | 1815     | 2     | 428           | 193   | 1769                              | 36   | 10   | 2                     | 0   | 0    | 86                           | 51   | 56   |
| Zone III            | 28  | 3013                | 402   | 2863     | 26    | 150           | 376   | 2823                              | 38   | 2    | 0                     | 0   | 26   | 63                           | 35   | 278  |
| Zone IV             | 23  | 2198                | 137   | 2096     | 20    | 102           | 117   | 2079                              | 4    | 13   | 4                     | 3   | 10   | 94                           | 0    | 23   |
| Zone V              | 28  | 3827                | 296   | 3478     | 31    | 349           | 265   | 3390                              | 76   | 12   | 17                    | 0   | 14   | 97                           | 6    | 162  |
| Zone VI             | 31  | 2250                | 59    | 1967     | 8     | 286           | 51    | 1880                              | 49   | 35   | 0                     | 0   | 8    | 1                            | 0    | 50   |
| Zone VII            | 82  | 5469                | 123   | 5080     | 12    | 389           | 111   | 4839                              | 185  | 56   | 6                     | 3   | 3    | 13                           | 20   | 78   |
| Zone VIII           | 17  | 1738                | 82    | 1683     | 2     | 550           | 80    | 1612                              | 49   | 22   | 0                     | 1   | 1    | 0                            | 0    | 80   |
| Zone IX             | 21  | 838                 | 127   | 837      | 0     | 1             | 127   | 805                               | 26   | 6    | 0                     | 0   | 0    | 0                            | 93   | 34   |
| Zone X              | 37  | 3904                | 299   | 3805     | 0     | 99            | 299   | 3776                              | 24   | 5    | 0                     | 0   | 0    | 133                          | 66   | 100  |
| Total               | 380 | 27345               | 1904  | 25477    | 101   | 1868          | 1803  | 24818                             | 497  | 162  | 29                    | 7   | 62   | 487                          | 271  | 1045 |

VP: Vegetative propagules, LP: Live plants, MTS: Medium-term storage, Rej.: Rejected; FGB gene bank, Her.: Herbarium, NI: No information

Table 2. Detailed account of germplasm received, till May 2001

| Crop group                    | Number of accessions |
|-------------------------------|----------------------|
| Cereals                       | 7735                 |
| Pseudo-cereals                | 425                  |
| Millet and Minor millets      | 2552                 |
| Oilseeds                      | 2468                 |
| Pulses                        | 4333                 |
| Fibres                        | 246                  |
| Forages                       | 743                  |
| Vegetables and spices         | 3850                 |
| Fruits and Nuts               | 206                  |
| Medicinal and aromatic plants | 1251                 |
| Miscellaneous                 | 1009                 |

The accession of orthodox seeds having sufficient seed quantity (meeting the Gene Bank standards) are handed over for long-term conservation. So far a total of 2,351 accession of cereals, millets, oilseeds, pulses, vegetables etc. have been handed over for Long-term Storage (LTS).

The status report are subsequently generated indicating the various details of the undertaken exploration, which are circulated to the PI and concerned CCPI's for confirming with the respective collaborators.

## Germplasm Monitoring at National Gene Bank

**Veena Gupta, Kalyani Srinivasan, Neeta Singh, Sanjeev Saxena, SK Jain, Anjali Kak, Manju Uprety, AD Sharma, RS Yadav, Toshi, Abha Sharma and A K Singh**

*Germplasm Conservation Division, National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012*

**Key Words:** Conservation, Gene Bank, Germplasm Monitoring, Seed Viability, Vigour

The Indian gene centre possesses rich plant biodiversity. National Bureau of Plant Genetic Resource (NBPGR) has been entrusted with the responsibility of conservation of genetic diversity in domesticated plant species and their wild relatives on long-term basis for posterity as base collections, as a part of a national network on conservation of plant genetic resource (PGR). To achieve this in case of orthodox seed producing species, seeds are processed and stored at  $-20^{\circ}\text{C}$  in long-term modules. The International Board on Plant Genetic Resources (IBPGR), Advisory Committee on Seed Storage recommends that seeds stored, as base collection should be monitored every 10 years, and as active collections every 5 years for their seed viability, seed quantity and seed health. These recommendations are of greater significance in case of tropical conditions of high temperature and relative humidity like India. Monitoring of germplasm is an essential component of safe conservation for sustainable use. The IBPGR recommendations on regeneration includes regeneration of an accession, if the seed viability falls below 85% of the original viability and/or the seed quantity falls below the number of the seeds required for a minimum of three regeneration cycles. The fall in seed viability is an indicator of setting of genetic deterioration.

In the Indian national gene bank a large number of accessions have been in-storage for more than 10 years. Therefore, the monitoring of all these accessions as per the IBPGR (now International Plant Genetic Resource Institute, IPGRI) recommendations became essential to follow international standards. The monitoring of germplasm at national genebank has been given priority in past few years to access the genetic potential of germplasm conserved and identify the accessions requiring regeneration. The accessions identified for regeneration using the above standard are being supplied to the concerned national active germplasm site(s) for regeneration.

The gene bank seed inventory records are checked

at regular intervals and the list of accessions, which are to be monitored, is prepared.

While removing the seeds for monitoring it is ensured that sufficient seed material is available for subsequent regeneration of the accession.

The seed containers are conditioned to room temperature. The seed containers are immediately sealed after removing the seed material to prevent the entry of moisture from air.

Following two methods of seed testing are used during seed viability monitoring:

*Fixed sample size germination test* : This test is done using 100 seeds, each in two replications, following a suitable method of germination test (top of paper or between paper). The germination percentage is calculated on the basis of seed germinated. If the percent germination is above 90, the test is accepted as valid. If it is below 90%, the test is repeated using another 200 seeds. The mean germination percentage is calculated, and if the germination percentage is below 85, the accessions are labelled for regeneration.

*Sequential germination test*: This method is used with accessions, with less quantity of seeds. In this method 40 seeds are used for germination test. The number of seed germinated are counted and the germination percentage is compared, with the number of seeds germinated (Table 1), to identify the accessions requiring regeneration.

The results of monitoring of germplasm in different crops have been summarised (Table 2) These results show that the germplasm accessions in most crops, except for oats, pigeon pea, chickpea, dolichos-bean, velvet-bean and cotton, have maintained the seed viability as per the international standards (without significant deterioration). Other crops like oats, pigeon pea and cotton etc. where the seed viability has gone down significantly, suggests their genetic deterioration and need for regeneration. Among these crops cotton registered the maximum deterioration in seed viability, which

Table 1. Sequential germination test

| No. of Seeds | Regenerate if number of germinated seed is $\leq$ | Repeat test if germination is between or equal to | Store if number of seeds germinated is $>$ |
|--------------|---------------------------------------------------|---------------------------------------------------|--------------------------------------------|
| 40           | 29                                                | 30-40                                             | --                                         |
| 80           | 64                                                | 65-75                                             | 76                                         |
| 120          | 100                                               | 101-110                                           | 111                                        |
| 160          | 135                                               | 136-145                                           | 146                                        |
| 200          | 170                                               | 171-180                                           | 181                                        |
| 240          | 205                                               | 206-215                                           | 216                                        |
| 280          | 240                                               | 241-250                                           | 251                                        |
| 320          | 275                                               | 276-285                                           | 286                                        |
| 360          | 310                                               | 311-320                                           | 321                                        |

Ellis *et al.*, 1980

Table 2. Results of monitoring of accessions of various crops stored for 10 or more years as base collections

| Crop name        | No. of acc. monitored | Initial viability range (%) | Present viability range (%) | Acc. with acceptable viability | % acc. for regeneration |
|------------------|-----------------------|-----------------------------|-----------------------------|--------------------------------|-------------------------|
| Wheat            | 71                    | 90-100                      | 85-100                      | 100**                          | Nil                     |
| Oat              | 84                    | 86-100                      | 59-100                      | 94**                           | 6                       |
| Barley           | 58                    | 94-100                      | 90-100                      | 100**                          | Nil                     |
| Maize            | 65                    | 80-100                      | 80-100                      | 100**                          | Nil                     |
| Amaranth         | 20                    | 87-100                      | 85-100                      | 100**                          | Nil                     |
| Pigeon pea       | 447                   | >85%                        | --                          | 98****                         | 2                       |
| Chickpea         | 55                    | 90-100                      | 82-100                      | 82*                            | 10                      |
| Mung             | 71                    | 90-100                      | 84-100                      | 97                             | 3                       |
| Dolichos         | 136                   | 80-85                       | 75-65                       | 64                             | 36                      |
| Urd              | 55                    | 85-90                       | 82-90                       | 98                             | 2                       |
| Welwet bean      | 13                    | 80-90                       | 75-85                       | 50                             | 50                      |
| Pea              | 575                   | 85-90                       | 80-85                       | 95                             | 5                       |
| Rapeseed mustard | 250                   | 80-100                      | 80-100                      | 100***                         | Nil                     |
| Sesame           | 72                    | 80-95                       | 80-90                       | 100***                         | Nil                     |
| Cotton           | 362                   | --                          | 0-59                        | 37**                           | 63                      |
| Jute             | 107                   | 90-100                      | 85-100                      | 100                            | Nil                     |
| Tobacco          | 75                    | 95-100                      | 92-96                       | 100*                           | Nil                     |
| Ocimum           | 14                    | 100                         | 100                         | 100*                           | Nil                     |
| Total            | 1573                  |                             |                             |                                |                         |

The above number has been calculated from: \*10% of the randomly selected accessions \*\*20% of the randomly selected accessions

\*\*\*40% of the randomly selected accessions

\*\*\*\*100% of the accessions stored

ranged from 0-59% where 63% of accessions requiring regeneration. These results are in the line the observation of some other gene banks, such as National Seed Storage Laboratory Fort Collins, USA.

Further, these results indicate that most cereals maintain their seed viability for longer duration, compared to other crops. Therefore, in such groups the monitoring interval can be extended from 10 to 15 years. Whereas, in crops like cotton or chickpea, which loses viability

comparatively faster, more frequent monitoring is required to ensure the original genetic structure of an accession through regeneration.

### References

- IBPGR (1994) Gene Bank Standard. FAO/IPGRI Rome 46.
- Ellis RH, EH Roberts and J Head White (1980) A new, more economic and accurate approach to monitoring the viability of accessions during storage in seed banks. *Plant Genet. Resour. Newslett.* 41: 3-18.

## Importance of Passport Data in Plant Genetic Resources Management

**Kalyani Srinivasan, NK Choudhary, Veena Gupta, Neeta Singh, Sanjeev Saxena, SK Jain, Anjali Kak, Chitra Devi, Manju Upreti, AD Sharma, RS Yadav, Toshi, Abha Sharma and AK Singh**

*Germplasm Conservation Division, National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012*

**Key Words:** Germplasm, Conservation, Passport Data

Conservation of Plant Genetic Resources (PGR) without use has little importance. PGR are conserved for use by people as food, medicine, fibre, fodder and building material. Conversely, use without conservation means neglecting the genetic base needed by farmers and breeders alike to increase productivity in future. To be of use, material held in genebank must be well documented. This entails maintaining passport data, giving location, site characteristics, species, cultivators, characterization data, recording highly heritable character that can be used as a basis to distinguish one accession from the other and evaluation data giving traits such as yield, quality, phenology, growth habit and reaction to pest disease and abiotic stresses. Without these, genebanks run the risk of becoming libraries without readers.

Information system, which improves access to data, is becoming increasingly important worldwide. To cite an example is the data management model and computer based information system developed by CIMMYT known as the International Crop Information System (ICIS). The ICIS structure supports the shared development of tools for management and analysis of data on genealogy, nomenclature, evaluation, and characterization of genetic resources. The CGIAR Centres are taking steps to coordinate the genetic resources documentation and information system to ensure that databases operating in various centres are compatible to provide international access to the information.

### Need for Passport Data Updation

- Passport information of the PGR is important at national, regional and global levels to backup conservation of rapidly disappearing genetic stocks for future use in crop improvement programmes.
- The information may aid in rapid identification of required accession and/or characteristics and may help to prevent excessive duplication of efforts while showing where the gaps are.
- Passport information on the origin of the accession is also relevant. Base of access to the information

may make it the basis for both breeders (as is the case) and farmers (as it should also be) to use the materials.

Realizing this importance, the activity of passport data updation was enhanced and efforts from all angles have been taken to get the minimum passport information.

**Method of collection of passport information:** The structure of information documentation has been improved with the addition of more fields which have now been raised to 17 descriptors to document most of the user driven information. Efforts are on to augment passport information on the germplasm stored from different sources to accomplish the above mentioned needs. In this regard the donors of crop germplasm have been contacted through letters and in person and have been persuaded to provide whatever passport data they have. Besides this the germplasm collection reporters and exotic collection registers, collection memoir and catalogues are being screened to get all the passport information available on the accessions. The result of this activity in various crops by the respective crop curators is given in the Table 1. The descriptors that have been included in the proforma for passport updation are given in Table 2.

The Indian National genebank houses 2,02,228 germplasm accessions of various crops and is the fourth largest in its resource. The stored accessions include both indigenous germplasm augmented through crop specific and multicrop collection expeditions and exotic resources introduced from foreign countries. The status of the information documentation was reviewed and it was observed that only a small fraction of the total germplasm had relevant passport information (10-15%). Since this activity has been assigned utmost priority in most of the genebanks around the world as it is imperative that germplasm without appropriate information is of no use. The earnest efforts of the crop curators in this regard have been beneficial (Table 1) in identification of duplicates to reduce redundancy in collections in addition to updating of information. This

**Table 1. Number of records reviewed and updated for passport information in various crops**

| Crop            | Records reviewed | Records updated | % updated | Duplicates |
|-----------------|------------------|-----------------|-----------|------------|
| Wheat           | 4,500            | 2,700           | 60        |            |
| Maize           | 3,200            | 1,200           | 37        |            |
| Buckwheat       | 100              | 90              | 90        |            |
| Paddy           | 2,204            | 1,900           | 86        |            |
| Lentil          | 2,026            | 860             | 42        | 16         |
| Ricebean        | 983              | 695             | 71        | 81         |
| Pigeon pea      | 4,384            | 15              | 1         | 91         |
| Chickpea        | 10,459           | 3,214           | 30        | 979        |
| Cowpea          | 2,349            | 24              | 1         |            |
| Horsegram       | 1,327            | 868             | 65        | 72         |
| Adjukebean      | 151              | 38              | 25        |            |
| Cotton          | 3,052            | 2,000           | 65        |            |
| Jute and Fibres | 3,703            | 1,590           | 43        |            |
| Sorghum         | 11,112           | 145             | 1.5       | 333        |
| Groundnut       | 7,397            | 4,522           | 61        | 350        |
| M and AP        | 700              | 127             | 18        |            |
| Bitter Gourd    | 165              | 143             | 86%       | 4          |
| Okra            | 1656             | 28              | 2%        |            |
| Melon           | 1                | 1               | 100%      |            |

information updation is a continuous process and will go on until the data documentation is complete.

According to FAO Report (1996), 37% of the national collections and nearly all the CGIAR genebank, accessions have passport data, but in most cases these refer only to the country of origin. Plant breeders are often forced to develop their own collections because of the lack of information on collections in the genebanks. It is also observed that while some genebanks have their collections fully documented, computerized and even available on the internet (as in the case of Vavilov Institute and the US collections), others have not documented any of their collections. So the documentation of relevant passport data is essential for effective conservation and use.

#### References

FAO (1996) Report on the State of the World's Genetic Resource for Food and Agriculture, Commission on Genetic Resources for Food and Agriculture. CGRFA-Ex-2/96/2

**Table 2. Performa for passport data**

| SNo | National Identity | Collecting Institute | Collector No. | Donor Institute | Donor/ Other Identity | Crop name | Common Name | Taxonomic Code | Pedigree | Source | Biol. Status | Country of Origin | Location | Latitude | Longitude | Altitude |
|-----|-------------------|----------------------|---------------|-----------------|-----------------------|-----------|-------------|----------------|----------|--------|--------------|-------------------|----------|----------|-----------|----------|
|     |                   |                      |               |                 |                       |           |             |                |          |        |              |                   |          |          |           |          |
|     |                   |                      |               |                 |                       |           |             |                |          |        |              |                   |          |          |           |          |
|     |                   |                      |               |                 |                       |           |             |                |          |        |              |                   |          |          |           |          |
|     |                   |                      |               |                 |                       |           |             |                |          |        |              |                   |          |          |           |          |
|     |                   |                      |               |                 |                       |           |             |                |          |        |              |                   |          |          |           |          |
|     |                   |                      |               |                 |                       |           |             |                |          |        |              |                   |          |          |           |          |

Source: In=Institute/NRC/ARCs; F=Farmer; M=Market; NGO=Non-Governmental Organisations; OT=Others

Biological Status: W=Wild; RC=Released Cultivar; LR=Landraces; BL=Breeding Line; M=Mutant; GS=Genetic Stock; OT=Other

Country of Origin: Please provide ISO Codes

## *In Vitro* multiplication of *Pinus roxburghii* Sarg

Rajwant K Kalia, Sarita Arya, Sanjay Kalia, ID Arya and SK Sharma

Tissue Culture Laboratory, Division of Genetics and Tree Propagation, Forest Research Institute, Dehradun-248006, Uttarakhand

**Key Words:** *Pinus roxburghii*, *In Vitro* Multiplication, Chirpine, BAP

*Pinus roxburghii* Sarg commonly known as chirpine is an important plant of Indian subcontinent. It contributes significantly to the local and industrial economy of the country being an important source of timber and resin of commercial value. It also protects the watersheds, which sustain and regulate the water supply for millions who inhabit the Himalayan river basin. The need to develop procedures for rapid mass propagation of forest trees has been recognized for many years and is a prerequisite for employing tissue culture technique for *in vitro* conservation. *In vitro* micropropagation of conifers via adventitious shoot bud induction is one such procedure described for several species (Kaul, 1990). In an attempt to optimize adventitious bud differentiation, effects of mode of application of phytohormones to the mature zygotic embryos of *Pinus roxburghii* was studied.

The mature seeds of chirpine were surface sterilized with 0.1%  $\text{HgCl}_2$  and 3.0%  $\text{H}_2\text{O}_2$  (w/v) for 20 and 10 min., respectively. Each treatment was followed by 3 or 4 wash with sterilized distilled water. The megagametophytes were dissected out and further sterilized for 5 min. with 0.1%  $\text{HgCl}_2$  prior to embryo excision. The excised zygotic embryos were cultured on MS (Murashige and Skoog, 1962) medium supplemented with 3% sucrose, gelled with 0.8% agar and pH 5.8. The embryos were exposed to BAP in two ways:

1. Continuous exposure to lower BAP (5-25  $\mu\text{M}$ ) concentrations supplemented in the culture medium for 5 weeks.

2. Exposure to high BAP (125 or 250  $\mu\text{M}$ ) concentrations for 1, 2 or 4 h followed by culturing on MS basal medium for 5 weeks.

For elongation, the explants with induced adventitious buds were transferred to 1/2 MS basal medium and for rooting 2.5  $\mu\text{M}$  NAA was incorporated in 1/2 MS medium. The cultures were incubated under 16 h photoperiod at  $25 \pm 2^\circ\text{C}$ .

Preliminary investigations were carried out using BAP and kinetin individually for adventitious bud differentiation. BAP was found better compared to kinetin in terms of per cent response as well as average number of buds/explant. Pulido *et al.*, (1990) and Sen *et al.*, (1994) have also emphasized the efficiency of BAP over other cytokinins in inducing adventitious buds on embryos of other pine species.

The concentration of BAP in the semi-solid medium during continuous exposure also influenced the response (Table 1). Increase in BAP concentration produced clustered and stunted buds compared to the buds scattered on whole explant surface when exposed to lower BAP (5-10  $\mu\text{M}$ ) or given a pulse treatment (Fig. 1A). It was also recorded that the embryos provided with pulse treatment of BAP developed buds in 3-4 weeks compared to 4-5 weeks when continuous exposure was provided with BAP. Zel *et al.*, (1988) also reported that soaking explants in higher BAP was the most effective treatment for bud induction, which agrees with the results of Bornman (1985), where short-time treatment with high hormone concentration was found most effective.

The mode of application of BAP had profound effect on the number of adventitious buds produced as well as the placement of buds on explant surface. The embryo explants that were provided a pulse treatment with 250  $\mu\text{M}$  BAP for 2 h produced 38.7 buds/explant compared to 26.4 buds on 10  $\mu\text{M}$  BAP supplemented medium. It was observed that pulse treatment for 4 h with both 125  $\mu\text{M}$  and 250  $\mu\text{M}$  BAP was detrimental compared to 2 h (Table 2). Increase in explant mortality was observed with increasing exposure to pulse treatment of BAP (4 h).

**Table 1: Effects of BAP on induction of adventitious buds on mature zygotic embryos of *Pinus roxburghii* (Culture age: 5 weeks)**

| BAP ( $\mu\text{M}$ ) | Responsive explants (%) | Average number of buds | Average length of buds (mm) |
|-----------------------|-------------------------|------------------------|-----------------------------|
| 0                     | 0.0                     | 0.0                    | 0.00                        |
| 5                     | 40.0                    | $9.2 \pm 6.1$          | $1.3 \pm 0.4$               |
| 10                    | 66.7                    | $26.4 \pm 16.3$        | $1.8 \pm 0.8$               |
| 15                    | 60.0                    | $16.2 \pm 12.9$        | $1.7 \pm 0.5$               |
| 20                    | 56.7                    | $16.2 \pm 7.9$         | $1.4 \pm 0.5$               |
| 25                    | 43.3                    | $13.7 \pm 5.4$         | $1.2 \pm 0.4$               |

± Values represent the standard deviation.

**Table 2: Effects of pulse treatment of BAP on induction of adventitious buds on mature zygotic embryos (Culture age: 5 weeks)**

| BAP ( $\mu$ M) | Duration of pulse treatment (h) | Responsive explants (%) | Average length of buds | Average number of buds (mm) |
|----------------|---------------------------------|-------------------------|------------------------|-----------------------------|
| 125            | 1                               | 43.3                    | 12.1 $\pm$ 9.2         | 1.3 $\pm$ 0.5               |
|                | 2                               | 46.7                    | 12.6 $\pm$ 5.0         | 1.4 $\pm$ 0.5               |
|                | 4                               | 30.0                    | 12.3 $\pm$ 10.2        | 1.0 $\pm$ 0.3               |
| 250            | 1                               | 60.0                    | 14.7 $\pm$ 11.2        | 1.3 $\pm$ 0.4               |
|                | 2                               | 66.7                    | 38.7 $\pm$ 18.3        | 1.8 $\pm$ 0.6               |
|                | 4                               | 16.7                    | 11.4 $\pm$ 3.3         | 1.5 $\pm$ 0.5               |

$\pm$  Values represent the standard deviation

Elongation of buds was carried out on 1/2 MS medium (Fig. 1B). The concentration of cytokinin and its exposure period during the induction phase had a bearing on the per cent buds elongating as well as the average bud length. Higher the BAP concentration used in the medium, longer was the time required for bud elongation. It was also observed that the shoot buds clustered together have a lower frequency and rate of bud elongation compared to the buds scattered on whole explant surface. Chesick *et al.*, (1991) also reported similar results. Kaul (1990) reported that the buds induced on higher cytokinin concentrations were difficult to elongate. The buds induced in response to pulse treatment had a better rate of elongation compared to those provided continuous exposure. Amerson and Mott (1982) recorded similar observations in *Pinus sylvestris*. The buds were serially subcultured 3-4 times on basal medium to obtain shoots 1.0-1.5 cm long for rooting.

Induction of adventitious rooting in *in vitro* raised shoots of conifers is a key step in micropropagation, determining the pace of commercial application of tissue culture in clonal forestry. Rooting was induced in 70% shoots when exposed to 2.5  $\mu$ M NAA-supplemented medium for 1 month followed by transfer to liquid basal medium for elongation of the induced root primordia (Fig. 1C). The plantlets were transferred to soil after hardening and acclimatization.

**Acknowledgements:** The author is thankful to University Grants Commission for the financial assistance and Indian Council of Forestry Research and Education for providing the facilities.

## References

Amerson HV and RL Mott (1982) Improved rooting of western white pine shoots from tissue cultures. *Forest Sci.* **28**: 822-825.

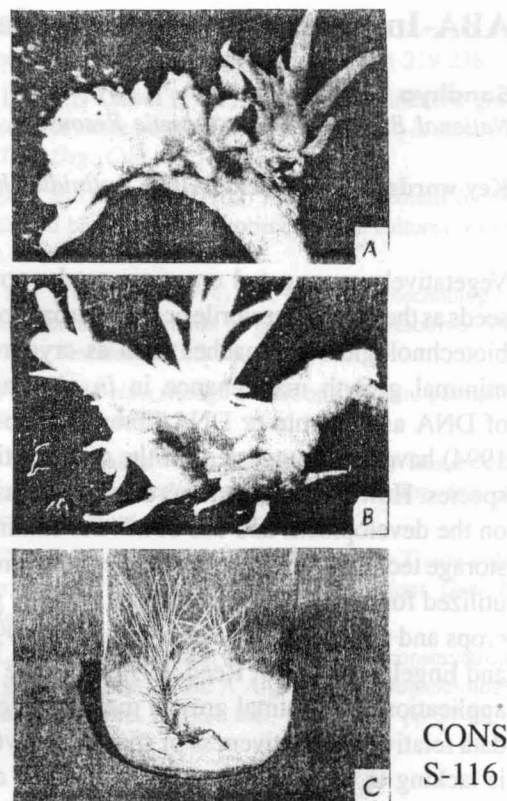


**Fig. 1. Multiplication of *Pinus roxburghii* through adventitious bud differentiation**

- A:** Adventitious buds scattered on whole cotyledon surface, cultured on basal medium after giving pulse treatment with 250  $\mu$ M BAP for 2 h (x 7)
- B:** Elongation of induced adventitious buds after first subculture to 1/2 MS basal medium (x 7)
- C:** Rooted plantlet in liquid 1/2 MS basal medium (with cotton support)

Bornman CH (1985) Hormonal control of growth and differentiation in conifer tissues *in vitro*. *Biol. Plant.* **27**: 249-256.

Chesick EE, CA Mohn and WP Hackett (1991) Plantlet production from white pine (*Pinus strobus* L.) embryos *in vitro*: bud induction and rooting. *Plant Cell Tiss. Org. Cult.* **26**: 107-114.

Kaul K (1990) Factors influencing *in vitro* micropropagation of *Pinus strobus* L. *Biol. Plant.* **32**: 266-272.

Murashige T and F Skoog (1962) A revised medium for rapid growth and bioassays with tobacco tissue cultures. *Physiol. Plant.* **15**: 473-497.

Pulido CM, IS Harry and TA Thorpe (1990) *In vitro* regeneration of plantlets of Canary island pine (*Pinus canariensis*). *Can. J. For. Res.* **20**: 1200-1211.

Sen S, ME Magallanes-Cedro, RH Kamps, CR McKinley and RJ Newton (1994) *In vitro* micropropagation of Afghan pine. *Can. J. For. Res.* **24**: 1248-1252.

Zel J, N Gogala and M Camloh (1988) Micropropagation of *Pinus sylvestris*. *Plant Cell Tiss. Org. Cult.* **14**: 169-175.

## ABA-Induced Growth Retardation of Kiwifruit (*Actinidia chinensis*) *In Vitro*

**Sandhya Gupta**

National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012

**Key words:** Absciscic acid (ABA), *Actinidia chinensis*, *In vitro* conservation, Kiwifruit, Slow growth

Vegetatively propagated crops cannot be conserved as seeds as they are either sterile or are heterozygous. Various biotechnological approaches such as cryopreservation, minimal growth maintenance in *in vitro* and storage of DNA as genomic or DNA libraries (Rao and Riley, 1994) have been suggested for the conservation of such species. However, to date most emphasis has been given on the development and use of *in vitro* minimal growth storage techniques. These techniques are currently being utilized for conservation of various clonally propagated crops and their related species (Ashmore, 1997; Withers and Engelmann, 1997; Reed, 1999). Despite the current applications of minimal growth maintenance strategies, data relative to effectiveness of specific growth retardant is lacking in the scientific literature (Jarret and Gawel, 1991). This paper describes ABA-induced inhibition of shoot growth of *Actinidia chinensis* (kiwifruit or Chinese gooseberry) *in vitro*, and discusses the potential use of ABA to enhance minimal growth for conservation of kiwifruit germplasm.

*In vitro* cultures of *Actinidia chinensis* cv. Allison (female), procured from Dr YS Parmar University of Horticulture and Forestry, Solan, were multiplied and used for investigation. Nodal segments used as explants were excised from 3-week-old stock cultures maintained on Murashige and Skoog's (1962) medium (MS) containing 3% (w/v) sucrose and solidified with agar (0.8% w/v). Cultures were raised in test tube (25 x 150 mm) containing 10-12 ml of MS supplemented with various concentrations of ABA (SRL) at 0.0, 0.01, 0.1, 1.0 or 10.0 mg/l. MS medium without ABA was treated as control. Twenty-four cultures were raised/treatment. Cultures were incubated at  $25 \pm 2^\circ\text{C}$  under 8 h photoperiod. About  $40 \text{ m mol/m}^2\text{s}^{-1}$  illumination was provided by 40 watt cool-white fluorescent tubelights (Phillips, India) adjusted 30 cm high from culture tubes. Cultures were maintained in similar culture condition up to 180 days. After 90 and 180 days cultures were subcultured/transferred to ABA-free MS medium. The quantitative data were recorded periodically. Values represent the mean of 24 cultures for each treatment. Statistical Error (SE) was

calculated on shoot length using the standard software. Viable nodes were defined as those from which visible shoot development could be observed after 30 days of transfer to MS medium.

ABA inhibited shoot development from axillary buds of kiwifruit at all concentration tested. No significant reduction in growth parameters was observed up to 30 days after culture initiation on low concentrations of ABA (0.01-1 mg/l). The 90-days-old cultures showed significant reduction in shoot length on 0.01-1 mg/l ABA-supplemented medium. The mean values of shoot length at 0.01, 0.1, 1.0 mg/l ABA were  $1.4 \pm 0.1$ ,  $0.7 \pm 0.0$  and  $0.3 \pm 0.0$ , respectively, which are significantly lower than the mean shoot length in control ( $2.7 \pm 0.1$ ). However, ABA at these concentrations did not inhibited number of shoots/culture. Similar trend in shoot growth reduction was observed in 180-day-old cultures also. Effects on growth inhibition by ABA has already been reported *in vitro* in *Solanum tuberosum* (Henshaw and O'Hara, 1983a,b; Westcott *et al.*, 1977), *Ipomea batatas* (Jarret and Gawel, 1991) and *Malus domestica* (Wilkins *et al.*, 1988). No shoot development was observed from nodes cultured on media containing 10 mg/l ABA after 90 days of culture initiation. However, nodal segments on this treatment remained green and some swelling of the axillary bud was evident. Although no shoot elongation occurred but viability of nodal segments was about 80% after 90 days from culture. Shoot regeneration from nodes, cultured in MS+10 mg/l ABA for 90 and 180 days, were not significantly different in length as compared to control. Jarret and Gawel (1991) reported that ABA at 10 mg/l completely inhibited axillary shoot development but did not affect the viability of *in vitro* cultures of sweet potato cv. Jewel over a culture period of 365 days. Viability, as determined by the ability to recover shoots from the recultured nodes on MS, exceeded 70% for all the treatments after 180 days from culture. Normal plantlets were recovered after transfer of nodes to MS medium.

Results of present investigation indicate that ABA (1-10 mg/l) effectively inhibits growth of kiwifruit *in*

*vitro* and that this effect does not diminish over a 6 months culture period. The study suggests use of ABA to increase *in vitro* conservation period of kiwifruit.

**Acknowledgement:** The author is thankful to Dr DR Sharma, Dean, Horticulture, Dr YS Parmar University of Horticulture and Forestry, for providing cultures of kiwifruit. Financial support from Department of Biotechnology, Government of India, is gratefully acknowledged. Technical assistance of Ramesh Chandra from NBPGR is also acknowledged.

## References

- Ashmore SE (1997) Status Report on the development and application of *in vitro* techniques for the conservation and use of plant genetic resources. International Plant genetic Resources Institute, Rome, Italy, 67 p.
- Henshaw GG and JF O'Hara (1983a) Tissue culture methods for the storage utilization of potato germplasm In: DS Ingram and JP Helgeson (ed.) *Tissue Culture for Plant Pathologist*. Blackwell Scientific Publications, Oxford, pp 71-76.
- Henshaw GG and JF O'Hara (1983b) *In vitro* approaches to the conservation and utilization of global plant genetic resources. In: SH Mantell and H Smith (ed.) *Plant Biotechnology*. Cambridge University Press, Cambridge. pp 219-238.
- Jarret R L and N Gawel (1991) Absciscic acid-induced growth inhibition of sweet potato (*Ipomoea batatas* L.) *in vitro*. *Plant Cell Tiss. Org. Cult.* 24:13-18.
- Murashige T and F Skoog (1962) A revised medium for rapid growth and bio-assays with tobacco tissue cultures. *Physiol. Plant.* 15:473-497.
- Rao VR and KW Riley (1994) The use of biotechnology for conservation and utilization of plant genetic resources. *Plant Gen. Res. Newslett.* 97: 3-20.
- Reed BM (1999) *In vitro* storage conditions for mint germplasm. *HortScience.* 34:350-352.
- Westcott R, GG Henshaw and WM Roca (1977) Tissue culture storage of potato germplasm: culture initiation and plant regeneration. *Plant Sci. Lett.* 9:309-315.
- Wilkins CP, HJ Newbury and JH Dodds (1988) Tissue culture conservation of fruit trees. *FAO/IBPGR Plant Gen. Res. Newslett.* 73/74: 9-20.
- Withers LA and F Engelmann (1997) *In vitro* conservation of plant genetic resources. In: A Altman (ed.) *Biotechnology in Agriculture*. Marcel Dekker Inc., New York, pp 57-88.

## In Vitro Conservation and Encapsulation of *Coleus forskohlii*

**Rajasri Bhattacharyya, Bidhisha Mondal and Sabita Bhattacharya**

Department of Botany, Bose Research Institute, Calcutta, West Bengal

**Key Words:** Conservation, *Coleus*, Tissue culture, Encapsulation

*Coleus forskohlii* Briq. (Lamiaceae) is an important plant in Indian Ayurvedic medicine because its roots produce a labdane diterpenoid, forskolin (Bhat *et al.*, 1977) which has a positive inotropic effect on heart action, lowers blood and intra ocular pressure and is an anti-inflammatory (Mukherjee *et al.*, 1996). Forskolin is commonly purified from tuberous roots of wild or cultivated *C. forskohlii* plants. Indiscriminate collection of *C. forskohlii* has led to rapid depletion of wild populations listing it as vulnerable plant in India. Therefore, the conservation of such rare and endangered plant species has become imperative. *C. forskohlii* is mainly propagated vegetatively to maintain clonal genotype. At present, the most common method to preserve the genetic resources of vegetatively propagated plant is, as whole plant in the field. But there are several serious limitations with field genebanks (Withers and Engels, 1990) mainly due to attacks by

pests and pathogens, exposure to natural disasters, etc. In addition distribution and exchange from field genebank is difficult because of the vegetative nature of the material and the greater risks of disease transfer.

The present work aims at detecting the most suitable way of conservation and recovery of true-to-type elite *Coleus forskohlii* plant through the use of *in vitro* culture and encapsulation technique.

Shoot tip (0.5 cm) and nodal explants were collected from micropropagated *C. forskohlii* plants maintained in laboratory condition. Murashige and Skoog (1962) medium (MS) was used as basal medium. Explants were cultured in 25 x 150 mm culture tubes (single explant/tube) containing 15 ml of semisolid 1/4 MS, 1/2 MS 2/3 ms (where concentration of the macro and micro salts were 1/4, 1/2, 2/3, respectively of the original concentration of MS) and MS medium supplemented

*vitro* and that this effect does not diminish over a 6 months culture period. The study suggests use of ABA to increase *in vitro* conservation period of kiwifruit.

**Acknowledgement:** The author is thankful to Dr DR Sharma, Dean, Horticulture, Dr YS Parmar University of Horticulture and Forestry, for providing cultures of kiwifruit. Financial support from Department of Biotechnology, Government of India, is gratefully acknowledged. Technical assistance of Ramesh Chandra from NBPGR is also acknowledged.

## References

- Ashmore SE (1997) Status Report on the development and application of *in vitro* techniques for the conservation and use of plant genetic resources. International Plant genetic Resources Institute, Rome, Italy, 67 p.
- Henshaw GG and JF O'Hara (1983a) Tissue culture methods for the storage utilization of potato germplasm In: DS Ingram and JP Helgeson (ed.) *Tissue Culture for Plant Pathologist*. Blackwell Scientific Publications, Oxford, pp 71-76.
- Henshaw GG and JF O'Hara (1983b) *In vitro* approaches to the conservation and utilization of global plant genetic resources. In: SH Mantell and H Smith (ed.) *Plant Biotechnology*. Cambridge University Press, Cambridge. pp 219-238.
- Jarret R L and N Gawel (1991) Absciscic acid-induced growth inhibition of sweet potato (*Ipomoea batatas* L.) *in vitro*. *Plant Cell Tiss. Org. Cult.* 24:13-18.
- Murashige T and F Skoog (1962) A revised medium for rapid growth and bio-assays with tobacco tissue cultures. *Physiol. Plant.* 15:473-497.
- Rao VR and KW Riley (1994) The use of biotechnology for conservation and utilization of plant genetic resources. *Plant Gen. Res. Newslett.* 97: 3-20.
- Reed BM (1999) *In vitro* storage conditions for mint germplasm. *HortScience.* 34:350-352.
- Westcott R, GG Henshaw and WM Roca (1977) Tissue culture storage of potato germplasm: culture initiation and plant regeneration. *Plant Sci. Lett.* 9:309-315.
- Wilkins CP, HJ Newbury and JH Dodds (1988) Tissue culture conservation of fruit trees. *FAO/IBPGR Plant Gen. Res. Newslett.* 73/74: 9-20.
- Withers LA and F Engelmann (1997) *In vitro* conservation of plant genetic resources. In: A Altman (ed.) *Biotechnology in Agriculture*. Marcel Dekker Inc., New York, pp 57-88.

## In Vitro Conservation and Encapsulation of *Coleus forskohlii*

**Rajasri Bhattacharyya, Bidhisha Mondal and Sabita Bhattacharya**

Department of Botany, Bose Research Institute, Calcutta, West Bengal

**Key Words:** Conservation, *Coleus*, Tissue culture, Encapsulation

*Coleus forskohlii* Briq. (Lamiaceae) is an important plant in Indian Ayurvedic medicine because its roots produce a labdane diterpenoid, forskolin (Bhat *et al.*, 1977) which has a positive inotropic effect on heart action, lowers blood and intra ocular pressure and is an anti-inflammatory (Mukherjee *et al.*, 1996). Forskolin is commonly purified from tuberous roots of wild or cultivated *C. forskohlii* plants. Indiscriminate collection of *C. forskohlii* has led to rapid depletion of wild populations listing it as vulnerable plant in India. Therefore, the conservation of such rare and endangered plant species has become imperative. *C. forskohlii* is mainly propagated vegetatively to maintain clonal genotype. At present, the most common method to preserve the genetic resources of vegetatively propagated plant is, as whole plant in the field. But there are several serious limitations with field genebanks (Withers and Engels, 1990) mainly due to attacks by

pests and pathogens, exposure to natural disasters, *etc.* In addition distribution and exchange from field genebank is difficult because of the vegetative nature of the material and the greater risks of disease transfer.

The present work aims at detecting the most suitable way of conservation and recovery of true-to-type elite *Coleus forskohlii* plant through the use of *in vitro* culture and encapsulation technique.

Shoot tip (0.5 cm) and nodal explants were collected from micropropagated *C. forskohlii* plants maintained in laboratory condition. Murashige and Skoog (1962) medium (MS) was used as basal medium. Explants were cultured in 25 x 150 mm culture tubes (single explant/tube) containing 15 ml of semisolid 1/4 MS, 1/2 MS 2/3 ms (where concentration of the macro and micro salts were 1/4, 1/2, 2/3, respectively of the original concentration of MS) and MS medium supplemented

with 1% sucrose. No growth hormones were added in any of the media. The pH of the medium was adjusted to 5.6-5.8 before addition of agar and were autoclaved at 121°C and 103.4 kPa for 15 min. Cultures were incubated under 18 h light provided by cool-white fluorescent tubes ( $41.76 \mu\text{mol/m}^2\text{s}^{-1}$ ) at  $25 \pm 2^\circ\text{C}$ . After 6 months data were recorded on total length of shoot, number of nodes and number of days to induce rooting. Shoot tips from cultures with considerably reduced growth were recultured on MS with Kn and IAA (both at 0.1 mg/l) to observe their regeneration efficiency. The matrix for encapsulation was prepared by mixing liquid MS medium with 3% sodium alginate. pH of the matrix was adjusted at 5.8 before autoclaving. Shoot tip and nodal explants (0.3-0.4 cm) excised from the source as mentioned above, were mixed with encapsulating matrix and dropped (single explant/drop) in a beaker containing the solution of a mixture of MS medium and 50 mM  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$  with gentle stirring to form the alginate beads. Beads were left in the solution for at least 30 min for complete complexation, after which the solution was decanted. The beads were washed with sterile distilled water twice, dried with sterilized filter paper and lastly transferred to petridish containing MS medium with 3% sucrose and without growth hormones. After sealing with parafilm petridishes were stored at  $4^\circ\text{C}$ ,  $-20^\circ\text{C}$ ,  $-70^\circ\text{C}$  in dark for different periods (7, 15, 30, 45, 60 days). The viability was tested by germinating them in medium exactly similar to that used during storage.

In the first part of the present experiment on medium term *in vitro* storage of *C. forskohlii*, effect of the composition of the culture medium (MS) was only considered. The modifications made to reduce growth rate of the cultures were, reduction of sucrose to 1% level, complete avoidance of growth hormones and lowering of mineral concentrations of MS long with normal MS minerals in the medium. It was observed that elongation of the cultured shoot was inversely proportional to the concentration of the salts (Table 1). For *C. forskohlii* MS (with 1% sucrose) proved to be the most suitable for medium term conservation. It slowed down growth rate effectively. Even after 6 months, shoots grew only about 1 cm (0.5 to 1.55 cm) without developing any new nodes. Least reduction in growth rate was noted in 1/4 MS where shoots increased up to a length of 5.8 cm and differentiated 5-6 nodes (Table 1). Contrasting to this result is the report of Kartha *et al.* (1981) where

**Table 1. Effect of salt concentration of MS medium on *in vitro* conservation of *C. forskohlii*.**

| Medium | Length of explants after 2 months (cm) $\pm$ S.E. | No. of node differentiated | Days of rooting |
|--------|---------------------------------------------------|----------------------------|-----------------|
| MS     | 1.55 $\pm$ 0.72                                   | 1-2                        | 100-110         |
| 1/2 MS | 3.00 $\pm$ 0.291                                  | 1-2                        | 60-70           |
| 2/3 MS | 4.05 $\pm$ 0.27                                   | 3-4                        | 45-50           |
| 1/4 MS | 5.8 $\pm$ 0.74                                    | 5-6                        | 20-30           |

low mineral elements (1/2 of the basal medium) was successfully used to conserve coffee plantlets rather than using medium with normal salt concentration.

In the present experiment roots were differentiated from shoots in all media even in the absence of growth hormones. Early rooting was found to be associated with better growth in low salt medium – 1/4, 1/2 or 2/3 MS and proved to be unsuitable for reaching the goal whereas root differentiation at later part of the culture period as in MS, didn't interfere slow growth of the cultures. Advantage of rooting in *in vitro* conservation was discussed by Chandel and Sharma (1997). It was pointed out that lately differentiating rooted shoot cultures had an added advantage in conservation of being able to absorb nutrients from the medium especially at the later stage when water and nutrients were nearly exhausted as compared to the shoot cultures without roots.

Regarding the second part of the experiment, short term storage of encapsulated shoot tips (EST) and nodal segments (ENS) of *C. forskohlii* were carried out at temperatures viz.  $-70^\circ$ ,  $-20^\circ$  and  $4^\circ\text{C}$  and their post storage viability was examined. An encapsulated matrix of 3% sodium alginate from Sigma, USA and 50 mM  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$  was most suitable for formation of firm and spherical beads (Fig. A) with diameter (in case of isodiametric beads) ranging from 0.4-0.5 cm. Encapsulation of different plant parts like shoot tip, nodal segment, root parts, protocorms in addition to embryo/somatic embryo is now considered to be a useful technique in conserving genetic resources (Uozumi and Kobayashi, 1995; Datta *et al.* 1999). In the present experiment, storage of both EST and ENS below  $4^\circ\text{C}$  showed drastic loss of viability even after the shortest storage period (7 days). Therefore, results on preservation at  $4^\circ\text{C}$  only were taken into consideration (Table 2). Storage of cultures at non-freezing temperatures ( $2^\circ$ - $8^\circ\text{C}$ ) has been successfully applied in several other

Table 2. Viability percentage of the encapsulated explants of *C. forskohlii* at different time intervals (storage temp. 4°C)

| Type of explant encapsulated | Time interval | % of regeneration $\pm$ S.E |
|------------------------------|---------------|-----------------------------|
| Shoot tip                    | 7             | 100 $\pm$ 0.00              |
|                              | 15            | 92 $\pm$ 1.076              |
|                              | 30            | 90 $\pm$ 1.074              |
|                              | 45            | 88 $\pm$ 0.286              |
|                              | 60            | 85 $\pm$ 0.291              |
| Nodal Part                   | 7             | 100 $\pm$ 0.00              |
|                              | 15            | 95 $\pm$ 0.079              |
|                              | 30            | 92 $\pm$ 0.421              |
|                              | 45            | 85 $\pm$ 1.05               |
|                              | 60            | 70 $\pm$ 1.52               |

plant species (Malemnganba *et al.*, 1996 Nayak *et al.*, 1998).

Considering germination percentage, there was no major difference between EST and ENS (Table 2). On immediate transplantation on basal MS medium enriched with 3% sucrose and without any growth hormone, 100% germination was noted. In this medium, induction of growth was observed within 9-10 days. The first sign of growth was emergence of green shoot tip through one pole of the bead and subsequently fine thread like roots through another. Fig. B shows 2-week-old *C. forskohlii* growing on the substrate, leaving aside the alginate matrix. High viability percentage (85% and 70% respectively) for 60 days stored EST and ENS may be due to the availability of nutrients within the gel matrix. Thus, longer storage period over 2 months could be planned for future experiments. Individual plantlets after growing up to a height of 3-4 cm (Fig. C) on the same medium in separate culture tubes, were transferred to small plastic cups containing soilrite: soil (1:1) (Fig. D). Cups with plants were initially covered with thin polythene sheets for 10 days to avoid dessication, after which the polythene sheets were removed and the plants were kept in the culture room for another 15 days before transfer to the greenhouse and establishment in the field (Fig. E).

## References

- Bhat SV, BS Bajwa, H Dornauer and NJ De Souza (1977) Structures and Stereochemistry of new labdane diterpenoids from *Coleus forskohlii* Briq. *Tetrahedron Lett.* **19**: 1669-1672.
- Chandel KPS and N Sharma (1997) Micropropagation of *Coleus forskohlii* (Willd.) Briq. In: YPS Bajaj (ed.)

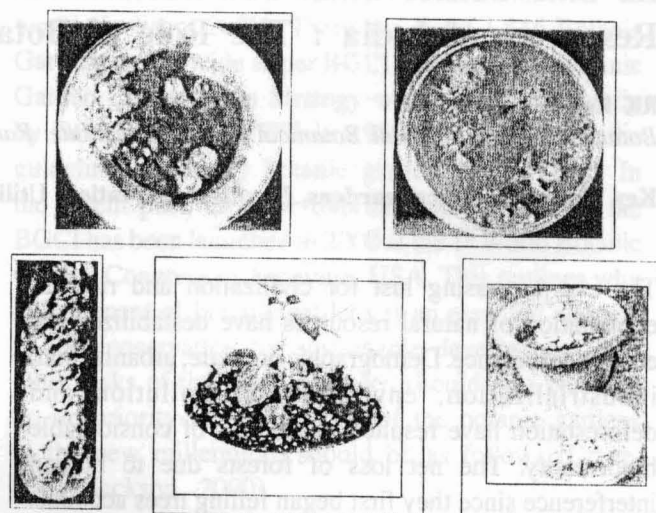


Fig. 1

- a. Encapsulated shoot tip and nodal segment of *C. forskohlii*  
 b. 2-weeks-old plantlets regenerated from ruptured beads  
 c. Proliferation of *C. forskohlii* after germination from encapsulated shoot tip  
 d. A plant in soilrite:soil mixture; e. Field trial plants

*Biotechnology in Agriculture and Forestry*. Vol **40**: Springer-Verlag, pp 74-78.

- Datta KB, B Kanjilal and D De Sarker (1999) Artificial seed technology. Development of a protocol in *Geodorum densiflorum* (Lam) Schltr. – An Endangered Orchid. *Curr. Sci.* **76**: 1142-1145.
- Kartha KK, LA Mroginski, KPahl and NL Leung (1981) Germplasm Preservation of Coffee (*Coffea arabica* L.) by in vitro culture of shoot apical meristems. *Plant Sci. Lett.* **22**: 301-307.
- Malemnganba H, BK Ray, Bhattacharya S and Deka PC (1996) Regeneration of encapsulated protocorms of *Phaius tankervilleae* stored at low temperature. *Indian J. Exp. Biol.* **34**: 802-805.
- Mukherjee S, B Ghosh and S Jha (1996) Forskolin synthesis in *in vitro* cultures of *Coleus forskohlii* Briq. Transformed with *Agrobacterium tumefaciens*. *Plant Cell Rep.* **15**: 691-694.
- Murashige T and Skoog F (1962) A revised medium for rapid growth and bioassays with tobacco tissue cultures. *Physiol. Plant.* **15**: 473-479.
- Nayak NR, SP Rath and SN Patnaik (1998) High frequency plant regeneration from alginate encapsulated protocorm like bodies of *Spathoglottis plicata* BL, a terrestrial orchid. *Phytomorphology* **48**: 179-186.
- Uozumi N and T Kobayashi (1995) Artificial seed production through encapsulation of hairy root and shoot tips. In: YPS Bajaj (ed.) *Biotechnology in Agriculture and Forestry*. Vol. **30**: pp 170-179. Springer-Verlag.
- Withers LA and JMM Engels (1990) The test tube genebank – a safe alternative conservation. *IBPGR Newslett. Asia Pacific.* **3**: 1-2.

## **Ex Situ Conservation and Sustainable Utilization of Plant Genetic Resources of India : The Role of Botanic Gardens in the New Millennium**

**RK Roy**

*Botanic Garden, National Botanical Research Institute, Rana Pratap Marg, Lucknow-226001, Uttar Pradesh*

**Key Words:** Botanical gardens, *Ex situ* conservation, Utilization

The ever-increasing lust for civilization and ruthless exploitation of natural resources have destabilized the ecological balance. Demographic pressure, urbanization, industrialization, environmental pollution and deforestation have resulted in the loss of considerable biodiversity. The net loss of forests due to human interference since they first began felling trees accounts to 15-20% of the world's forest cover. More factually, we are losing tropical forest at a rate of 50 hectare/minute and as a result one plant species is becoming extinct every day on an average (Anonymous, 1984; Myers, 1988). IUCN Red List of Threatened Plants suggests that 34,000 (10-12% of the world's flora) are facing extinction. In the United Nations Conference on Environment and Development (UNCED)-the 'Earth Summit' in Rio de Janeiro, Brazil in 1992 an international law was formulated which emphasizes the need for the preservation of global diversity (Jackson, 1997). A total of 153 countries have already signed and ratified this new law and have agreed to work for promoting its implementation.

**Plant Genetic Resource:** The genetic resources may be defined as the genetic material of plants, animals and other organisms which determines their characteristics and hence their ability to adopt and survive (Anonymous, 1999). The Plant Genetic Resources (PGR) are often classified into – cultivated varieties (cultivars), including elite and developing breeder lines folk varieties (land races) wild and weedy species genetic stocks (eg. aneuploid and polyploid lines; morphological/biochemical mutants. Conservation of PGR, their sustainable utilization and benefit sharing is a topic of debate. PGR have received world-wide attention by the plant conservationist as the restriction has been laid down for the free flow of PGR by the enforcement of Trade Related Aspects of Intellectual Property Rights (TRIPS), charter of World Trade Organisation's (WTO's) Agreement, Convention on Biological Diversity (CBD) and FAO's International Undertaking on Plant Genetic Resource (IUPGR). These recent enactments necessitated in depth study and

formulation of effective legislation so that the rights of the PGRs rest with respective countries besides their conservation and sustainable utilization.

India has been designated as one of the 12 mega gene centres in the world. Flora of Indian sub-continent is very rich in diversity and endemism largely due to the varied agro-climate conditions. For understanding vegetation diversity, India has been divided into 10 biogeographic zones and each zone has its own unique characteristic natural vegetation (Rodgers and Panwar, 1988). Within these zones, there are two 'hotspots' of biodiversity – Western Ghat and Eastern Himalayas. These areas are not only rich in biodiversity but also in endemic species. It is estimated that over 45,000 species of plants are available in India representing 11% of the known plant species of the world and are distributed into groups namely, Angiosperms (15,000), Gymnosperms (64), Pteridophytes (1,022), Fungi (23,000), Aglae – 2,500, and Bacteria – 850 (Rao, 1997). Further, the flowering plants of India represent 6% of the world's known flowering plants (Nayar, 1977). Aside, half of the world's aquatic flowering plants exist in India (Lavana *et al.*, 1990). The plant species endemic to India are nearly 5,500 and about 1,500 are threatened species. But status of conservation for such vast floristic diversity is doomsday. As a result, 10 – 15% of the Indian flowering plants are under various degrees of threat. Nevertheless, 25% will become rare by the turn of the century (Jain, 1981).

**Conservation methods and sustainability:** The term 'conservation' may be defined as 'the management of human use of the biosphere so that it may yield greatest sustainable benefits to present generation while maintaining its potential to meet the needs and aspirations of the future generations. Thus, conservation is positive, embracing preservation, maintenance, sustainable utilization, restoration and enhancement of the natural environment. Before advocating any conservation measures for a threatened plant species, it is recommended that the critical assessment of the causes of threat is

made. Flood, landslide, drought and technological development are the natural factors which disturb ecological balance resulting in long range effect beside loss of vegetational cover. The qualitative assessment of threat is based on the field observation, a visual decline of species, lesser frequency of occurrence and long-spaced collection (Jain, 1981). Conservation has three specific objectives: to maintain a balance between essential ecological process and life support system; to preserve genetic diversity; to ensure sustainable utilization of natural resources.

There are two main approaches of conservation as follows:

*In situ* or on site: This refers to conservation of the plant species in its natural habitat within the community of which it is a part so that it has potential for continued evolution. Botanic Gardens should also participate in the environment planning and conservation biology research of the respective country to conserve as much as possible the world's plants in *in situ*.

*Ex situ*: It refers to maintenance of organisms outside or away from their natural habitat, such as in botanic garden, field genebank or by storage in the form of seed, vegetative propagules, tissue or cell culture. The commonest form of conservation is botanic garden. The purpose of *ex situ* conservation is to provide protective custody. It should be considered as part of an overall, integrated programme. *Ex situ* and *in situ* should be seen as complementary and mutually reinforcing approaches.

Plant species having economic importance should be identified for their use in commercial horticulture, forestry and agriculture. Access to the PGRs for the purpose of benefit sharing is also an important aspect. About 4 million accessions are currently held by the botanic gardens world-wide. These should be shared for various research and development purposes.

**Role of Botanic Gardens:** A Botanic garden is an institution holding documented collection of living plants for the purpose of scientific research, conservation, display and education (Jackson, 1999). They serve as a repository of germplasm collection specially rare and endangered ones of indigenous and exotic origin (Sharma and Goel 1994). Botanic Garden Conservation International (BGCI), an international organization with its headquarter in London, was established in 1987 for global co-operation and monitoring the conservation programmes of the botanic gardens. BGCI has 500

member botanic gardens in 111 countries all over the world (Jackson, 2000). There are about 1,846 Botanic Gardens world-wide as per BGCI database. The Botanic Garden Conservation Strategy was worked out jointly by BGCI, IUCN, WWF in 1989 which provides the guidelines for every botanic garden in the world. In the recent past, the new International Agenda for the BGCI has been launched in 2000 at the 1<sup>st</sup> World Botanic Garden Congress in Asheville, USA. This outlines why involvement of botanic gardens is an essential element in the conservation for sustainable development. The other tasks of the botanic garden should also be taken up on priority basis. The role of the botanic gardens in the new millennium should be as follows (Crane, 2001, Jackson, 2000).

- *Ex-situ* conservation of plants specially rare and endangered ones. This emphasizes improvement in the germplasm collection management, establishment of seed bank, management and maintenance of gene pool. New links have been developed with the International Crop Genetic Resources Conservation sector, marked by the recognition of the role of botanic gardens and their collections in FAO Global Plan of Action.
- To study the habitat requirement, distributional range, biology and reproductive potential of the plant species so as to provide the required micro-climate, essential for the plant growth.
- Introduction of newer species through exchange programme from other botanic gardens, arboreta located in the iso-climate zones of the world for enrichment of germplasm collection and their subsequent utilization for the benefit of the people.
- To increase the basic knowledge of plant diversity.
- To build public understanding through educational programme.
- To play an active role in the conservation and sustainable utilization of plant resources.
- Public awareness with educational programme highlighting the importance of plant conservation and sustainable utilization, control of environmental pollution is one of the important role of the botanic garden in the 21<sup>st</sup> century. They should encourage visits of the students from school and universities.
- Sharing of the surplus propagules with the other botanic gardens, arboreta and research institutions to increase the survival chances and to avoid the

catastrophic loss of genetic material at one centre resulting in total extinction of the species.

- Networking of the botanic gardens specially within the country in order to have the first hand information on the existing genetic resources, status of the rare and endangered plant species so that the species which needs conservation measures are identified and ultimately identifying plant material for exchange. A national inventory of threatened, endangered or rare plants should be prepared.
- A significant number of plant species are grown in public parks along national highways, school and college campus and private gardens. Botanic gardens should also list such collection or individual specimen besides providing facilities for propagation of such species.
- Multiplied species are to be reintroduced in the wild as a measure to replenish the dwindling population.
- The new international agenda advocates much broader role to be played by the botanic gardens in other discipline, involving much greater integration of tools, methodologies and tasks.

**Acknowledgement:** The author is grateful to the Director, NBRI for providing the necessary facilities and encouragement.

## References

- Anonymous (1984) Global Changes. National Council of Science Museum, Calcutta.
- Anonymous (1999) Diversity for development, the new strategy of the International Plant Genetic Resources Institute, Rome, Italy.
- Crane (2001). Botanic Gardens for the 21st Century. *Gardenwise* XXI: 4-8.
- Jackson WP (1997) Botanic gardens and the Convention on Biological Diversity, *Botanic Garden Conservation News*, 1: 16-19.
- Jackson WP (1999) Plenary address *BGCI 4<sup>th</sup> International Congress on Education in Botanic Gardens* held in Thiruvananthapuram, Kerala, India.
- Jackson WP (2000) Launch of the new international agenda for botanic gardens in conservation at the 1<sup>st</sup> World Botanic Gardens Congress, Asheville 2000, *BGCI News*. 23-25.
- Jain SK (1981) An Insight into the problem of threatened plants. *Indian Natl. Sci. Acad. Newslett.* 66:1-3.
- Lavania GS, SC Paliwal and B Gopal (1990) Aquatic Vegetation of the Indian Sub-continent. In: B Gopal (de.) *Ecology and Management of Aquatic Vegetation in the Indian Sub-continent*. Klewer Academic. The Netherlands.
- Myers N (1988) Tropical forests and their species-Going Going? In: *Biodiversity*. National Academy Press. Washington D.C. USA.
- Nayar MP (1977) Changing pattern of India flora. *Bull. Bot. Surv. India*. 19: 145-154.
- Rao RR (1997) Diversity of Indian Flora. *Proc. Indian Nat. Sci. Acad.* B-63: 127-138.
- Rodgers WA and HS Panwar (1988) Planning a wildlife protected area network in India, Vol. 1-2: (Mimeographed) Wildlife Institute of India, Dehra Dun.
- Sharma SC and AK Goel (1994) Role of Botanic gardens in modern times. *Indian J. Forestry* 17: 230-238.

## Genetic-Diversity of Medicinal and Aromatic Plants of Himalayan Region (Himachal Pradesh) and its Conservation

**NS Chauhan**

Associate Professor, Department of Forest Products, Dr YS Parmar University of Horticulture and Forestry, Nauni-Solan-173230, Himachal Pradesh

**Key Words:** Medicinal plants, Aromatic plants, Himalayas, Genetic diversity

India in general and Himalayas in particular are the reservoir of genetic wealth, ranging from tropical, sub-tropical, sub-temperate to temperate including dry temperate and cold deserts, culminating into alpine-both dry and moist, covering a great variety of flora and fauna. But these genetic resources are threatened by the exploding human and cattle population, unsustainable resource extraction and unfriendly waste dumping. Many

species have already disappeared or are in the process of extinction and are designated as endangered species. Such disappearance of genetic resources is related to the extinction of innumerable species with which it is intrinsically linked through food webs and food chains. This has also lead to serious ecological consequences with an eventual bearing on productivity, which is affecting the basic life support system and livelihoods

catastrophic loss of genetic material at one centre resulting in total extinction of the species.

- Networking of the botanic gardens specially within the country in order to have the first hand information on the existing genetic resources, status of the rare and endangered plant species so that the species which needs conservation measures are identified and ultimately identifying plant material for exchange. A national inventory of threatened, endangered or rare plants should be prepared.
- A significant number of plant species are grown in public parks along national highways, school and college campus and private gardens. Botanic gardens should also list such collection or individual specimen besides providing facilities for propagation of such species.
- Multiplied species are to be reintroduced in the wild as a measure to replenish the dwindling population.
- The new international agenda advocates much broader role to be played by the botanic gardens in other discipline, involving much greater integration of tools, methodologies and tasks.

**Acknowledgement:** The author is grateful to the Director, NBRI for providing the necessary facilities and encouragement.

## References

- Anonymous (1984) Global Changes. National Council of Science Museum, Calcutta.
- Anonymous (1999) Diversity for development, the new strategy of the International Plant Genetic Resources Institute, Rome, Italy.
- Crane (2001). Botanic Gardens for the 21st Century. *Gardenwise* XXI: 4-8.
- Jackson WP (1997) Botanic gardens and the Convention on Biological Diversity, *Botanic Garden Conservation News*, 1: 16-19.
- Jackson WP (1999) Plenary address *BGCI 4<sup>th</sup> International Congress on Education in Botanic Gardens* held in Thiruvananthapuram, Kerala, India.
- Jackson WP (2000) Launch of the new international agenda for botanic gardens in conservation at the 1<sup>st</sup> World Botanic Gardens Congress, Asheville 2000, *BGCI News*. 23-25.
- Jain SK (1981) An Insight into the problem of threatened plants. *Indian Natl. Sci. Acad. Newslett.* 66:1-3.
- Lavania GS, SC Paliwal and B Gopal (1990) Aquatic Vegetation of the Indian Sub-continent. In: B Gopal (de.) *Ecology and Management of Aquatic Vegetation in the Indian Sub-continent*. Klewer Academic. The Netherlands.
- Myers N (1988) Tropical forests and their species-Going Going? In: *Biodiversity*. National Academy Press. Washington D.C. USA.
- Nayar MP (1977) Changing pattern of India flora. *Bull. Bot. Surv. India*. 19: 145-154.
- Rao RR (1997) Diversity of Indian Flora. *Proc. Indian Nat. Sci. Acad.* B-63: 127-138.
- Rodgers WA and HS Panwar (1988) Planning a wildlife protected area network in India, Vol. 1-2: (Mimeographed) Wildlife Institute of India, Dehra Dun.
- Sharma SC and AK Goel (1994) Role of Botanic gardens in modern times. *Indian J. Forestry* 17: 230-238.

## Genetic-Diversity of Medicinal and Aromatic Plants of Himalayan Region (Himachal Pradesh) and its Conservation

**NS Chauhan**

Associate Professor, Department of Forest Products, Dr YS Parmar University of Horticulture and Forestry, Nauni-Solan-173230, Himachal Pradesh

**Key Words:** Medicinal plants, Aromatic plants, Himalayas, Genetic diversity

India in general and Himalayas in particular are the reservoir of genetic wealth, ranging from tropical, sub-tropical, sub-temperate to temperate including dry temperate and cold deserts, culminating into alpine-both dry and moist, covering a great variety of flora and fauna. But these genetic resources are threatened by the exploding human and cattle population, unsustainable resource extraction and unfriendly waste dumping. Many

species have already disappeared or are in the process of extinction and are designated as endangered species. Such disappearance of genetic resources is related to the extinction of innumerable species with which it is intrinsically linked through food webs and food chains. This has also lead to serious ecological consequences with an eventual bearing on productivity, which is affecting the basic life support system and livelihoods

of millions of organisms living on the earth. The present paper deals with the genetic diversity of floral wealth in Himachal Pradesh with special reference to medicinal and aromatic plants. The conservation of diversity in plant based ecosystems has special significance in mountains as people are traditionally bound with the natural resources for multifaceted uses such as food, fodder, medicinal and aromatic plants and host of other uses. However, this resource is being lost at an alarming rate due to heavy dependence of people on natural resources for the aforesaid needs and other developmental activities such as roads, hydroelectric dams, industrialization, conversion of forests for agriculture and horticulture, unplanned grazing *etc.* The cattle pressure in hills, in general is much more than their carrying capacity and their uncontrolled invasion into reserve forests affects not only the regeneration, but also, leads towards the extinction of many species. The unmanaged exploitation of herbal wealth by the pharmaceutical firms is another major factor that is threatening the occurrence of these valuable plants.

Biodiversity provides a fundamental base to the mountaineous agriculture and to their economic systems. It is the source of resiliency and regeneration, necessary for sustainability of agricultural systems. It is the ultimate basis for local self sufficiency and a global asset, bringing benefits to people in terms of material welfare in more ways than we realize.

Himachal Pradesh, like any other mountainous region, is a vast repository of plant ecosystems embodying profuse variation at intra- and inter-specific levels. Owing to the mountainous terrain and varying altitudinal zone, the diversified climatic conditions are characterized by the short mid summer and considerably long severe winters. In general, the climate is humid subtropical in southern low areas, temperate in middle altitudinal area, cold alpine (semi-arctic) and glacial in North and northeast regions. In winters, snowfall takes place up to 1,500 msl, whereas, above 4,500 msl, there is precipitation snow. Total participation varies from 900 mm (in Shiwalik zone) to 3,550 mm (foothills of Dhauladhar range) and 750 mm in the southern Himalayan range. It further falls to about 500 mm in Lahaul and Kinnaur, and to about 200 mm in Spiti region. The wide range of altitude, topography and climatic conditions have endowed Himachal Pradesh with a rich and diversified flora. Various workers have conducted surveys in the area during the past over two centuries.

Chowdhary and Wadhwa (1984) in their analysis of the flora of Himachal Pradesh have reviewed the work of various earlier workers as given below. The earliest attempt to collect plants from Himachal Pradesh was made by William Moorcroft (1765-1825) who collected plants from Kangra, Kullu, Lahaul and Spiti in 1821. The countess of Dalhousie collected about 600 species of plants from Shimla in 1829 covering 500 sq. miles area with an altitude of 600-3500 m.

According to different estimates nearly 3,324 species are reported from Himachal Pradesh (flowering plants 3120, conifers 13, pteridophytes 124, orchids 67). More than 45 % of these species are endemic, while 5 % are shared by exotics. About 78 plant species are threatened to endangered. Majority of these possess medicinal and aromatic value. Recent surveys and new reports by various researchers have added more species to the list (Table 1).

The medicinal and aromatic plant resources of the Himalayan region contribute a major share in the national economy and provide sustainable resources to the hill people. Western Himalayas of which Himachal Pradesh forms a central part, is a vast repository of healing herbs. In ancient times, our Rishi-Munies have pursued their scholarly endeavours in this sacred land, away from the noisy city life, in calm and peaceful atmosphere. A plethora of plant life predominated by medicinal and aromatic plants occurs in this region ranging from subtropical zone to the cold desert areas. Almost all these plants grow wild in valleys, forests, pastures or occur as weed near fields and village habitats. Western Himalaya encompasses about 50 per cent drug plants mentioned in the British Pharmacopoeia and the 80 per cent of Ayurveda, 46 per cent of Unani, 33 per cent of Allopathic medicines. The most important are the drugs of *Ashtavarga* and *Dashmool* in addition to the *aconites*, *valerians*, *jurineas*, *Angelica*, *Dactylorhiza*, *junipers*, *Hippophae*, *arnebias*, *Saussureas*, *Pleurospermums*, *Gentians* and *Swertia* growing in various ecological niches.

Himachal Pradesh is the largest supplier of chilgoza, chicory, kuth, *Dioscorea*, dhoop, *Picrorrhiza*, valerian and *Ephedra* in the country. Out of the large resources of medicinal and aromatic plants which are credited with medicinal properties, 80-85 plants are collected and marketed annually. The pressure on these traditionally known herbs is so great that many of them have entered the list of endangered species, some such herbs are:

Table 1. Species of threatened or endangered plants of medicinal and aromatic value from Himachal Pradesh

| Biodiversity                           | Areas Studied  |                          |                                          |                                 |                        |                   |                     |
|----------------------------------------|----------------|--------------------------|------------------------------------------|---------------------------------|------------------------|-------------------|---------------------|
|                                        | Nauni<br>Solan | Pabbar<br>valley, Shimla | Kangra<br>(Gaddi inhabited<br>area only) | Kunihar<br>forest div.<br>Solan | Spiti,<br>Lahaul-Spiti | Rohtang,<br>Kullu | Churdhar<br>Sirmour |
| Total no. of Families                  | 115            | 107                      | 52                                       | 80                              | 50                     | 58                | 53                  |
| Total no. of Genera                    | 541            | 650                      | 124                                      | 213                             | 218                    | 142               | 139                 |
| Total no. of species                   | 723            | 761                      | 161                                      | 256                             | 477                    | 182               | 195                 |
| Dicots                                 | 601            | 649                      | 145                                      | 231                             | 411                    | 162               | 172                 |
| Monocots                               | 96             | 89                       | 11                                       | 23                              | 60                     | 14                | 18                  |
| Gymnosperms                            | 26             | 13                       | 5                                        | 2                               | 6                      | 6                 | 5                   |
| Ferns, lichens and fungi               | NA             | 10                       | NA                                       | 7                               | 1                      | NA                | NA                  |
| Medicinal and aromatic plants          | 260            | 462                      | 81                                       | 197                             | 74                     | 93                | 108                 |
| Timber species                         | 27             | 8                        | NA                                       | 35                              | 9                      | 7                 | 9                   |
| Fodder                                 | 55             | 40                       | NA                                       | 72                              | 55                     | 30                | 35                  |
|                                        |                | (excluding<br>grasses)   |                                          |                                 |                        |                   |                     |
| Fibre and flosses                      | 8              | 4                        | 5                                        | 20                              | 12                     | NA                | NA                  |
| Tanins and dyes                        | 6              | 35                       | 10                                       | 36                              | 19                     | 8                 | 12                  |
| Gums and Resins                        | 61             | 8                        | NA                                       | 17                              | 10                     | NA                | NA                  |
| Fuel Wood                              | 30             | 35                       | 20                                       | 76                              | 50                     | 15                | 20                  |
| Bee flora                              | 30             | 32                       | NA                                       | 59                              | NA                     | NA                | NA                  |
| Edible species                         | 15             | 37                       | 20                                       | 75                              | 22                     | NA                | NA                  |
| Ornamental/landscape species           | 100            | 120                      | 10                                       | 135                             | 35                     | 20                | 30                  |
| Miscellaneous                          | 69             | 13                       | 20                                       | 80                              | 19                     | NA                | NA                  |
| Ethno-botanically<br>important species | 85             | 85                       | 67                                       | 205                             | 104                    | 46                | 39                  |

*Dioscorea*, Atish, salampanja, chora, daruhaldi, karu, kutki, pushkarmool, bankakri, revandchini, chirayata, and tejpatra. On the other hand, hundreds of herbs which can form potent sources to meet the growing demands of the drug industry are not being utilized or are exploited to a relatively lesser degree. Lack of marketing facilities and reluctance of the user industrial units to consume material within the state, can be attributed as a cause for this.

In the lower Shiwalik ranges common drug plants found *Dashmool* group, the three *Myrobalans* *Helicteres isora*, *Celastrus paniculatus*, *Centella asiatica*, *Acacia catechu*, *A. nilotica*, *Cassia fistula*, *C. absus*, *Cissampelos pareira*, *Withania somnifera*, *Mucuna pruriens*, *Pueraria tuberosa*, *Justicia adahotoda*, *Holarrhena antidysenterica*, *Bacopamonnieri*, *Plumbago zeylanica*, *Calotropis procera*, *Evolvulus alsinoides*, *Citrullus colocynthis*, *Bryonopsis laciniata* and *Mallotus philippinensis*.

In the temperate zone commercially exploitable herbs are found like, *Valeriana jatamansi*, *Selinum tenuifolium*, *S. vaginatum*, *Berberis aristata*, *Skimmia laureola*, *Viola* species, *Morchella esculenta*, *Taxus wallichiana*, *Hedychium acuminatum*, *Symplocos paniculata*, *Bergenia*

*ciliata*, *Thalictrum foliolosum*, *Angelica glauca*, *Dioscorea deltoidea*, *Heracleum candicans*, *Podophyllum hexandrum*, *Thymus serpyllum*, *Polygonatum verticillatum*, *P. cirrhifolium*, *Polygonum aviculare*, *P. recumbens* and the life rejuvenating drugs of *Ashtavarga* group (Collet 1921, Uniyal and Chauhan 1971, 1972; Chauhan, 1984).

The tree limit roughly corresponds to the perpetual snowline i.e. 3700 m above mean sea level. Conifers like Silver fir with Rhododendrons, birch, kharshoo oak, junipers and dwarf salix form the demarcation line between the temperate and the alpine zones reaching the highest limit. The alpine grasslands, usually above 3800 msl remain snow covered for 4-8 months and are remarkable for the variety of beautifully coloured flowers of valuable medicinal herbs like *Aconitum heterophyllum*, *A. violaceum*, *A. deinorrhizum*, *Ephedra gerardiana*, *Rhododendron anthopogon*, *R. lepidotum*, *Nardostachys grandiflora*, *Dactylorhiza hatagirea*, *Picrorrhiza kurrooa*, *Corydalis gowaniana*, *Jurinea dolomiaea*, *Heracleum candicans*, *Aconogonum rumicifolium*, *Valeriana pyrolaefolia*, *Pleurospermum brunonis*, *Delphinium vestitum*, *Saussurea obvallata*, *S. gossypiphora*, *Tanacetum longifolium*, *Polygonum macrophyllum*, *Achillea*

*millefolium*, *Rheum australe*, *Senecio amplexicaule*, *Gentiana kurroo*, *Arnebia benthami*, *A. euchroma* and species of *Allium* (Uniyal and Chauhan 1971, 1972, Chauhan, 1984, 1988, 1989a,b, 1992, 1995, 1997).

*Saussurea costus* (kuth), *Bunium persicum* (kalajira), *Cichorium intybus* (chicory), *Crocus sativus* (kesar) and *Humulus lupulus* (hops) in Lahaul and Spiti, Kinnaur and Pangi-Bharmour; whereas *Zingiber officinale* (adarak) is commercially cultivated in Sirmour, Solan and Bilaspur. People cultivate *Allium cepa* (piaz), *A. sativum* (lahsun), *Ocimum sanctum* (tulsi), *Amomum subulatum* (barillaichi), *Foeniculum vulgare* (mithi sonf), *Trigonella foenum-graecum* (methi), *Curcuma longa* (haldi) and *Mentha spicata* (pudina) to meet their domestic requirements in the lower valley areas. Cultivation technology for exotics like *Glaucium flavum*, *Solanum laciniatum*, *Rosmarinus officinalis*, *Glycyrrhiza glabra*, *Salvia sclarea*, *S. bisor*, *Matricaria chamomilla* and indigenous drugs like *Withania somnifera*, *Mimosa pudica*, *Dioscorea deltoidea* and *Digitalis lanata* has been developed by Dr YS Parmar University of Horticulture and Forestry, Solan.

#### *Endangered Species of Medicinal and Aromatic Plants*

As a result of continuous and relentless extraction during the course of many decades, dozens of valuable species are facing danger to their survival in their natural abode in the absence of management practices for their regulated and scientific exploitation, protection, conservation and multiplication. Unregulated exploitation and disorganized trade practices are responsible for the sharp decline of the herbal wealth of the state. Local villagers in their off time collect the herbs and sell them to local shopkeepers in exchange for their daily need items. In the process, the collection rules are frequently flouted, the life cycle of the plant is broken and the quality of the material so collected gets deteriorated.

Commercial exploitation of forests have not been commensurate leading to afforestation, but has lead to modification of habitats. Lack of wisdom and scientific mechanisms behind introduction of exotic species too, have caused disastrous affects on local resources. The introduction of monoculture in the form of plantations by chir, *Eucalyptus*, *Populus*, *Acacias* etc. is damaging the biodiversity existing in such habitats. Overexploitation of medicinal plants have resulted in threatening the existence of *Aconitum deinorrhizum*, *A. heterophyllum*, *Arnebia benthami*, *Artemisia sieversiana*, *Atropa acuminata*, *Berberis aristata*, *Colchicum luteum*, *Curculigo*

*orchioidea*, *Dioscorea diltoidea*, *Eulophia campestris*, *Eremurus himalaicus*, *Gentiana kurroo*, *Ginkgo biloba*, *Inula racemosa*, *Nardostachys grandiflora*, *Rauwolfia serpentina*, *Saussurea bracteata*, *S. gossypiphora*, *Swertia chirayita*, *Urginea indica* and *Valeriana hardwickii* etc. Recent emphasis on tourism development in the state being given a priority status is resulting into excessive pressure on plant resources in such tourist hot spots. Plucking of flowers, uprooting of curious species laying of tents, mule paths, sliding and skiing activities have adversely affected the natural regeneration of species thereby making the ground unfavourable.

Biodiversity conservation is getting world-wide attention and huge resources are being pumped in to these endeavours. Conservation, like development, is for the people and at no stage, it forbids the use of natural resources for developmental purposes, but implies that resources should be utilized and managed in such a way that they are available for use on sustainable basis for future generations too. This effort definitely requires various effective measures and mechanisms to ensure that the biodiversity is utilized, conserved and managed in such a way that it is available for use today, and also in the years to come on sustainable basis. Following measures are being adopted for conservation of biodiversity in Himachal Pradesh. A sufficiently large area has been e-marked for *in situ* conservation of plants and animal life, but legal and social controls on the usage of such lands vary greatly and habitats for target species can not be secured fully. For *in situ* conservation of herbal resources of the State a new project entitled, "Vanaspati Van" has been started with the financial aid of Rs. 5.16 crores from the Ministry of Health and Family Welfare, Govt. of India. Out of the total 91 National Parks in the country, 2 have been established in Himachal Pradesh i.e. Pin Valley National Park and Great Himalayan National Park in the District of Lahaul-Spiti and Kullu, respectively in addition to 32 wildlife sanctuaries. These will definitely serve in conserving biodiversity in their respective regions.

Such measures refer to the conservation of species outside their natural abode and can be achieved by establishing breeding seed orchards, clone banks or seedling banks, arboreta/botanic gardens/herbal gardens, seed banks, pollen banks, tissue banks etc. As a step towards conservation of biological diversity of medicinal and aromatic plants of Himalayan region, the Dr YS Parmar University of Horticulture and Forestry, Nauni-

Solan has done systematic survey of medicinal plant wealth and a state level Herbarium has been established in the University. *Ex situ* conservation measures for developing/establishing Arboreta/Botanic/Herbal Gardens at different agroclimatic zones of Himachal Pradesh initiated under the Central Sector Scheme "Cultivation of Medicinal and Aromatic Plants" funded by the Ministry of Agriculture and Co-operation and Ministry of Health and Family Welfare, GOI, New Delhi. Many projects for undertaking propagation and conservation of germplasm of medicinal and aromatic plants through tissue culture and cryo-preservation and maintaining the herbal garden of the endangered, threatened and rare medicinal and aromatic plants and their mass scale propagation are lying for financial approval with the funding agencies. Efforts are also afoot to preserve germplasm for long term conservation in collaboration with NBPGR, New Delhi and micropropagation through tissue culture with Department of Biotechnology, New Delhi. The state department of Ayurveda is planning to develop 4 herbal gardens; one each at Jogindernagar, Hamirpur, Sangla and Saribasa. The department of Forest Farming and Conservation is initiating drives for afforestation of species of medicinal and aromatic plants in their plantation programmes through its research division. Demonstration plots will be laid on farmers field by the department of Horticulture with technical collaboration of YS Parmar University.

Himachal Pradesh has vast potential for cultivation of medicinal and aromatic plants in its varying agroclimatic zones as well. Dr YS Parmar University of Horticulture and Forestry, Nauni-Solan has established herbal gardens in different agro-climatic zones of Himachal Pradesh with the objective to conserve the herbal wealth. More than 250 species are being grown and seed/planting material is supplied to various institutions in the country, farmers, NGO's and industries.

Recent developments and efforts being put in by the government, several departments and Dr YS Parmar University of Horticulture and Forestry, Nauni-Solan towards conservation, protection and cultivation of such herbs in herbal gardens, farmers' fields, forest plantations using *in situ* and *ex situ* measures show a ray of hope towards the positive. The laying of demonstration plots

in farmers' fields, establishing Vanaspati Van (*in situ* and *ex situ* conservation) and strengthening and encouraging domestication efforts will definitely give a boost to manage this important resource on sustainable basis and usher in economic prosperity to the people of this hill state.

## References

- Aitchison JET (1869) A catalogue of the plants of the Punjab and Sindh. Taylor and Francis, London. Reprinted 1982. Bishen Singh Mahendra Pal Singh, Dehra Dun (Uttar Pradesh).
- Brandis D (1874). The forest flora of the Northwest and Central India. London. Reprinted 1972. Bishen Singh Mahendra Pal Singh, Dehra Dun (Uttar Pradesh).
- Chauhan NS (1984). Medicinal Wealth of Pabbar Valley in Himachal Pradesh. M.Sc. Thesis, HPKW, Palampur.
- Chauhan NS (1988) Endangered ayurvedic pharmacopoeial plant resources of Himachal Pradesh. In: *Indigenous Medicinal Plants*. (P. Kaushik ed.). Today and Tomorrows Publisher's, New Delhi.
- Chauhan NS (1989a) Potential of aromatic plants of Himachal Pradesh. *Indian Perfumer* 33(2): 118-112.
- Chauhan NS (1989b) Medicinal and aromatic plants of Himachal Pradesh and their role in social forestry programme, 3rd Forestry Conference 2: 89(1-9) FRI, Dehra Dun.
- Chauhan NS (1990) Medicinal orchids of Himachal Pradesh. *J. Orchid Society of India* 4: 99-105.
- Chauhan NS (1991) Plant resources of Himachal Pradesh. St. and E Council, HP, Shimla.
- Chauhan NS (1992) Commercial medicinal and aromatic plants of Himachal Pradesh. HP State Science, Technology and Environment Council, HP, Shimla.
- Chauhan NS (1995) Plant resources of economic use in Himachal Pradesh. Department of Forest Products, Dr YS Parmar University of Horticulture and Forestry, Nauni-Solan (HP), 72 p.
- Chauhan NS and Thakur S (1995) Conservation of plant genetic resources of Himachal Pradesh. *Indian J. Forestry* 18: 226-238.
- Chauhan NS (1997) Sustainable management of medicinal wealth resources perspectives and issues. A chapter in the book edited by LR Verma (in press).
- Chowdhery HS and BM Wadhwa (1984) Flora of Himachal Pradesh. BSI Publication.
- Collet H (1921) *Flora Simlensis*. Thacker and Spink, Calcutta.
- Uniyal MR and NS Chauhan (1971) Medicinal plants of Uhal valley in Kangra forest division. *HP J. Res. Ind. Med.* VI: 287-299.
- Uniyal MR and NS Chauhan (1972) Commercially important medicinal plants of Kullu. Forest Division, HP. *Nagarjun* IV: 28-32.

## Effect of Various Physico-chemical Treatments in Breaking Hardseededness in *Mucuna pruriens*

**Veena Gupta, Kalyani Srinivasan and Sanjeev Saxena**

National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012

**Key Words** *Mucuna pruriens*, Dormancy, Germination, Medicinal Plant

*Mucuna pruriens*, a leguminous twining herb, has a wide distribution in tropical and sub-tropical regions of the world. It is one of the most important medicinal plants used as effective nervine tonic, anthelmintic and aphrodisiac. The seed contains L-dopa ( $\alpha$ -4-hydroxy phenylalanine). Seed coat-imposed hardseededness is observed in this genus like many other genera of the family. The hard seed character in leguminous plants is thought to be due to the thick palisade cell layer (Elbagoury, 1974). But these have the advantages in the maintenance of the seed quality, preventing post-harvest sprouting and are potential reserves of species of the perennial crops. Several investigators working with small legumes have demonstrated the effectiveness of different scarification and cutting and piercing methods (Rolston, 1978) for overcoming hardseededness. Various treatments employed to break dormancy in this species and results obtained are reported in this communication.

Physiologically matured seeds of *Mucuna pruriens* were subjected to the various dormancy breaking treatments viz.- (i) Cutting (a gentle cut to the seed coat anywhere else other than near the radicle or hypocotyl region), (ii) Physical scarification (seeds were rubbed in between the two sheets of sand paper), (iii) Acid scarification (seeds were soaked in 50 % sulphuric acid for 30 min followed by thorough washing in running water for 1 h (concentrated sulphuric acid was found to have a charring effect on seed and hence diluted acid was used), (iv) hot water treatment (seeds were dipped in hot water at 50°C for 30 min. and 80°C for 5 min and removed and cooled at room temperature). Three replicates of 25 seeds each were placed in moist paper towels at 25°C in dark. Protrusion of radicle in seeds considered as the germinated seeds. Observations were recorded after 2 days and the first count was taken on 2<sup>nd</sup> day and final count on 15<sup>th</sup> day. The percentage on normal and hard seeds was calculated. Mean germination time (MGT) was calculated according to the methods of Ellis and Roberts (1980) while mean daily germination was calculated as the final germination

percentage divided by the total number of the days for the test. Germination count was taken every day taking the protusion of radical as indication. Seedling fresh weight, root length and shoot length were taken on seventh day. Dry weight of the seedling was taken after drying for three days at 75°C. Vigour index was calculated as the product of shoot length and germination percentage.

In agriculture, hardseededness can be disadvantageous as the lack of simultaneous germination prevents the establishment of uniform stand. This probably needs considerable attention especially in genebanks because it not only interefers with the result of the germination tests designed to assess the viability of the accession but can also reduce the amount of precious seed which emerges when sown for regeneration or multiplication or for any other purposes. The seeds of *Mucuna pruriens* registered hardseedness upto 40% due to the hard seed coat which completely prevents the imbibition and also the gaseous exchange. Seeds were subjected to different chemical and physical treatments to break this hard seed coat and data in respect to germination and vigour related parameters was analysed. The present study suggests that cutting the seed coat was most effective for eliminating the dormancy and achieving the germination percentage upto 100. Hot water, sand paper scarification and acid treatment was ineffective in breaking the hard seed coat. Although mean germination time (MGT) did not vary significantly among different treatments, the mean daily germination (MDG) revealed significant differences. A maximum MDG was revealed by cut treatment (19.73%) while minimum was in hot water treatment (11.73%) (Table 1). Scarification with conc. sulphuric acid and sand paper revealed MDG on par with control. The improvement by cutting seed coat may be attributed to easy imbibition of water through the cut area thereby facilitating the onset of germination due to immobilisation of the reserves. This is supported by the significant improvement in the seedling vigour and the rate of the germination. The vigour data showed that root length and shoot length did not vary significant in various

Table 1. Dormancy breaking techniques vs seed germination and vigour parameters in *Mucuna pruriens*

| Treatment      | Normal seedling | Hard seed | MGT  | MDG   | Root  | Shoot | Vigour index |
|----------------|-----------------|-----------|------|-------|-------|-------|--------------|
| Control        | 55.33           | 40.00     | 2.49 | 13.33 | 11.10 | 12.13 | 807          |
| Cut            | 98.66           | 0.00      | 2.36 | 19.37 | 14.46 | 17.26 | 1705         |
| Sand           | 66.00           | 32.66     | 2.42 | 13.20 | 12.46 | 11.76 | 755          |
| Acid           | 66.66           | 33.33     | 2.18 | 13.33 | 13.10 | 9.23  | 613          |
| Hotwater 50° C | 66.66           | 33.33     | 2.33 | 12.00 | 11.56 | 12.60 | 695          |
| Hotwater 80° C | 58.66           | 0.00      | 2.23 | 11.73 | 11.06 | 8.13  | 271          |
| CD 5%          | 12.55           | 11.72     | 0.55 | 2.59  | 1.19  | 4.16  | 110          |

treatments but comparatively cut treatment showed higher values for both the parameters. Vigour index was maximum in cut treatment followed by control. Minimum vigour index was noted in hot water treatment at 80°C while rest of the treatments were at par with the control. Although many workers have reported significant improvement in germination with conc. sulphuric acid as in Alfalfa (Tomar and Maguire 1989), *Cassia serica* (Jayakumar *et al.* 1989) and in *Acacia farnesiana* (Rana and Nautiyal, 1989), in the present study, *Mucuna pruriens* did not show any response to this treatment. Similarly mechanical scarification using sandpaper was also found to be ineffective in this genus. Hot water treatment at 50°C for 30 min. failed to improve the permeability of the seed coat whereas treatment at 80°C for 30 min. was lethal to the seeds. Along with reduction in the germination percentage, these treatments also showed a corresponding decrease in the vigour parameters. This was probably due to considerable injury inflicted to the non-dormant seeds present in the seed population. Similar negative results due to hot water treatments have been reported in kasuri methi (Sinha *et al.* 1993) and *Vicia faba* (Jha and Sinha, 1989). The tremendous increase in the EC of the seeds leachates in consistent with the fact that there is a perceptible injury to the cellular membrane due to the higher temperature to which they were subjected to in the hot water treatment.

Thus, of the several tried treatments to overcome the seedcoat dormancy in *Mucuna pruriens*, only the cutting treatments has been found to eliminate this phenomenon completely. In seed testing, since the objective is to achieve the maximum germination percentage within the shortest possible time and speed as well as final germination are taken into consideration to judge effectiveness of the pretreatment, in *Mucuna pruriens* it is the cutting treatment which should be followed.

#### References

- Rolston MP (1978) Water impermeable seed dormancy. *Bot. Rev.* 365-396.
- Rana U and AR Nautiyal (1989) Coat imposed dormancy in *Acacia farnesiana* *Seed Res.* 17: 122-127.
- Tomar RPS and JD Maguire (1989) Hard seed studies in *Alfalfa*. *Seed Res.* 17: 29-31.
- Elabagoury OH (1974) Effect of different fertilizers on the germination and hard seed percentage of lentil seeds (*Lens culinaris* med.) *Seed Sci. Technol.* 2: 427-434.
- Sinha SK, BN Jha and SK Varsheney (1993) Effect of various treatments on hardseedness in kasuri methi (*Trigonella corniculata* L.). *Seed Res.* 21: 114-116.
- Jha BN and RP Sinha (1989) Hardseedness in *Vicia faba* L. *Febs Newsletter* 24: 37
- Ellis and Roberts (1980) Improved equations for the prediction of seed longevity. *Ann. Bot.* 45: 13-30.
- Jayakumar R, M Mahadevappa, S Joshi and TG Prasad (1989) Dormancy studies in *Cassia serica* seeds. *Seed Res.* 17: 118-121.

Many promising lines were identified for different characters as revealed in Table 2. Among the genotype evaluated, genotype NIC-7187 found superior for yield contributing traits *i.e.* primary branches/plant, main shoot length, harvest index and seed yield/plant and genotype IC-94030 was observed superior for secondary branches/plant, number of siliqua on main shoot, seed/siliqua length, seed yield/plant, 1000-seed weight and oil content. Desirable traits such as lower plant height and small siliqua beak length is observed in genotype EC 305374.

The data reveals the vast potential of existing germplasm in developing genotypes, with desirable traits. However, efforts should be made to broaden genetic base of oilseed brassicae by collecting landraces having desired economic attributes.

**Table 2. Promising accessions of toria for different economic traits**

| Attributes                             | Germplasm accessions                                |
|----------------------------------------|-----------------------------------------------------|
| Plant height (<60 cm)                  | EC-305374, EC-333595, EC-305594, IC-147592, TS-50   |
| Primary branches/plant (>7.0)          | YS-36-4, NDT-9902, NIC-7187, IC-289660, IC-94030    |
| Secondary branches/plant (>15.0)       | YS-36-4, MCT-96, IC-94030, NDT-9902, EC-333597      |
| Main shoot length (> 76.0 cm)          | NIC-7187, EC-333597, IC-94030, IC-94030, NDT-9902   |
| No. of siliquae on main shoot (> 74.0) | NDT-9902, PBT-221, IC-94030                         |
| Seeds/Siliqua (> 17.0)                 | NDT-9902, JMT-9341, MCT-96, IC-94030                |
| Siliqua length (> 4.0 cm)              | IC-94030, NDT-9902, IC-76707, IC-94306, IC-289660   |
| Seed yield/plant (>18.0 g)             | IC-289660, NIC-7187, EC-333597, IC-94030, EC-333597 |
| Harvest index (> 35%)                  | NRCT-98-120, TH-9802, NIC-7187, EC-305574           |
| Siliqua beak length (< 1.0 cm)         | IC-94030, TS-50, PBT-221, EC-305374, EC-333597      |
| 1000-seed weight (> 3.5 g)             | PT-303, IC-94030, TH-9802, NRCT-98-120, NDT-9902    |
| Protein content                        | TK-9902, TS-51, PBT-126-6, PBT-221                  |
| Oil content (> 40%)                    | YS-36-4, IC-94030, IC-94030, IC-76707, IC-289660    |

## Variability and Character Association Among Floral Traits and Yield in Bread Wheat (*Triticum aestivum* (L.) em. Thell)

**SK Singh\* and RM Singh**

Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, Uttar Pradesh

**Key Words:** Wheat (*Triticum aestivum*), Variability Character Association, Floral Traits, Field Traits

Development of hybrids in wheat is being considered as an alternative approach to achieve a quantum jump in grain yield. Thus, selection for floral traits which enhance magnitude of out-crossing such as duration of floral opening, greater anther extrusion in the male parent; openness of florets and stigma receptivity in the female parent is crucial for successful development of hybrids. An experiment was conducted to investigate the extent of variability among wheat genotypes for floral traits and yield along with nature of association among these traits.

The experimental material consisted of 491 diverse genotypes of bread wheat including land races, released varieties and advanced lines introduced from CIMMYT, Mexico. These were grown in randomized block design in three replications during *rabi* 1996-97. Crop was sown in the last week of November in a double row plot of 3 m length with inter-and intra-row spacings of 25 cm and 10 cm, respectively. The data were recorded for 7 floral traits, *viz.*- days to 50% flowering, anther length, stigma length, anther extrusion, openness of floret, duration of flower opening, pollen viability and yield/plant in 10 randomly selected plants. Coefficients of variability, broad sense heritability (%), genetic advance

\*Present Address: Scientist (Plant Breeding), Directorate of Wheat Research, PO Box 158, Karnal-132001, Haryana

and correlation coefficients were worked out using INDOSTAT package.

Highly significant differences were observed among wheat genotypes for all the traits (Table 1). A wide range was observed for all the traits. Maximum frequency of genotypes was observed in the range of 75-80 days for days to 50% flowering, 4.0-4.5 mm for anther length, 3.0-3.5 mm for stigma length, 40-60% for anther extrusion, 20-25 degree for openness of floret, 15-20 minutes for duration of floral opening, 90-92% for pollen viability and 12-14 g, for yield/plant. The phenotypic coefficient of variation (PCV) was higher than their respective genotypic coefficient of variation (GCV). Anther extrusion showed maximum coefficient of variation followed by duration of floral opening and openness of floret at phenotypic as well as genotypic level (Joppa *et al.* 1968; Choudhary *et al.* 1994). Genotypes showing superiority

for yield along with floral traits were WL711, Raj 3077, HUW 234, DWR 185, K 7410, WH 157, K 9006, WH 147, K 9312, PRL/Tori, Galvez 87, CPAN 3006, WL 6975, UP 2338 and BW 11259 which may be used as parent in crossing programme to produce desirable recombinants. High estimates of heritability in broad sense were observed for anther extrusion, duration of floral opening and yield/plant. High genetic advance as per cent of mean was also observed for anther extrusion, duration of floral opening and openness of floret. High genetic advance coupled with high heritability for these traits would offer more gain during selection (Atashi-Rang and Lucken, 1978). The phenotypic correlation coefficients (Table 2) indicated positive and highly significant associations of yield/plant with anther length, stigma length, anther extrusion and duration of floral opening. Similar trend was also

**Table 1. Range, mean, phenotypic and genotypic coefficients of variation, heritability (%), genetic advance and genetic advance as per cent of mean in wheat**

| Character                      | Range       | Mean  | PCV   | GCV   | Heritability %<br>(broad sense) | Genetic<br>advance | Genetic advance<br>as % of mean |
|--------------------------------|-------------|-------|-------|-------|---------------------------------|--------------------|---------------------------------|
| Days to 50% flowering          | 68.33-90.33 | 80.61 | 6.18  | 6.16  | 99.56                           | 10.21              | 12.67                           |
| Anther length (mm)             | 2.94-5.07   | 4.16  | 8.09  | 8.06  | 99.37                           | 0.69               | 16.55                           |
| Stigma length (mm)             | 1.93-3.52   | 2.98  | 10.35 | 10.29 | 98.81                           | 0.62               | 21.07                           |
| Anther extrusion (%)           | 9.74-79.64  | 49.93 | 35.81 | 35.78 | 99.87                           | 36.78              | 73.67                           |
| Openness of floret<br>(degree) | 12.53-35.80 | 24.07 | 18.33 | 17.79 | 94.16                           | 8.56               | 35.55                           |
| Duration of floral<br>Opening  | 8.66-40.33  | 21.13 | 30.33 | 30.29 | 99.76                           | 13.16              | 62.33                           |
| Pollen viability (%)           | 85.49-98.35 | 91.55 | 2.54  | 2.49  | 95.95                           | 4.60               | 5.02                            |
| Yield/plant (g)                | 8.53-19.75  | 13.04 | 14.11 | 14.06 | 99.39                           | 3.76               | 28.88                           |

**Table 2. Phenotypic (rp) and genotypic (rg) correlation coefficient for floral traits and yield in wheat**

| Character                     | Days to<br>50%<br>flowering | Anther<br>length | Stigma<br>length | Anther<br>extrusion | Openness<br>of floret | Duration of<br>floral<br>opening | Pollens<br>viability | Yield/<br>plant |
|-------------------------------|-----------------------------|------------------|------------------|---------------------|-----------------------|----------------------------------|----------------------|-----------------|
| Days to 50% flowering         |                             | -0.100           | -0.102           | -0.168              | -0.095                | -0.176                           | -0.717               | -0.208          |
| Anther length                 | -0.099                      |                  | 0.836            | 0.331               | 0.126                 | 0.295                            | 0.090                | 0.478           |
| Stigma length                 | -0.101                      | 0.831**          |                  | 0.330               | 0.055                 | 0.305                            | 0.113                | 0.449           |
| Anther extrusion              | -0.167                      | 0.330**          | 0.328**          |                     | 0.245                 | 0.900                            | 0.268                | 0.206           |
| Openness of floret            | -0.093                      | 0.120            | 0.052            | 0.237*              |                       | 0.217                            | 0.100                | 0.206           |
| Duration of floral<br>opening | -0.175                      | 0.294**          | 0.303**          | 0.898**             | 0.211*                |                                  | 0.322                | 0.196           |
| Pollen viability              | -0.700**                    | 0.087            | 0.110            | 0.263**             | 0.094                 | 0.314**                          |                      | 0.154           |
| Yield/plant                   | -0.207*                     | 0.475**          | 0.445**          | 0.204*              | 0.200*                | 0.195*                           | 0.150                |                 |

\*, \*\* Significant at 5% and 1% level, respectively Above diagonal: Genotypic correlation Below diagonal: Phenotypic correlation

observed at genotypic level. Floral traits (anther length, stigma length, anther extrusion, duration of floral opening and openness of florets) had positive association among one another. However, days to 50% flowering showed significant negative associations with pollen viability and yield/plant (Chhabra and Sethi, 1991; Hucl, 1996). As these traits promote natural out crossing, the association of these traits with higher yield indirectly suggests the possibility of exploiting these traits for successful development of hybrids in wheat.

## References

- Atashi-Rang Gand KA Lucken (1978) Variability, combining ability and inter-relationships of anther length, anther extrusion, glume tenacity and shattering in spring wheat. *Crop Sci.* **18**: 267-272.
- Chhabra AK and SK Sethi (1991) Inheritance of cleistogamic flowering in durum wheat (*Triticum durum*). *Euphytica* **55**: 147-150.
- Choudhary MA, N Mahmood and I Khaliq (1994) Pollen production studies in common bread wheat. *Rachis*. **11**: 68-72.
- Hucl P (1996) Outcrossing rates for 10 Canadian spring wheat cultivars. *Canadian J. Plant Sci.* **76**: 423-427.
- Joppa LR, IH McNeal and MA Berg (1968) Pollen production and pollen shedding of hard red spring (*Triticum aestivum* L. em. Thell.) and durum (*T. durum* Desf) wheats. *Crop Sci.* **8**: 487-490.

## Comparison of Direct and Indirect Effects of Yield Traits on Yield in Tall and Dwarf Genotypes of Pea (*Pisum sativum* L.)

**SK Singh and SBL Srivastava**

Department of Genetics and Plant Breeding, CSA University of Agriculture and Technology, Kanpur-208002, Uttar Pradesh

**Key Words: Evaluation, Correlation, Pea, Yield Traits**

Most of the present cultivars belong to tall group and significantly contribute to the production of peas. Tall types have disadvantages of lodging, bird damage and low harvest index. Dwarf genotypes are the recent developments having tendrils to escape bird damage, lodging resistant and more seed: foliage ratio. In general, dwarf types are low yielder but more plant population per unit area results in yield advantage over tall types. Thus, there is need to compare the effect of various traits on yield in both the groups which may be useful in improvement programme.

Two separate experiments for 20 tall and 12 dwarf genotypes were conducted in randomized block design with three replications in experimental field at Oilseeds Research Farm of the University. The row and plant spacing was 40 x 20 cm in tall types and 30 x 15 cm in dwarf types in 6-row plot. The observations were recorded on 10 randomly selected plants in each treatment for days to flower, plant height (cm), number of primary branches, number of nodes, inter node length (cm), number of pods/plant, number of seeds/pod, 100-seed weight (g) and yield/plant (g). The genotypic association

was calculated and partitioned into direct and indirect effects by path coefficient analysis (Wright, 1921) using SPAR programme.

Highly significant differences were observed between treatment means for all the traits in both the groups. Yield showed the high and positive genotypic association with number of pods/plant and number of primary branches in tall types and with number of pods/plant, inter node length and plant height in dwarf types (Pratap *et al.* 1995; Kumar *et al.* 1999). The path analysis of yield components on yield/plant (Table I) in tall genotypes showed the maximum positive direct effect by plant height followed by number of pods/plant, number of seeds/pod, 100-seed weight and number of primary branches while in dwarf types, highest direct contribution was shown by days to flower, number of pods/plant and 100-seed weight in positive direction (Pratap *et al.* 1995; Bharadwaj and Kohli, 1999).

The strong and positive correlation of yield with number of pods/plant in both the population was also a result of positive indirect effects *via* number of nodes