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Nutritive Values of Five Wild Edible Ferns of North East India

AK Handique
Department of Biotechnology, Gauhati University, Guwahati-781014, Assam

A number of wild ferns which are abundant in North East India, have been used as leafy vegetables by various ethnic groups since time immemorial. Analysis for major nutritional components on dry weight basis shows that they are very rich in crude protein; ranging from 18.63 to 33.2 mg/100 mg. Total carbohydrate varies from 5.6 to 11.01 mg/100 mg. Lipid contents are low, ranging from 2.42 to 3.8 mg/100 mg. Crude fibre and ash content vary from 7.8 to 20.93 mg/100 mg and 9.66 to 14.0 mg/100 mg respectively. The analysis corroborates the traditional belief that some wild ferns are nutritionally rich.

Key Words: Edible fern, North East India, Nutritive value

Introduction

Ferns are generally dismissed as a group of lower plants occurring in the wild with little or no economic importance. A lesser known fact about these plants is that many fern species have been used as leafy vegetables by various ethnic groups of North East India and many other tropical countries since time immemorial. Some of them are so delicious and popular that they have become part of ethnic culture and tradition. The tender leaf of *Diplazium esculantum* is one such fern widely consumed in Assam and other North Eastern States of India. In fact one of the most popular dishes in Assam, 'Mas-tenga' is prepared out of the tender leaf of *D. esculantum*, pseudo-fruit of ou-tenga *(Dillenia indica)* and the fish 'Magur Mas' *(Clarius batrachus)*. It is not possible to state exactly since when they began to be used as food but as per legend and also historical account they are in use as food from even before 15th century. The fern which is perennial in nature, is collected from the wild throughout the year except in the winter months. It is very popular among all sections of society, particularly middle class and poor. During the time of scarcity, particularly when there is flood; the rural people become overdependant on this fern. In these days of increasing concern for biodiversity, it is important to assess lesser known food plants for their nutritive values to make best use of them. The present work deals with the chemical analysis of five edible species of fern to assess their nutritive value.

Materials and Methods

Five wild edible fern species from Assam and Nagaland States of North East India were collected for analysis of major nutritional components. The species are – *Diplazium esculantum* (Retz.) Copl., *Ceratopteris thallictroides* (Brongn.), *Diplazium squamigerum* (Mett.) C.Chr., *Diplazium sp.* and *Dryopteris cochleata* (D.Don) C.Chr. All these are terrestrial ferns growing in moist, shady places except *Ceratopteris* which is an aquatic fern found mostly in shallow wetlands of Assam. *D. cochleata* is a high altitude fern collected from areas near Khonoma (Altitude 5000 ft.), Nagaland. These are non-conventional leafy vegetables in the sense that they are not cultivated. They are perennial and grow luxuriantly during summer and autumn, when they are sold in the local markets. In case of *D. esculantum* only the tender leaf with circinate vernation are eaten.

The plants were collected from their natural habitats during summer when growth is luxuriant. The fresh leaves were washed with distilled water and dried in an oven at 50 C till constant weight was recorded. Moisture content was calculated and chemical analysis was done on dry weight basis. Crude protein was estimated by microkjeldahl method. The value of nitrogen thus obtained was multiplied by the conversion factor 6.25 to get the crude protein value. Carbohydrate was estimated by anthrone method (Cleg., 1956). For estimation of total soluble sugar, finely grounded samples were stirred with warm 80% ethanol in magnetic stirrer for about three hours and then centrifuged to obtain the supernatant which was evaporated until dry. The dried residue was dissolved in distilled water and total soluble sugar was estimated by anthrone method. Total lipid was estimated by extracting the sample with petroleum ether in soxhlet apparatus for over eight hours following which the solvent was evaporated away. From the difference in weight of the flask, total lipid was calculated. Crude fibre was estimated as per the method outlined by Raghuramualu *et al.* (1983). For ash content, the sample was ashed in a muffle furnance at 650^0 C for three hours and weight of ash was recorded. Three

replications were made for each sample and standard error of the values were calculated.

Results and Discussion

Among the five fern species in the present study, *D. esculantum* contains the highest amount of crude protein which is 33.27 mg/100 mg followed hy *Diplazium* sp. with 29.11 mg/100 mg; which are relatively high protein values. Even the lowest value of 18.63 mg/100 mg found in *Dryopteris cochleata* is a relatively good amount. Both *C. thallictroides* and *D. cochleata* contain about 20 mg/100 mg crude fibre, the highest in the present study while the lowest value of 7.8 mg/100 mg was observed in case of *D. esculantum.* Ash content varied from 9.66 mg/100 mg to 14.0 mg/100 mg; the highest recorded in *D. cochleata* followed by *D. esculantum* with 13.15 mg/100 mg. However, lipid contents were fairly uniform, ranging from 2.4 to 3.8 mg/100 mg. Total carbohydrate level varied from 8.93 to 11.01 mg/100 mg with the exception of *D. esculantum* where it is quite low with 5.6 mg/100 mg. The level of total soluble sugar varied from 1.65 to 3.85 mg/100 mg. The total soluble sugar constitute about 17.0 to 35.0% of total carbohydrate (Table 1).

It is clear that the edible ferns are excellent source of protein, minerals and crude fibre. Crude fibre itself is not a nutrient component since it is not digested but it is considered to be nutritionally important and in fact, a daily intake of 40 gm dietary fibre is recommended by Gopalan *et.al.* (1989). The protein content of some of the ferns is at par or even superior to some of the best known leafy vegetables like spinach, fenugreek, portulaca, chenopodium etc. where protein content vary from 24 to 31 mg/100 mg (Srivastava, 1990). Thus *D. esculantum* with 33.27 mg/100 mg crude protein appears to be among the leafy vegetables with very high protein content, if not highest of all. In case of *D. esculantum* only the tender young leaves are eaten and hence it was analysed. It is a well known fact that young tender leaf with active growth is metabolically much active than older leaves and hence supposed to contain higher amount of enzymatic protein. This may be a reason why in *D. esculantum* protein is much higher than the other ferns where both young and old leaves are eaten. Apparently for the same reason crude fibre in *D. esculantum* is quite low. Apart from high protein and mineral content, *D. escultantum* is rich in various essential free amino acids (Handique, 1993), thus enhancing its nutritive value. Some of these ferns are available in rural as well as urban markets of whole North East India at a very cheap rate throughout entire summer and autumn. Morover the regeneration ability and frequency is so high that within 3 to 4 days fresh harvest can be made from the same locality thereby ensuring steady flow of the vegetables to the local markets. In rural market, one pack of tender leaves of *D. esculantum* weighing about 500 gm is priced at just Rupees 2.00. This is equal to 30.27 gm crude protein. By contrast, same amount of beef muscle contain 29.04 gm, fowl 36.0 gm, pork muscle 21.3 gm and mutton muscle 26.36 gm crude protein. But market

Table 1. Major nutritional components of five edible fern species used as leafy vegetable

Species	Moisture %	Major nutritional components (mg/100 mg dry weight)					
		Crude protein	Total carbohydrate	T.S.S.	Total lipid	Crude fibre	Ash
Diplazium esculantum	81.84	33.27	5.60	1.85	3.80	7.80	13.15
	±0.987	±0.811	±0.202	±0.0	±0.173	±0.343	±0.155
Ceratopteris thallictroides	85.86	21.01	11.01	3.85	2.70	20.93	10.83
	±0.328	±0.902	±0.280	±0.086	±0.144	±0.444	±0.0
Diplazium sp.	78.53	29.11	9.10	2.07	2.42	15.66	12.66
	±0.488	±0.936	±0.208	±0.0	±0.0	±0.242	±0.182
Diplazium squamigerum	78.95	27.80	8.93	2.40	3.08	14.33	9.66
	±0.866	±0.277	±0.480	±0.115	±0.086	±0.190	±0.0
Dryopteris cochleata	77.56	18.63	9.86	1.65	3.30	20.33	14.00
	±0.208	±0.144	±0.308	±0.086	±0.0	±0.190	±0.0
Fowl*	72.2	25.9	—	—	0.6	—	1.3
Pork muscle*	77.4	18.7	—	—	4.4	—	1.0
Spinach*	92.1	25.31	36.70	—	8.86	7.59	21.5
Cabbage*	91.9	12.22	56.79	—	1.23	12.34	7.4

* Source : Gopalan *et al.* (1989)
± Standard Error of mean
T.S.S.: total soluble sugar

price for the same amount of meat varies from Rupees 50 for fowl and mutton to Rupees 35 for pork in local markets.

Dietary allowance (RDA) for Indian people recommended by Indian Council of Medical Research in 1988 (Gopalan *et al.,* 1989) varies based on age group, profession etc. For example, for an adult person doing heavy work recommended net energy requirement is daily 3500 kcal., protein 60 gm and fat 20 gm. Therefore, the tender leaf of the fern *D. esculantum* can provide nearly half of daily protein requirement. Of the five fern species *D. esculantum* is found in almost all the states of North East India except in high altitude areas while the other two *Diplazium* species and *D. cochleata* are seen in some rural markets of the tribal states of Nagaland and Manipur. Arora and Pandey (1996) in their enumeration of wild edible plants of India listed 21 pteridophyte species as edible out of which 16 are used as leafy vegetables. The present study shows that some of the edible ferns are among the cheapest and nutritionally among the best.

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Variability for Leaf Hairiness Pattern in *Gossypium* L. Species

SS Mehetre*, VL Gawande, AR Aher and VM Saitwal
All India Coordinated Cotton Improvement Project, MPKV, Rahuri-413722, Dist. Ahmednagar, Maharashtra

Different species in the genus *Gossypium* L. were found to have glabrous to densely hairy leaves with variation in type of hairs. These leaf hairs reported to correlated with jassid resistance in cotton. Variation in the morphology of leaf hair also contributes to the degree of resistance. In this context, sections from fully grown leaves were stained and observed under microscope. Variability of leaf hairiness pattern of wild species *viz.*, G. *anomalum, G. davidsonii, G. mustelinum, G. raimondii, G. thurberi and G, barbasonum* was compared with cultivated *G. arboreum* var,' Y-1', *G. herbaceum* var. GBHV-189 and *G. hirsutum* var. JLH-168. Leaves of *G. raimondii* had longest hair length on leaf lamina as well as on midrib also it had highest number of hairs per unit area and higher cross sectional midrib length and width. The findings indicated that *G. raimondii* is the most useful species in respect of all desirable hair attributes studied followed by *G. anomalum* and *G. barbasonum.*

Key Words: *Gossypium* spp., Hairiness, Variability

Apart from the degree of hairiness ranging from glabrous to a densely hairy plant body, there is variation in the type of hairs on the cotton plant. Youngman and Pande (1929) in their study of the epidermal outgrowths in the genera *Thespesia* and *Gossypium* describe two types of hairs, (i) the single hair – unicellular outgrowths and (ii) the stallet hair, which originates from tufts of several cells fused at their bases.

Apparent functions of trichomes are reviewed (Wagner *et al.*,2004) extensively leaf hairiness is associated with jassid resistance (Parnell *et al.*, 1949). Resistance to cotton leafhoppers in cotton has been found to be correlated with hairiness of the plant and particularly of the leaves. There has also been rather frequent evidence that not all hairy plants are resistant to jassids. This has been true in an early report from Africa (Parnell, 1925), in Queensland (Marriott, 1943), and particularly in India (Husain and Lal, 1940). Parnell *et al.* (1944) presented a diagram showing relationship between hair length, hair density per square millimeter and the number of nymphs per 10 leaves for 72 plants from the F_2 generation of crosses between U 4 (*G. hirsutum*) and *G. barbadense* (Sea Island and Egyptian) cotton was supported.

Jassids *Empoasca devastans* lays fewer eggs on resistant than susceptible cotton (Varma and Afzal, 1940). The fecundity of adult females is not affected by rearing the nymphs on resistant plants (Husain and Lal, 1940) but since the adult lays eggs over a period of several weeks the fecundity may be affected by their food while the eggs developing. Thus it is possible that antibiotic factors are involved in resistance of cotton to this insect. A screening of wild species against diseases and pests has indicated that there was differential response of wild species for sucking pests specially jassid resistance. Hence, it was thought necessary to study the pattern of leaf hairiness in cultivated as well as wild species of *Gossypium.*

Fully-grown leaves were selected in all the species for study. Leaf sections 10-15 μ were cut and stained with crystal violet and light green stain (Johanson, 1960) and observed under microscope. Ten observations were recorded from each leaf. Three leaves were studied and each leaf was treated as one replication. The data was subjected to statistical analysis (Panse and Sukhatme, 1965). Analysis of variance (Table 1) indicated that there were significant differences for all the parameters studied.

The hair length (μ/hair) in *G. raimondii* (Fig. 9 and 10) was longest 394.57 μ hair (Table 2) followed by *G. harbaceum* (297.26), *G. anomalum* (294.92) *G. davidsonii* (Fig. 7 and 8) (248.61), while *G. thurberi* (Fig. 12 and 13) and *G. hirsutum* (Fig. 11) were glabrous. Minimum distance (8.64) was found between two hairs in *G. raimondii* followed by *G. harbaceum* (111.97), *G. arboreum* (Fig. 1 and 2) (123.97), *G. mustelinum* (124.64) (Fig. 5 and 6). The hairs of *G. davidsonii* were distantly (534.53) located. Maximum number of branches/ spot were observed in *G. anomalum* (7.85) followed by *G. mustelinum* (5.45), *G. raimondii* (5.15), *G. barbasonum* (Fig. 3 and 4) (5.00), *G. raimondii* had highest number of hairs per unit area (53.50) followed by *G. barbasonum* (14.40), *G. arboreum* (8.20). Maximum cross sectional midrib length (955.09) was observed in *G. raimondii* followed by *G. harbaceum* (727.15) *G. hirsutum* (712.99),

* *For correspondence E-mail: subhashmehetre@rediffmail.com*

Table 1. Analysis of variance for seven different hair characters

Source of variation	Hair length (μ)		Distance between hair spots (μ)		Branches/spot		Hairs/unit area		Midrib length (μ)		Midrib width (μ)		Midrib hair length (μ)	
	d.f.	M.S.	d.f.	M.S.	d.f.	M.S.	d.f.	M.S.	d.f.	M.S.	d.f.	M.S.	d.f	M.S.
Replication	3	466.96	3	943.76	3	0.165	3	0.021	3	559.79	3	1169.77	3	859.26
Treatment	8	25858.78**	8	99423.88**	6	15.105**	5	1489.52**	10	64721.8**	10	51060.8**	4	171219.5**
Error	24	940.38	24	2800.20	18	0.251	15	1.787	30	901.26	30	1859.10	12	702.62

** Significant at 1 % level of significance

Table 2. *Per se* performance of different *Gossypium* species for seven hair characters

S.No.	Species	Hair length (μ)	Distance between hair (μ)	Branches/ spot	Hairs/ unit area	Midrib length (μ)	Midbrib width (μ)	Midrib hair length (μ)
1.	*G. anomalum*	294.92	365.24	7.85	3.72	601.85	537.86	452.56
2.	*G. davidsonii*	248.61	534.53	2.90	2.90	617.85	553.86	259.27
3.	*G. mustelinum*	223.95	124.64	5.45	—	591.85	588.53	—
4.	*G. raimondii*	394.57	108.64	5.15	53.50	955.09	873.78	698.51
5.	*G. thurberii*	—	—	—	—	560.70	604.35	—
6.	*G. barbasonum*	225.94	422.56	5.00	14.40	517.87	469.22	169.95
7.	*G. arboreum* Var. Y-1	233.28	123.97	—	8.20	486.55	439.89	—
8.	*G. hirsutum* Var JLH-168	—	-	—	—	712.99	660.17	303.422
9.	*G. herbaceum* GBHV-189	297.26	111.97	—	7.30	727.15	593.19	—
10.	*G. arboreum* Kudakutti	198.62	322.59	2.40	—	642.51	581.86	—
11.	*G. arboreum* Punaspatti	99.98	289.26	2.80	—	615.85	561.21	—

G. davidsonii (617.85), *G. anomalum* (601.85). Highest midrib width was noticed in *G. raimondii* (873.78) followed by *G. hirsutum* (660.17), *G. thurberi* (604.35), *G. harbaceum* (593.19), *G. mustelinum* (588.53). Of the eleven species studied, only five produced hair on the midrib with highest midrib hair length 698.51 in case of *G. raimondii* followed by *G. anomalum* (452.56), *G. hirsutum* (303.42), *G. davidsonii* (259.27) and *G. barbasonum* (169.95). The hairs on midrib (Stellate hairs) had more number of rays or branches per spot than observed on leaf blade in most of species, which had hairs on midrib. This confirms the earlier finding (Ramiah and Paranjape, 1944). Further, in case of *G. barbasonum*, certain hair terminals had swelling which was not observed in rest of the species studied.

Looking to the above results it appeared that *G. raimondii* is superior in respect of all desirable attributes hairs studied followed by *G. anomalum, G. barbasonum*, while *G. thurberi* was found to be completely glabrous, hence hold promise in transfer of this character to cultivated species for developing bollworm tolerance. Interspecific hybridization between *G. arboreum* x *G. anomalum, G. arboreum* x *G. thurberi, G. hirsutum* x *G. anomalum, G. hirsutum* x *G. raimondii, G. davidsonii* x *G. anomalum, G. herbaceum* x *G. anomalum* has been obtained. Thus, the introgression of hairiness for developing jassid resistant varieties of *G. hirsutum* and *G. arboreum* cotton can be planned through interspecific hybridization. While planning such programme, resistance to white fly, earliness and prolific boll bearing should also be given due importance. A microscopic examination of hairiness in a large number of cotton types both *arboreum* and *herbaceum* has shown that both the types of hair, single and stellate, are present in all the types but while the single hair is distributed all over the plant-body the stellate hair is mostly confined to the foliar organs, leaves, bracteoles and petals. The number of rays in the stellate hair varies from 2 to 12, the most common number being 8 for *arboreums* and 6 for the *herbaceums*. The length of the hair is generally found to be longer in the *herbaceum* than in the *arboreum* (Ramiah and Paranjape, 1944). The findings of present study are in line with the earlier reports.

As indicated by Zang *et al.* (2000) the variability observed for the pattern and development in the linted as well as lintless wild *Gossypium* spp will provide clues to understanding the molecular basis of fiber development in linted/ lintless species.

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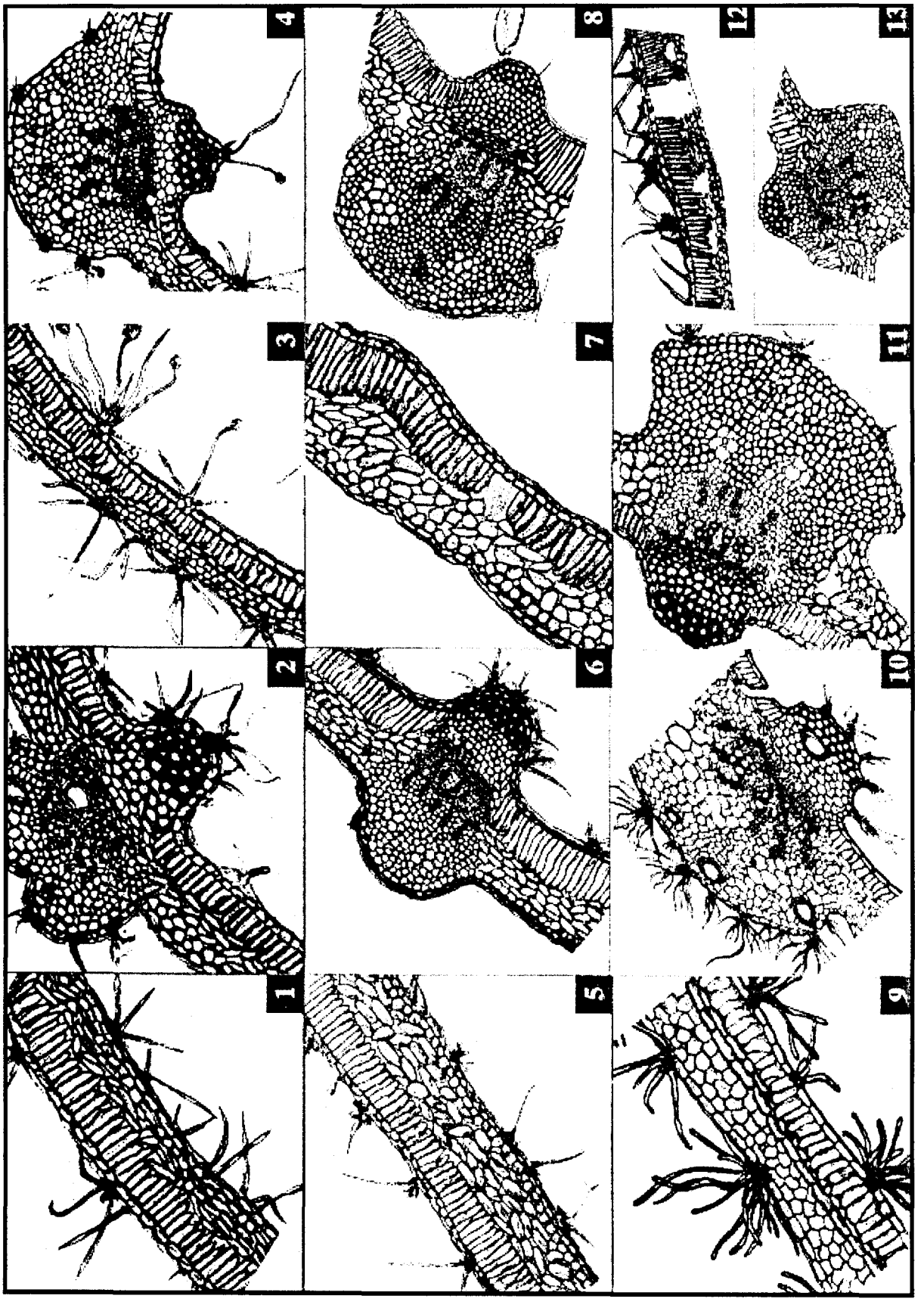

Drawings of cross section of leaf and midrib, respectively in Fig. 1 and 2: *G. arboreum*; Fig. 3 and 4: *G. barbasonum*; Fig. 5 and 6: *G. mustelinum*; Fig. 7 and 8: *G. davidsonii*; Fig. 9 and 10: *G. raimondii*; Fig. 11: *G. hirsutum*; Fig. 12 and 13: *G. thurberii*

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Analysis of Genetic Variability, Heritability and Genetic Advance for Yield and Yield Components in Low Land Rice

R Chandra and SK Pradhan*
Crop Improvement Division, Central Rice Research Institute, Cuttack, Orissa

Estimates of genetic variability, heritability and genetic advance were studied in 65 low land rice genotypes. Phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the 12 studied characters indicating the influence of environment on the characters. Grains per panicle had maximum GCV followed by plot yield, grain yield per plant, harvest index, panicle number, plant height and 1000-seed weight. A moderate to high degree of heritability estimates and genetic advance was for days to 50% flowering, plant height and grains per panicle. Moderate heritability values with low genetic advance was observed for panicle length, plot yield, 1000-grain weight, grain weight per plant and harvest index.

Key Words: Genetic Variability, Heritability, Genetic Advance, Low Land Rice

Importance of genetic variability in any breeding material is a pre-requisite as it provides not only a basis for selection but also some valuable information regarding selection of diverse parents for use in a hybridization programme. The most important function of heritability estimates in the improvement of yield is by utilizing heritable components of variation. Possible advance through selection based on phenotypic values can be predicted only from knowledge of the degree of correspondence between phenotypic and genotypic values. Burton (1952) has suggested that the genetic components of variation together with heritability estimates would give the best picture of the amount of advance to be expected from selection. Many reports on estimates of genetic variability are available in rice but information on low land rice is limited. Hence, the present study has been undertaken to determine the estimates of variability, heritability and genetic advance for grain yield and its components from 65 low land rice genotype.

Meterials and Methods

The present experiment material consisted of 65 low land rice genotypes collected from different sources. These were grown in a randomized complete block design with two replications during wet season of 2000 in low land with water depth varying from 30-50cm. Thirty days old single seedling per hill was transplanted with five rows per entry having 29 hills per row in 20x15cm spacing. Observations for quantitative traits viz., days to 50% flowering, plant height, number of panicles/plant, panicle length, number of spikelets/panicle, spikelet fertility%, grain weight per panicle, L/B ratio of grain, grain yield /plant and 1000-grain weight were recorded from five competitive plants of the middle row of each entry while days to 50% flowering, straw yield and plot yield were on the plot basis. Biological yield per plot was recorded by harvesting all plants of the plot from the ground level excluding roots. All the harvested plants were kept for sun drying and weight was recorded. The genotypic and phenotypic coefficients of variations were computed as suggested by Burton, 1952. Heritability and genetic advance were worked out as per the method outlined by Hanson *et al.* (1955).

Results and Discussion

Highly significant differences were observed among the cultivars for all the characters studied (Table 1). The estimates of genetic parameters are presented in Table 2. It is observed that phenotypic coefficient of variation was higher than the genotypic coefficient of variation, indicating the greater influence of environment on the expression of characters. Bhattacharya and Mishra (1981) and Gomathinayagam *et al.* (1990) have made similar observation in rice.

It is observed that considerable range of variation exhibited by the genotypes for all the traits. The maximum range of variation was observed for grains per panicle followed by grain weight per plant, plot yield, panicle number and 1000-grain weight. There is scope for further improvement of these characters. The extent of coefficient of variations indicated that grains per panicle had maximum gcv (41.70) followed by plot yield, grain yield per plant, harvest index, panicle number, plant height and 1000-grain weight. High genotypic coefficient of variance for characters could be ascribed to genotypes. These traits thus offer scope for selection. These observations are in conformity with those of Rahangdale and Khorgade (1988). However, the coefficients of variation (cv) were low for traits like days to 50% flowering, L/B ratio, panicle

* *Author to whom correspondence should be made*

Table 1. Analysis of variance for 12 characters of 65 low land rice genotypes (Mean sum of square)

Characters	Sources of variation (d.f)		
	Replication (1)	Genotypes (64)	Error (64)
Days to 50% flowering	1.5	345.38**	1.85
Plant height (cm)	662.13**	954.30**	65.99
Panicles per plant	7.05	7.53**	2.45
Panicle length (cm)	9.87*	13.93**	1.46
Number of grains/panicle	7525.25**	6071.16**	409.80
Fertility %	234.0*	318.04**	53.47
Grain weight/plant	94.23**	50.05**	9.13
L/B ratio	0.05**	0.42**	0.002
Straw weight (kg/ha)	518518.51**	706172.83**	222222.22
Plot yield (kg/ha)	217.78	271.11**	20.00
1000-grain weight	0.41	31.21**	0.55
Harvest index	19.28	107.25**	12.71

*and ** significant at 5% and 1% levels of probability, respectively

Table 2. Estimates of mean, range, CV, GCV, PCV, heritability and genetic advance of 12 characters

Characters	Mean	Range	CV %	GCV%	PCV%	h^2	GA%
Days to 50% flowering	113.75	77.50-137.50	1.20	11.52	11.58	98.85	26.85
Plant height (cm)	109.88	63.43-146.65	7.39	19.18	20.56	87.10	40.51
Panicle number	8.16	5.30-15.60	19.16	19.53	27.36	51.00	2.35
Panicle length (cm)	25.78	14.85-30.43	4.69	9.69	10.76	81.00	4.63
Grains per panicle	127.59	25.35-275.80	15.87	41.70	44.61	87.40	102.44
Fertility %	72.69	42.86-89.52	10.06	15.82	18.75	71.20	19.99
Grain weight per plant (gm)	12.90	2.64-21.63	23.40	35.04	42.14	69.20	7.75
L/B ratio of grain	3.49	2.40-4.85	1.41	13.03	13.10	98.80	0.93
Straw yield (kg/ha)	2932.89	1466.67-4466.67	16.10	16.80	23.27	52.10	0.33
Plot yield (kg/ha)	1480.89	333.33-2711.11	14.99	35.44	38.48	84.80	0.45
1000-grain weight (gm)	21.86	13.24-34.42	3.39	17.91	18.23	96.50	7.93
Harvest index (%)	32.63	17.20-46.35	10.93	21.07	23.73	78.80	12.57

length, plant height and 1000-grain weight. On the other hand, the higher coefficients of variation estimates in number of panicles/plant, grains/panicle, grain yield/plot, fertility %, straw yield/plot and harvest index provide clue about the highly vulnerable nature of the characters under handicapped low land ecosystem.

The heritability estimates for all the 12 characters ranged from 51 % for number of panicles/plant to 98.85% for days to 50% flowering. The genetic advance expressed as percentage of mean varied from 0.33% in straw yield to 102.44% in number of grains/panicle. A moderate to high degree of heritability estimates associated with moderate to high genetic advance was for days to 50% flowering, plant height and grains per panicle. This indicates the presence of additive gene effects and hence selection on the basis of phenotypic performance would be effective (Panse, 1957). The characters like panicle length, plot yield, L/B ratio of grain, 1000-grain weight and harvest index which showed moderate to high heritability values in conjunction with low genetic advance might be under the control of non-additive gene effects. A similar observation was made by Singh *et al.* (1990) for length of panicle; Gomathinayagam *et al.* (1990) for grains per panicle and for grain yield by Shukla *et al.* (1972) and Chaudhury *et al.* (1973). Thus information regarding the genetic coefficient of variation, heritability and genetic advance would be useful in developing reliable selection indices.

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Citrus Genetic Diversity in Central India

I.P. Singh and Shyam Singh
National Research Centre for Citrus, P.B. 464, Shankarnagar P.O., Amravati Road, Nagpur-440010, Maharashtra

Two exploration tours were conducted in Vidarbha, Marathwada and Western Maharashtra in the year 2000 and 2001. A total of 52 accessions belonging to mandarin, rough lemon, Rangpur lime, sweet orange and acid lime groups were collected from different parts of Maharashtra and added to National gene bank. These include improved cultivars, superior clones and different strains of rootstocks. This is observed very potential area for collection of Mandarin, Acid lime and Mosambi germplasm. Citrus genetic diversity in central India is maintained mostly by farmers as on farm conservation. This is one of the most potential areas in country for citrus cultivation where, all the three commercial citrus crops are grown.

Key Words: Citrus, Germplasm, Exploration, Rootstock, Threat

Central India is maintained mostly by farmers as on farm conservation. This is one of the most potential areas in country for citrus cultivation. In this region, all the three commercial citrus crops are grown in different pockets. Besides rough lemon, Rangpur lime, sweet lime and lemon are also grown and because of demand, are maintained by farmers on their farms. In Central India two main field gene banks have been established, one at NRCC, Nagpur and another at MPKV, Rahuri, Ahmadnagar. Besides this some good citrus genetic materials are also maintained in field gene bank of Dr. PDKV, Akola and Katol. Details of germplasm maintained in these gene banks were reported by Singh *et al.* (1999) and Pujari *et al.* (1999). In these gene banks most of the accessions were collected from different Institutions. Therefore NRCC planned exploration mission especially in these famous commercial citrus area to collect available variability.

Material and Methods

Two exploration tours were conducted in Vidarbha, Marathwada and Western Maharashtra in the year 2000 and 2001. We surveyed Balapur area of Akola, Paithan, Gangapur and Khultabad area of Aurangabad, Badnapur and Ambad area of Jalna, Rahuri and Shrigonda area of Ahmednagar and Shirur area of Pune and Amravati, Washim, Hingoli, Nanded and Beed (Figs. 1 and 2). The sites were characterized by land features from plain land of farmers field to home garden. Samples were collected in form of fruits and budsticks.

Soil and Climate

The majority soils are shallow to deep with clayey texture, full of $CaCo_3$ concentration and soil pH varying from 7.3 to 8.2 having montmorillonitic (swell when wet and shrink when dry) mineralogy. The soils range from principally black mixed with red and shallow to deep soils. Most of the rain is received in July and August with a total rainfall of 500 mm to 900 mm per year. Climatically, the area is classified as tropical, where the maximum temperature goes upto 47° C during peak summer (May) and minimum upto 7–8° C during the peak winter (December-January). Collection sites covered a wide altitudinal range from 281 m to 650 m above sea level. The sweet orange growing Marathwada region is hotter and humid compared to Nagpur mandarin growing climate of Vidarbha region of Maharashtra.

Results and Discussion

A total 52 accessions of citrus belonging to different citrus groups were collected (Table 1). Maharashtra has on top havs highest area under citrus cultivation in the country. All three commercial citrus crops (mandarin, sweet orange and acid lime) are grown here. Famous Nagpur mandarin is grown in Vidarbha region of Maharashtra and adjoining area of M.P. Most well known belt of Nagpur mandarin cultivation is the foot hill region of Satpura in central India from Jalgaon (MS) to Pandhurna (M.P.). However due to water shortage a number of orchards started drying up in Pandhurna area (MP) and Warud, Narkhed area in the year 2002 (Figs. 3 and 4). Nagpur mandarin is commercially grown in Warud, Morshi (Amravati), Katol, Narkhed, Ramtek, Umred (Nagpur), Arvi, Karnaja (Wardha), Dhigras, Darwha (Yevatmal) Achalpur-Chandur Bazar (Amravati).

Mosambi (*Citrus sinensis*) genetic diversity is also maintained by farmers in their orchards. It is commercially grown in Jalna, Aurangabad, Ahmednagar, Pune, Nanded,

E-mail: citrus_ngp @ sancharnet. In

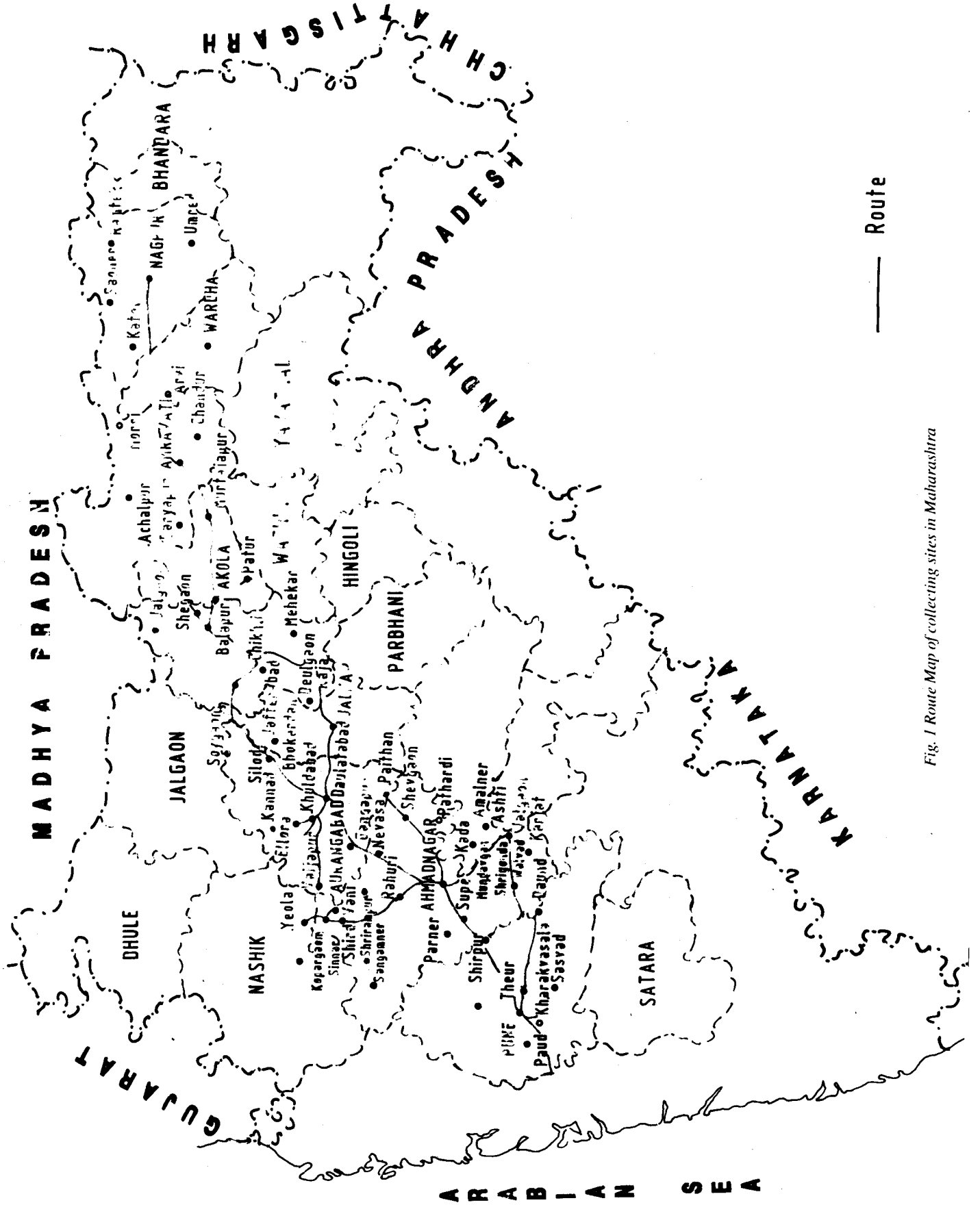

Fig. 1 Route Map of collecting sites in Maharashtra

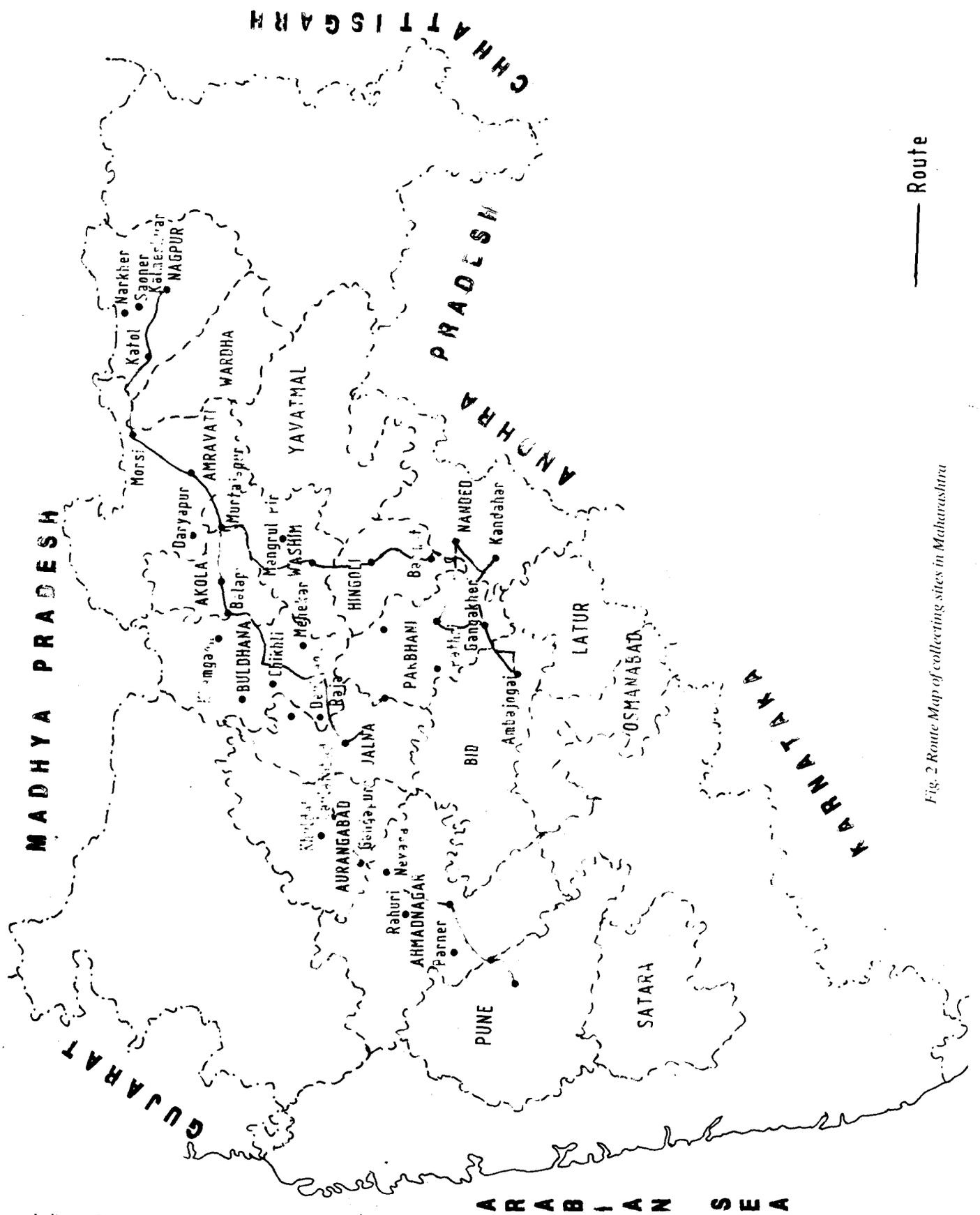

Fig. 2 Route Map of collecting sites in Maharashtra

Parbhani areas of Marathwada region of Maharashtra and is now gaining popularity in area like Narkhed, Katol, Jallalkheda, Buldhana and Yeotmal area due to mainly longer post harvest life and comparatively less problem associated regular flowering coupled with better marketing option.

Acid lime is mainly grown in Akola, Nanded, Srigonda and Parbhani areas of Maharashtra. Variability in acid lime fruit size was observed since it is propagated by seed only. Variability in Kagzi lime was observed in terms of fruit yield, size, shape and number of seeds per fruit. Similar variation in Kagzi lime strain was also reported

Table 1: List of Citrus germplasm collected during exploration in Vidarbha, Marathwada and Western Maharashtra region of Maharashtra

Sl. No.	IC-Number	Collector No.	Name of crop (Citrus)/spp.	Area of collection
1	IC-311473	IPS/58a	Kagzi lime (*C. aurantifolia*)	Akola
2	IC-311474	IPS/59a	Kagzi lime (*C. aurantifolia*)	Akola
3	IC-311475	IPS/60	Kagzi lime (*C. aurantifolia*)	Akola
4	IC-311476	IPS/61	Mosambi (*C.sinensis*)	Aurangabad
5	IC-311477	IPS/62	Rootstock (*C. jambhiri*)	Aurangabad
6	IC-311478	IPS/63	Mosambi (*C. sinensis*)	Paithan, Aurangabad
7	IC-311479	IPS/64	Mosambi (*C. sinensis*)	Paithan,Aurangabad
8	IC-311480	IPS/65	Mosambi (*C. sinensis*)	Paithan,Aurangabad
9	IC-311481	IPS/66	Mosambi (*C. sinensis*)	Paithan, Aurangabad
10	IC-311482	IPS/67	Mosambi (*C. sinensis*)	Paithan, Aurangabad
11	IC-311483	IPS/68	Mosambi (*C. sinensis*)	Paithan, Aurangabad
12	IC-311484	IPS/69	Mosambi (*C. sinensis*)	Jalna
13	IC-311485	IPS/70	Mosambi (*C. sinensis*)	Jalna
14	IC-311486	IPS/71	Kagzi lime (*C. aurantifolia*)	Aurangabad
15	IC-311487	IPS/72	Kagzi lime (*C. aurantifolia*)	Aurangabad
16	IC-311488	IPS/73	Kagzi lime (*C. aurantifolia*)	Aurangabad
17	IC-311489	IPS/74	Mosambi (*C. sinensis*)	Ahmednagar
18	IC-311490	IPS/75	Mosambi (*C. sinensis*)	Ahmednagar
19	IC-311491	IPS/76	Mosambi (*C. sinensis*)	Ahmednagar
20	IC-311492	IPS/77	Rootstock (*C. jambhiri*)	Ahmednagar
21	IC-311493	IPS/78	Mosambi (*C. sinensis*)	Ahmednagar
22	IC-311494	IPS/79	Mosambi (*C. sinensis*)	Ahmednagar
23	IC-311495	IPS/80	Mosambi (*C. sinensis*)	Ahmednagar
24	IC-311496	IPS/81	Kagzi lime (*C. aurantifolia*)	Ahmednagar
25	IC-311497	IPS/82	Kagzi lime (*C. aurantifolia*)	Ahmednagar
26	IC-311498	IPS/83	Mosambi (*C. sinensis*)	Pune
27	IC-311499	IPS/84	Mandarin (*C. reticulata*)	Pune
28	IC-311500	IPS/85	Rootstock (*C. jambhiri*)	Pune
29	IC-311501	IPS/86	Mosambi (*C. sinensis*)	Pune
30	IC-311502	IPS/87	Mosambi (*C. sinensis*)	Ahmednagar
31	IC-311503	IPS/88	Mosambi (*C. sinensis*)	Ahmednagar
32	IC-311504	IPS/89	Mosambi (*C. sinensis*)	Aurangabad
33	IC-311505	IPS/90	Mosambi (*C. sinensis*)	Aurangabad
34	IC-322244	IPS-285	Kagzi lime (*C. aurantifolia*)	Amravati (M.S)
35	IC-322245	IPS-286	Kagzi lime (*C. aurantifolia*)	Washim (M.S.)
36	IC-322246	IPS-287	Kinnow (Hybrid)	Washim (M.S.)
37	IC-322247	IPS-288	Mosambi (*C. sinensis*)	Hingoli (M.S.)
38	IC-322248	IPS-289	Rough lemon (*C. jambhiri*)	Nanded (M.S.)
39	IC-322249	IPS-290	Mosambi (*C. sinensis*)	Nanded (M.S.)
40	IC-322250	IPS-291	Sathgudi (*C. sinensis*)	Nanded (M.S.)
41	IC-322251	IPS-292	Rough lemon (*C. jambhiri*)	Nanded (M.S.)
42	IC-322252	IPS-293	Rangpur lime (*C. limonia*)	Nanded (M.S.)
43	IC-322253	IPS-294	Mosambi (*C. sinensis*)	Nanded (M.S.)
44	IC-322254	IPS-295	Kagzi lime (*C. aurantifolia*)	Beed (M.S.)
45	IC-322255	IPS-296	Kagzi lime (*C. aurantifolia*)	Beed (M.S.)
46	IC-322256	IPS-297	Kagzi lime (*C. aurantifolia*)	Beed (M.S.)
47	IC-322257	IPS-298	Mosambi (*C. sinensis*)	Jalna (M.S.)
48	IC-322258	IPS-299	Rough lemon (*C.jambhiri*)	Jalna (M.S.)
49	IC-322259	IPS-300	Rough lemon (*C.jambhiri*)	Aurangabad (M.S)
50	IC-322260	IPS-301	Galgal (*C. pseudolimon*)	Ahmednagar (M.S.)
51	IC-322261	IPS-302	Kagzi lime (*C. aurantifolia*)	Pune (M.S.)
52	IC-322262	IPS-303	Mosambi (*C. sinensis*)	Jalna (M.S.)

(Chakrawar and Jature, 1980) in this area. It was observed in Balapur area of Akola that farmers add urea in weedicides and this is claimed to act more effectively in controlling the weeds in citrus orchards than applying weedicides alone.

Paithan area of Aurangabad is famous area for Mosambi cultivation. Two types of Mosambi were observed, one local type with smaller fruit and thick skin and another bigger size fruit with thin skin (nucellar Mosambi). Now farmers prefer to grow nucellar Mosambi, since they get better price in the market. This has made a parallel threat to local type Mosambi, though it has better post harvest life. NRCC selected many superior clones of Mosambi from these areas (Singh and Singh, 2003).

Badnapur and Ambad area of Jalna were visited to collect better clones of Mosambi. Total of 7 orchards were visited in this area, variability was observed in fruit size, skin thickness and longevity of orchards. In general, decline of citrus in this area was observed to start at the orchard age of 10 with orchard age lasting upto 20 years. However in Talegaon village, one orchard at the age of about 40 years is still in bearing stage and looked healthier without any pest infestation. Plants from these orchards were earmarked for further study. These plants may serve as mother plants for large-scale production of disease- planting material of Mosambi.

On the way to Rahuri 11 orchards of Mosambi and acid lime were explored and variability was observed in one orchard at Khultabad area. Fruit samples were collected from selected plant. In this area, Mosambi and acid limes are grown on commercial scale. Rahuri and Srirampur area, famous for Mosambi cultivation during 1960, were surveyed. However, not a single orchard more than 10 year old could be located.

Shrigonda area of Ahmednagar is famous for acid lime cultivation (Desai, *et al.* 1997). However, few orchards of Mosambi were also noticed in this area. A total of 9 orchards were explored in this area and variability was observed with regard to fruit yield, size of fruit and tree size. In this area few cluster bearing plants were selected for further investigation. Shirur area of Pune and Ganganagar area of Aurangabad were also explored. In this area beside acid lime and Mosambi, excellent rootstock plants were observed growing and fruit samples of Jambhiri was collected.

The trees were observed to be medium and heavy bearing. Fruit size variation was observed in sweet orange and more visibly in acid lime. One collection from a 12-year-old orchard was found to possess rich and well developed oil glands. The budsticks were collected from an orchard bearing good number of fruits and interestingly, the orchard appeared to be in excellent condition at the age of 45 yrs.

Cluster bearing in sweet orange was also observed. In one collection, only two plants were found as the best surviving members of a 10 yrs old orchard in Aurangabad district. The areas of Ahmednagar and adjoining Aurangabad experienced a shift from citrus to sugarcane cultivation in the past two decades.

During the exploration it was observed that most of the acid lime plants are affected by canker, except in Beed area near Parli. In Parli area, plants of acid lime looked healthy without any apparent disease and insect pest problem. This is one of the promising potential areas for citrus cultivation. Farmers in this area are growing acid lime on large scale and are getting good price of their produce.

Fig. 3 and 4: Threat to citrus genetic diversity in Central India: Large scale drying of Nagpur mandarin and cutting by farmers due to water shortage in Central India

In Limbgaon, Nanded more than 70 per cent plants were observed to be affected by *Phythopthora*. Limbgaon area of Nanded is famous for raising nursery plants of Mosambi and acid lime on commercial scale and supplying the seedling to the farmers in different parts of Maharashtra. Chakrawar and Rane (1977) selected superior clone of mandarin (mutant) from these area. In Srigonda area, very close planting (3m x3m) of acid lime was observed. This was in sharp contrast to other areas of Maharashtra like Akola, where planting distance of 6m x 6m is maintained by the farmers. During the exploration it was observed that farmers were not growing any rootstock plants or other non-commercial citrus in their orchards. It is, therefore, important to collect all the available rootstocks and other non-commercial citrus species from the area, so that these materials may be evaluated and some promising ones identified.

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Invasive Alien Species: The Indian Scene

RS Rana, BS Dhillon and RK Khetarpal
National Bureau of Plant Genetic Resources, New Delhi

The international importance of invasive alien species (IAS) is highlighted by the Article 8h of Convention on Biological Diversity (CBD), 1992, which emphasizes on prevention of the introduction of species which threaten other species, habitats or ecosystems. A Global Invasive Species Programme (GISP) was launched to assemble and identify practices for the prevention and management of IAS. Among the various international instruments, CAB International plays a key role to provide technical support at international and national level in identification of new alien species, publication of distribution maps and databases. In India, invasive weeds infest extensive tracts of agricultural and forest land. Various aspects of control of alien weeds and pests are being dealt with by a number of authorities. Recently, several initiatives have been taken at national level to identify specific actions to mitigate the threat of IAS. The present study highlights the national and global status, regulatory mechanisms and management options of invasive aliens. A national strategy for their management in line with the 15 Guiding Principles given by CoP 5 and 6 has been proposed with several steps involved in its mode of implementation. Legislative measures like the Destructive Insects and Pests Act (1914) have been reviewed and the Plant Quarantine Order (Regulation of Import into India) 2003 has been enforced from January 1, 2004 and Environment (Protection) Act (1986) has also been reviewed and amended periodically, but still there is a lack of cohesive policy and action plan to deal with IAS. An overview on the national system for management of IAS has been proposed involving all the stakeholders to deal with biological invasions in a step-wise manner and future line of action recommended.

Key Words: Alien, Invasive Species, Regulation, India

Among the major threats faced by India to its native species of plants and animals (and their habitats and ecosystems), the one posed by the invasive alien species is truly scaring since it is considered second only to that of the habitat loss. This has happened largely because the natural barriers such as oceans and mountains that once prevented/restricted the movement of species have been rendered ineffective by the increased volume of trade and international transport over the past few centuries, ending millions of years of biological isolation. Non-native ('alien species') may be brought deliberately, in authorized or unauthorized manner, or they may enter by accident through 'hitch-hiking' in containers, ships or cars, 'hidden' in soil or just 'carried away' by wind.

In this paper the problems faced by India due to invasive non-native species are discussed and various measures including prevention of their entry, their early detection and eradication and control are considered to limit their further spread and mitigate their negative impacts with special emphasis on plant species. Overall focus is on regulating and managing the intentional and unintentional introductions that may pose biosecurity threats, and biological risks to natural ecological systems or to the well-being of humans, animals or plants inhabiting the affected areas.

Invasive Alien Species

'Alien Species' refer to non-native or exotic organisms that occur outside their natural ranges and dispersal potential. In other words, they inhabit areas that they cannot occupy without direct or indirect introduction or care by humans. This term also covers any parts, gametes or propagules of such species (species, subspecies, or lower taxa) that might survive and subsequently reproduce in their newly found 'homes'. Species carried suddenly to new environments may usually fail to establish and survive but they may also thrive and become invasive in some cases.

'Invasive Alien Species' (IAS) denote those 'alien species' that have been moved (often aided by humans) outside their natural habitats to new areas where they have established themselves and invaded the new environments acting as an agent of change by competing with and overcoming the pre-existing native flora and fauna. Found in all categories of living organisms and all types of ecosystems, these are widespread in the world. Plants, mammals and insects (along with their associated pathogens and pests) comprise the most common types of invasive alien species in terrestrial environments.

Many alien species are non-invasive and support our farming systems and other human livelihoods in

a big way. In fact, nearly half of our food and other cultivated plants have come from other countries. Only those alien species that cause substantial negative impacts to the environment, ecosystems, habitats, native biodiversity, economies, and human health are considered the "Invasive Alien Species". Farmers still dread the invasion by migratory locust swarms devouring their field crops. Devastating effects of exotic aquatic weeds like water hyacinth (*Eichhornia crassipes*) and great nuisance value of aggressive exotic land species like Lantana (*Lantana camara*) and congress grass (*Parthenium hysterophorus*) are well known. More recently, the carnivorous 'African Catfish' (also called 'Thai Magur') has hit the diversity of native fish species in many parts of the country.

Many biologists are still trying to elucidate the capability of invasive species to aggressively invade new areas in the hope that incipient invasions may be predicted and stopped. Several explanations have been proposed in this context. A major contributing factor appears to be that the invading organism has been relieved of the pressures of its predators/ parasites that keep its population under check in its native habitat, enabling it to proliferate unhindered in its new territories. In addition, it may be biologically "very hardy", characterized by a short generation cycle and a varied diet. A common feature of many invasive species is that they often thrive in an ecosystem that has already been disturbed by humans or some other factor(s). Whatever the precise causes, the consequences of such invasions may mean severe alteration of habitats and disruption of natural ecosystem processes with catastrophic impact on the native species.

Intentional and Accidental Introductions

The introduction of alien species may be through both intentional and accidental means either deliberately for commercial or recreational purposes (e.g., crop plants and their varieties; fish for aquaculture; pasture species for rangelands; ornamental or other horticultural species; exotic animals for zoological gardens) but there are also unintentional introductions of weeds, insect pests and pathogens), and other species, through traded commodities, especially of agricultural produce, timber, livestock, etc.

Most of the deliberate introductions have proved to be of immense value in serving human needs, more so for agricultural and forestry purposes. The great bulk of human dietary needs in most parts of the world are currently met by species that have been introduced from elsewhere (Hoyt, 1992). More than half of the plants now commercially grown in India, for example, are introductions from other lands in recent or remote past. Many among them got so naturalized and diversified here that local people find it difficult to believe that they have travelled here from far away places. A case in point is the sorghum and pearl millet crops that have their origin in Africa. Likewise, it is difficult to imagine an Africa without cattle, goats, maize, and cassava, or a North America without wheat, soybeans, cattle and pigs, or a Europe without tomatoes, potatoes, and maize - all introduced species. Species introductions, therefore, are an integral part of agricultural biodiversity in virtually all parts of the world. Increasing concerns for maintaining the health of these introduced species also led to the introduction of additional alien species for use in biological control programmes based on the import of natural enemies of insect pests and pathogens from the areas of their origin.

Much of the work to date on IAS has focused attention on their biological and ecological characteristics, the vulnerability of ecosystems to such invasions, and the use of various means of control against the invaders. The time has come to extend these considerations to cover other aspects such as global trade, settlement patterns, agriculture, economics, health, water management, climate change, genetic engineering and many other relevant fields (Drake et al., 1989).

Threats to Biological Diversity

Every IAS that becomes established in a new environment alters the composition of native biological communities in some way. These alterations can disturb the structure and functioning of the invaded ecosystems with profound socio-economic impacts.

Four aspects of the exotic invasives are noteworthy. Firstly, people are largely responsible for moving organisms or their reproductive/ vegetative parts from one place to another, especially through modern global transport and travel. Secondly, while some species are capable of invading well-protected/ undisturbed ecosystems, IAS more often seem to invade habitats that have been already altered by humans, such as the agricultural fields, grazing lands, abandoned mining areas, human settlements, and roadways. The degradation of natural habitats, ecosystems and

agricultural lands (for example, loss of vegetation cover and soil, pollution of land and waterways) that has occurred throughout the world has made it easier for some alien species to establish and become invasive since they are 'colonising' species that benefit from the reduced competition that follows habitat degradation. Thirdly, alien species are often intentionally introduced for direct or indirect economic benefits without proper risk assessment regarding their becoming invasive later on in situations favourable to them. Fourthly, the negative consequences of IAS affect various strata of communities quite differently, the deprived sections bearing the burden more than others.

A perusal of the literature reveals that the scope and cost of biological alien invasions by microorganisms, aquatic plants, land plants, aquatic invertebrates, land invertebrates, fishes, reptiles and mammals is global and enormous, in both ecological and economic term (Khetarpal, 2002). The ecological cost is the irretrievable loss of native species and ecosystems. In addition, the direct economic costs of IAS run into many billions of dollars annually. Arable weeds reduce crop yields and increase costs; weeds degrade catchment areas and freshwater ecosystems; tourists and homeowners unwittingly introduce alien plants into wilderness and natural areas; insect pests and pathogens of crops, livestock and forest trees reduce yields and increase control costs. Environmental and socio-economic impacts of harmful IAS are already evident in many countries as widely experienced in the case of alien aquatic weeds like water hyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia* spp.) that are increasingly choking waterways and degrading freshwater ecosystems and terrestrial weeds as lantana (*Lantana camara*) and congress grass (*Parthenium hysterophorus*) which occupy agricultural and barren lands.

Recent Global Developments

Despite enriching effect of biodiversity at the local level, the evidence shows negative effects of many introductions on species and genetic diversity at both the local and global level. Such introductions can lead to severe disruption of ecological communities (Drake *et al.*, 1989; Zaret and Paine, 1973; Mooney and Drake, 1987), and heavily influence the genetic diversity of indigenous species. Some protected areas established to conserve native species have been profoundly affected by introduced species and wherever the direct cause of extinction is identifiable, introduced species head the list. Globally, almost 20 per cent of the vertebrates thought to be in danger of extinction are threatened in some way by invasive species (Table 1). Increased international trade is now considered as having the massive potential to cause introductions of more harmful exotic species (Jenkins, 1996).

Table 1. Threatened terrestrial vertebrate species affected by introductions in the continental landmasses of the different biogeographic realms and on the islands

Taxonomic group	Mainland areas		Islands (Insular areas)	
	%	(n)*	%	(n)*
Mammals	19.4	(283)	11.5	(61)
Birds	5.2	(250)	38.2	(144)
Reptiles	15.5	(84)	32.9	(76)
Amphibians	3.3	(30)	30.8	(13)
Total for all groups Considered	12.7	(647)	31.0	(294)

* Total number of threatened terrestrial vertebrate species
Source: Macdonald *et al.* (1989)

The emerging general global picture depicts a tremendous mixing of native and alien species in most parts of the world. The future is expected to bring considerably more ecological shuffling as people influence ecosystems in various ways, not the least through both purposeful and accidental introduction of species. This shuffling/ re-shuffling will have both winners and losers although the overall effect is likely to be a global loss of biodiversity at species and genetic levels (McNeely, 2001).

International Legal Instruments

Key international legal instruments, that address the threat of IAS, include the United Nations Convention on the Law of the Sea, the Convention on Biological Diversity, the Ramsar Convention on Wetlands and other multilateral environmental agreements, as well as instruments developed for the plant, animal and human health sectors, or to address particular vectors, such as the International Plant Protection Convention (IPPC) and instruments developed under the Office International des Epizooties (OIE) and specialized agencies such as the Food and Agriculture Organization (FAO), the International Civil Aviation Organization (ICAO), the International Maritime Organization (IMO) and the World Health Organisation (WHO).

Prevention is treated inconsistently across existing multilateral environment agreements (MEA), the level

ranging from strong[1] to weak[2]. Most of the instruments provide no indicators of where prohibitions or restrictions should be imposed, unless their scope is limited to protected areas. No procedures are established for cooperation with countries that are the source/ origin of alien species that may impact on biodiversity. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is the only multilateral environmental agreement to mandate species-specific reciprocal controls between States of export and import.

The Convention on Biological Diversity requires Parties "as far as possible and as appropriate, [to] prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species" (Article 8(h) (CBD, 2002). The Convention contains no specific requirements of how this is to be done, though non-binding, 15 Guiding Principles have been recommended (CBD, Cop 6, 2002).

The Convention on the Law of the Sea requires Parties to take all measures necessary to prevent, reduce or control pollution of the marine environment resulting from the intentional or accidental introduction of alien or new species to a particular part of the marine environment, which may cause significant and harmful changes thereto (Article 196). Regionally, environmental protocols developed under the UNEP Regional Seas Programme contain specific requirements to prevent introductions to marine and coastal ecosystems (Eastern African region, Wider Caribbean region, South-East Pacific and Mediterranean).

- **Instruments to Protect Plant, Animal and Human Health**

Some of the earliest instruments that address the threats of IAS aim at controlling the introduction and spread of insect pests and diseases in order to protect human, animal and plant health. For example, the IPPC provides a framework for international cooperation to secure common and effective action to prevent the introduction of pests of plants and plant products, and to promote appropriate measures for their control. The IPPC was revised in 1997 primarily in response to the adoption of the 1995 WTO Agreement on the Application of Sanitary and Phytosanitary Measures (the "SPS Agreement"). However, the IPPC concerns only with pests classified as "injurious to plants or plant products". This wording covers alien organisms that could damage wild plants but not explicitly those that may harm ecosystem functions or/ plant genetic diversity.

The Office International des Epizooties develops standards and guidance on pests and diseases of animals (but not animals themselves as pests). Standards are set out in the International Animal Health Code for Mammals, Birds and Bees, including on import risk analysis and import/export procedures, and in the International Aquatic Animal Health Code, the aim of which is "to facilitate trade in aquatic animals and aquatic animal products".

The 1995 WTO Agreement on the Application of Sanitary and Phytosanitary Measures is relevant to alien species characterized as pests or diseases. A WTO member may adopt national measures to protect human, animal or plant health/life from risks arising from the entry, establishment or spread of pests, diseases, or disease-causing organisms and to "prevent or limit other damage" within its territory from these causes.

The 1969 WHO International Health Regulations, amended in 1973 and 1981, aim at ensuring the maximum security against the international spread of diseases. The goals are to: (i) detect, reduce or eliminate sources from which infection spreads; (ii) improve sanitation in and around ports and airports; and (iii) prevent dissemination of vectors. These Regulations are being revised and modernized to adapt to changes in disease epidemiology and control and to substantial increases in the volume of international traffic.

- **Instruments to Address Risks from Transport**

No binding standards apply to international transport, though some countries have moved ahead and adopted legislation in this area. IMO has adopted Guidelines (voluntary) for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens.[3] Mandatory international regime to regulate and control ballast

1. Prohibition under AEWA and the Alpine Convention Protocol, strict control under the Convention on Migratory Species and the Bern Convention.

2. The ASEAN Agreement, " Endeavour to regulate, and where necessary, prohibit...".

3. Annex to resolution A.868 (29), 20th IMO Assembly, 1997, which updates the 1993 IMO Guidelines for Preventing the Introduction of Unwanted Aquatic Organisms and Pathogens from Ships' Ballast Waters and Sediments Discharges (IMO Assembly Res. A.774

water is under preparation. The Cartagena Protocol on Biosafety includes provisions for handling, transport, packaging and identification (Article 18).

- **Provisions Relating to Intentional Introductions**

A major gap exists in relation to the introduction of alien species into freshwater systems. The work programme on the biodiversity of inland waters under the Convention on Biological Diversity (decision IV/4) recommends that Parties should develop inventories and impact assessments of alien species in such ecosystems and mitigate negative consequences of such species on inland water ecosystems especially at the watershed, catchment and river basin level. The FAO Code of Conduct for Responsible Fisheries provides some guidance, for example, for pre-introduction discussion with neighbouring States when non-indigenous stocks are to be introduced into transboundary aquatic ecosystems. It calls for harmful effects of non-indigenous and genetically altered stocks to be minimized especially where significant potential exists for spread into other states or country of origin. The FAO Code of Conduct for the Import and Release of Exotic Biological Control Agents has been adopted as an international standard under the IPPC. However, there are no binding instruments on deliberate introductions.

The Cartagena Protocol on Biosafety includes provisions for advance informed agreement by the receiving country for living modified organisms for intentional introduction into the environment (Articles 7–10).[4]

- **Standards for Risk Assessment**

There are no legally binding international guidelines for risk assessment of invasive alien species *per se*. General guidelines, including those recently developed for aquatic animals, do exist for assessing the risk of introduction and spread of exotic animal disease and plant pests, including weeds. The Cartagena Protocol on Biosafety includes provisions for the management of risks posed by living modified organisms (Article 16), and includes a list of points to be considered in risk assessment.

For WTO members, national measures for prevention of alien species that may affect international trade must be consistent with WTO principles and rules, as expressed through the SPS Agreement. Where an international standard is set by an organization recognized under that Agreement, States should base national measures on that standard. The SPS Agreement currently recognizes standards set by IPPC (pests of plants and plant health), OIE (pests and diseases of animals) and Codex Alimentarius Commission (food safety and human health). This excludes taxa that are pests in their own right but are not vectors of disease or injury to plants, plant products and animals. The mandates of the three organizations are broad enough to cover certain environmental and societal impacts, but no standards (adapted to date) take these dimensions adequately into account. However a working group under the IPPC is exploring the option of incorporating such environmental criteria into its standards for risk analysis.

The lack of reliable, consistent and comprehensive data is possibly the biggest challenge in the successful application of risk assessment to invasive alien species. This is particularly true for biological baseline data and economic impacts. These gaps exist both in the type and the quantity of data available, compared to what is required for comprehensive risk assessments to be undertaken. In addition, lack of coordination in data collection programmes may yield data that cannot be used to form a comprehensive picture of the situation. Poor accessibility to information also hinders the majority of countries in their development of representative tools and procedures.

CBD Approach to Invasive Alien Species

The impact of these invasive species is being addressed in many ways including eradication, control, mitigation of their impacts combined with legislation and guidelines at national, regional and international levels. It is recognized as a cross-cutting issue within the Convention and priority attention is being given to geographically and evolutionarily isolated ecosystems as represented by small islands. The Conference of Parties (COP) to CBD has referred to alien species in a number of its decisions while recognizing the importance of the Global Invasive Species Programme (GISP) calling on it to develop a second phase of its activities and requested the Global Environment Facilities (GEF) and other bodies to provide financial support for this purpose. The Invasive Species Specialist Group (ISSG), a global group of 146 scientific and

4. *A simplified procedure applies for LMOs intended for direct use as food or feed, or for processing (Article 11).*

policy experts on invasive species from 41 countries and a part of the Species Survival Commission (SSC) of the International Union for Conservation of Nature. And Natural Resources (IUCN) also provides advice on threats from invasives and control or eradication methods.

Parties have been invited to develop country-driven projects at both national and supra-national levels to address alien species and to incorporate the issue into their biodiversity strategies and action plans. Parties have also been urged to carry out a number of actions regarding alien species, including application of the interim guiding principles, undertaking of case studies, development of mechanisms for transboundary, regional and multilateral cooperation, and development of education, training and public-awareness measures. The COP has also resolved that the GEF should provide adequate and timely support for country-driven projects at national, regional and subregional levels addressing the issue of alien species.

While reaffirming the priority to full and effective implementation of Article 8(h), COP-6 (held in The Hague in April 2002) urged the Contracting Parties, other Governments and relevant organizations to promote and implement the 15 Guiding Principles. It has also urged the Parties, Governments and relevant organizations to promote and carry out research and assessments on:

- The impact of invasive alien species on biological diversity;
- The socio-economic implications of invasive alien species particularly the implications for indigenous and local communities;
- The development of environmentally benign methods to control and eradicate invasive alien species, including measures for use in quarantine.
- The costs and benefits of the use of biocontrol agents to control and eradicate invasive alien species;
- Means to enhance the capacity of ecosystems to resist or recover from alien species invasions;
- Priorities for taxonomic work through the Global Taxonomy Initiative; and
- Criteria for assessing risks from introduction of alien species to biological diversity at the genetic, species and ecosystem levels.

Review of Case-studies

Sixty case studies, based on experiences, had been received by CBD as of October 2000. An analysis of the main issues, emerging from these case studies, is presented below, broken down into six main areas: prevention, detection, eradication, containment, control and general issues/points.

Prevention

Attempts to develop tools to predict whether a species is likely to become invasive have had some success. In some cases, it may be possible to identify that a species is highly likely to be invasive, for example, because it has been invasive in a similar habitat. Saying with certainty that a species will not be invasive appears to be more difficult as the case studies include examples where predictions about behaviour were incorrect. For this reason, it can be concluded that a precautionary approach would be to treat every alien species as potentially invasive until there is evidence to indicate that it is not.

The case-studies indicate that species in their natural environment may exhibit quite different characteristics when they are translocated elsewhere. Therefore, while behaviour in the originating environment may indicate potential problems, it is unlikely to be an indicator of safety. In many cases, species that became invasive outside of their natural range did not show invasive characteristics in their natural environment.

Detection

The guiding principles recognize that early detection is an important component of any prevention/eradication approach. Information document UNEP/CBD/SBSTTA/INF/3 sets out a range of ways in which the rate of early detection can be increased. Several case studies show that the ability to undertake eradication successfully is often dependent on early action. In addition, case studies show that rapid response to an invasion may be essential to prevent irreversible damage occurring. The case-studies and information document UNEP/CBD/SBSTTA/INF/3 include examples where early detection can be achieved through formal monitoring/surveillance programmes, as well as through less formal means, including public reporting of new species.

Several case studies indicate that the ability to

mount a rapid response would be greatly enhanced if there already existed:

- A clear allocation of responsibilities to agencies with the ability to undertake the work;
- Authority to take actions already established (e.g. the use of certain types of poisons may have already been approved through the normal process, ready for when they are needed, or relevant laws may be in place);
- Established funds, or access to a fast-track funding process;
- The ability to undertake actions that would not normally be allowed (e.g. blocking the movement of goods and vehicles, destroying private property) where such actions are needed to respond to an emergency;
- Clearly understood and established procedures for responding to new incursions that outline who is responsible for taking initial actions, rules for gaining additional government funding, how decisions will be taken on an appropriate response, and what actions can be taken to prevent further spread.

Eradication

Eradication is recognized in the guiding principles to be the preferred method for dealing with invasive alien species if prevention is not successful. The guiding principles recognize that this depends on it being cost effective. The case studies include examples where eradication was difficult and expensive. They also include examples, however, where eradications were successful and cost-effective, and show that our knowledge base and capacity to undertake eradication is increasing.

Containment

Containment is a useful approach and the case studies provide a number of circumstances where this approach has been employed. These include its use as a temporary measure while long-term measures are being decided, to prevent the spread of the species to new areas, or to allow localized eradication without the cleared area being immediately re-invaded.

Control

There is a wide range of control measures available that can be used to mitigate the impacts of invasive alien species. The most frequently mentioned methods are mechanical removal, biological control, poisoning, and trapping. However, the case studies provide a variety of other options, including the development of physical barriers to the movement of species and changing the nature of potential vectors. In addition to the success stories, the case studies include failed programmes, which also provide valuable information for other Parties.

Some case studies showed that where an area is subject to more than one invasion, the removal of one species may result in changes in the populations of the other species that may then result in a greater overall problem for biodiversity. This would suggest that it is important for the planning of a control programme to include consideration of the likely effects of the programme on other invasive alien species present in the area.

Information document UNEP/CBD/SBSTTA/6INF/3 suggests biological control may be a valuable option, but not without risks. The case studies include both successful use of biological control, and problems created by poorly designed projects. Careful research and assessment is necessary in any proposed biological control programme.

General Points/Issues

A number of case studies documented the direct economic costs of alien species invasions. The economic costs of some of these invasions were very high. Identifying costs was cited in some cases as a major factor in gaining support for prevention and management programmes. Most of the economic studies focused on alien species in the primary production sectors, rather than those affecting biodiversity, but these species often also have biodiversity impacts. The economic costs of alien species included the following:

- Direct and indirect costs of prevention, eradication or control (including delays to the movement of goods and passengers);
- Direct effects on economic sectors (e.g. agriculture, forestry, shipping);
- Effects on human health, resulting in lost productivity and medical costs;
- Indirect costs to the economic sector, for example from loss of markets or damage to the tourism industry.

Some case studies indicated that prevention, eradication and control can be very costly, and, hence,

prioritizing of actions was an important element to allow scarce resources to be targeted to where they would achieve optimal benefit.

The case studies show that alien species may threaten many sectors of society and there is need for integration between the sectors to increase the cost-effectiveness of alien species work. Key sectors mentioned were health, agriculture, forestry, fisheries, aquaculture, tourism, shipping, and construction. Several case studies exemplified how public attitudes to alien species problems can greatly influence the effectiveness of prevention, eradication and control programmes. Public-awareness campaigns in some cases were reported to have greatly enhanced public understanding of the impacts of alien species, and the practicalities and risks of various management options.

Almost all the thematic national reports identified a lack of resources as a major limiting factor for alien species response work. Some case studies included examples of the use of community and international volunteers in detection and management programmes. These case studies suggest that the use of communities and volunteers may represent a significant untapped resource for other programmes.

The case studies included examples showing that cooperative efforts between countries provided major benefits, and in some cases was essential for the effective treatment of the problem. The reasons for cooperative arrangements varied, and included the following:

- Countries share biodiversity that was threatened;
- Countries were the source of the alien species, and the site of the invasions (this was particularly relevant for biological control work);
- Countries faced similar problems, and sharing of experiences or cooperative development of new information or techniques benefited both;
- Countries had political relationships, for example, a donor-recipient relationship;
- Activities (for example, management of border-control arrangements) needed to be operated at a regional level;
- Mitigation effort in one country was considered to be fruitless because of the threat of constant re-invasion from a neighbouring country that was not carrying out mitigation actions.

Review of National Reports on Implementation of Article 8(h) of CBD

By the end of January 2002, a total of 65 reports had been received from the Parties to CBD including 13 reports from Asia, 17 from Africa, 9 from Central and Eastern Europe, 8 from Latin America and the Caribbean and 19 from the Group of Western and Other States. The differences among regional groups of Parties in the implementation of the Article 8(h) are not remarkable. However, some regional groups of Parties are further advanced in legislation and policy and programme development than other groups of Parties. Generally the Parties of all groups are at a similar level of implementation, which may be attributed to the fact that the issue of alien species is relatively new and the work on various aspects of the issue is still ongoing within CBD or other relevant forums.

Judging from the responses concerning identification of alien species, risk assessment and measures taken, it is clear that more needs to be done for a full implementation of the Article 8(h), though a number of Parties have made some progress in scientific research, monitoring, legislation and planning. Some Parties have identified the following as constraints for implementation of the Article 8 (h): weak capability of research, inventorying, risk assessment and monitoring; lack of measures to control unintentional introduction; inconsistency of policy among relevant sectors and industries; weak information exchange and cooperation among the Parties at the regional level; and lack of regulatory and technical tools.

At the national level, most countries have at least a minimal system in place for regulating alien species introductions. Except for a few countries, these are rarely comprehensive and they were not designed to conserve biodiversity against invasion impacts (except, possibly, in a limited way for protected areas).

Quite often, suitable tools are in place but underused. Competent authorities usually have general powers under quarantine/agricultural legislation to adopt import/movement regulations for designated 'noxious weeds' and to require farmers and landowners to control such weeds. However, implementing regulations are not always issued promptly or publicized and applied.

Effective prevention also depends on restricting further imports and internal movements of alien species that present invasion risks: this is important to support

containment strategies and prevent spread to other areas. This is potentially a gap under the IPPC whose provisions apply only where the species concerned is designated as a quarantine pest and thus subject to official control where an invasive alien species is not regulated as a plant pest by an individual country, IPPC provisions do not apply (Gupta and Khetarpal, 2004). The IPPC provisions do not appear to support restrictions on pests with environmental impacts.

Invasive Alien Species in India

Plant diversity in India is remarkably rich largely because of the vast variations in soil, altitudinal and climatic conditions. About 46,000 plant species have been documented here, of which nearly 17,000 are vascular while *ca* 5,000 among them are endemic (Nayar and Sastry, 1987). Indian flora is considered a part of the Indo-Malayan sub-kingdom under the paleotropical kingdom.

High mountain ranges in the North and presence of sea on three sides of the Indian sub-continent provide favourable situation for the preservation of unique flora. Although these natural barriers have protected the indigenous flora yet the land mass connections in the north and the west have provided migratory routes to many exotic elements from North-East Africa or West Asia, and South-West China. As a result, a large number of species have come to India from the surrounding countries and their great influence on the flora of India is evident (Chatterjee, 1940).

Exotic weeds have established in India ever since the arrival of Portuguese who introduced several economically important plants brought from Brazil, Mexico, parts of Africa and other places on their commercial route (Sankaran *et al.*, 2001). They introduced many ornamental and medicinal plants also. In the process, seeds of many obnoxious weeds also got mixed up and they firmly established here and spread widely. These weedy species seem to have been aided to some extent by shifting agriculture, faulty pasture practices, establishment of townships and colonies, and mass shifting of labourers from one region to another for construction or plantation work.

It is estimated that 18% of Indian flora comprises invasive aliens, of which about 55% are American, 10% Asian, 20% Asian and Malesian and 15% European and Central Asian species (Nayar, 1977). Tropical weedy species, in general, have proved to be aggressively invasive in nature endangering the native flora. Notable examples include *Eupatorium odoratum*, *E. adenophorum*, *Acanthospermum hispidum*, *Parthenium hysterophorus*, *Mikania micrantha*, *Erigeron karvinskianus*, *Conyza bonariensis*, *Flaveria australasica*, *Tithonia diversifolia*, *T. tagetiflora*, *Synedrella nodiflora*, *Crassocephallum crepidioides*, *Xanthium strumarium*, *Tridax procumbens*, *Amaranthus spinosus*, *Cassia tora*, *C. occidentialis*, *Cannabis sativa*, *Chenopodium ambrosioides*, *Nicotiana plumbaginifolia*, *Alternanthera pungens*, *Gomphrena celosioides*, *Euphorbia prostrata*, *E. geniculata*, *Jatropha gossypifolia*, *Oxalis richardiana*, *O. cernua*, *O. corymbosa*, *Scoparia dulcis*, *Argemone mexicana*, *Lantana camara*, *Croton bonplandianum*, *Hyptis suaveolens*, *Peristrophe bicalyculata*, *Calotropis* spp., and several grasses. They have over-run the native vegetation in many parts of India.

Of these, the recently introduced *Parthenium hysterophorus* (commonly referred to as 'rag weed', 'Santa Maria', 'white top', 'congress grass' or 'carrot weed') has become the greatest menace to natural flora in the plains. This weed, first reported from Poona (Rao, 1956), has spread amazingly fast across agricultural fields, fallows, railway lines, roadsides, aquatic situations, forest-cleared areas and even forested areas is believed to have entered India in the early 1950s. It is the most dominant and obnoxious weed today invading almost all habitats and supplanting the native flora.

Similarly two species of *Eupatorium* namely *E. ordoratum* and *E. adenophorum* have become quite adventive in comparatively open forests, fallows and roadsides on hills of Himalayan region as well as in parts of Western Ghats. At lower elevations, *Mikania micrantha* has become a great menace to forests of northeast India where this weedy species climbs over forest trees masking the photosynthetic surface of host plants, suppressing forest undergrowth as well as tree seedlings and creating nuisance in forestry operations. It is another example of a recently introduced tropical American species that has become a dominant element of the flora in most parts of North-east India. Another weed that has been naturalized in a remarkably short span of time is *Croton bonplandianum*, a South American weed that arrived here around 1900.

A large number of exotic weeds of the Asteraceae family, in particular, have become naturalized in India

impacting negatively on the distribution of native flora. *Ageratum conyzoides*, like other tropical American weeds, is an adventive species that occupies wastelands, agriculture fields, and forestlands in India. *Ageratina adenophora,* a native of tropical America and Mexico, that entered India around 1900, has also become an aggressive weed at higher elevations throughout the tropical belt in the Himalayas and also in Nilgiris in South India. *Chromolaena odorata,* native to tropical America and Mexico that arrived here around 1900, became the most dominant weed in and around Karapura, Kakanakote and Heggadadevana Kote forests replacing all other ground vegetation including the noxious *Lantana*. It has become particularly aggressive in the higher elevations as well as in the sub-Himalayan states. It is said that it was first introduced in northeast India (Rao and Suryanarayana, 1979), particularly in tea plantations and has been introduced to south India by plantation labourers returning to Kerala.

Although, the spread of alien weeds depends to a large extent on disturbance of the native habitat, there are many instances that indicate that invasion of weeds like *Ageratina, Chromolaena*, *Mikania* and *Parthenium* can proceed even without continuing disturbance. Nevertheless, disturbed habitats are being created at a much faster pace than ever before in the country. Botanists need to assess the species that have become extinct or rare in different biogeographic regions of the country due to the introduction of exotic weeds. Alien species are also known to cause major economic losses in agriculture, forestry and several other segments of Indian economy and these losses should be systematically assessed through appropriate criteria and indicators.

The distribution and economic impact of alien invasive weeds, insect pests and pathogens in India has been recently reviewed (Khetarpal, 2002). At global level, some rough estimates, based on some simplistic and selective criteria, indicate economic and environmental losses to exceed US $ 115 billions per year (Pimentel *et al.*, 2001).

Some Experiences

*Water Hyacinth (**Eichhornia crassipes**)*

Native of tropical South America, it has become naturalized throughout the tropics, growing gregariously and inhabiting stagnant or slow-moving waters. It was introduced in India from Brazil in the beginning of the 20th century due to its ornamental appeal. It is a free-floating or surface perennial and one of the worst aquatic weeds that presently occurs all over the globe. Large bladder-like swollen petioles cause the plant to float high and it is easily blown about by wind making it a very troublesome weed. It is a serious threat to wetlands biodiversity, particularly in West Bengal where it is estimated to infest over 15,000 ha of once clear water surface choking ponds, lakes and rivers. The affected areas enlarge alarmingly in monsoon months. In certain areas this weed has also invaded paddy fields making them unproductive.

In West Bengal, the eradication of water hyacinth has been made compulsory by legislation within notified areas. Special water hyacinth weeks are organized during which people in groups clear infested areas. In Assam, provisions have been made in Municipal and Local Self Government Acts to enforce land holders to eradicate this weed. The Madras Agricultural Pests and Diseases Act 1919, makes the destruction of the weed obligatory on the part of the owner or holder of the land, channel or pond. In Uttar Pradesh, the state government has assisted in the removal of water hyacinth through grants for compost making.

In view of the amazingly quick spreading ability of this weed, eradication can be effective only when the chances of re-infestation are totally blocked. Its primary sites of occurrence are inland waters and, hence, greater attention needs to be paid to them. Numerous methods for its eradication have been tried but without much success. Recent focus seems to be on finding ways and means of utilizing its biomass.

*Lantana (**Lantana camara**)*

Out of the four important species of lantana in India, *Lantana camara* is considered to be the most noxious pest. It is a prickly perennial shrub. A native of tropical America and introduced in this part of the world as an ornamental and hedge plant in the beginning of 19th century, it is now completely naturalized here and found throughout India. Due to its prolific growth habit and wide adaptability, lantana has overrun large areas including cultivable and waste lands, forests, grazing and pasture lands and even plantations. Worst affected areas are parts of Deccan, Coorg, Wynaad, Nilgiris and lower hills of Western Ghats. It has also invaded parts of Uttar Pradesh, Uttaranchal and Assam. Lantana also poses serious fire hazard in deciduous forests because of its ability to burn even when green.

Another highly invasive alien species, namely, *Chromolaena odorata*, which is a climber, is reported to be replacing lantana in parts of Karnataka. Studies in these areas have revealed the negative impact of this species on biodiversity conservation and the livelihoods of local people who depend largely on natural forest resources (Poulsen, 2001).

Measures to eradicate lantana or even to check its spread have not succeeded largely because too little was done, and that also too late. It has high regeneration potential, and the sporadic efforts to control have not yielded the desired results. Uprooting of this species and its replacement by planting fodder trees has potential application in plains but this approach is not feasible in hilly terrains. Chemical control appears to be effective but it is not practicable view of huge costs involved and also environmental risks. Biological control, using lantana eating insects like *Telenemia*, has had some success but has not been tried on a large scale in carefully selected situations. The management approach based on utilizing this species locally and also on commercial scale, holds some promise but remains to be tested on a large scale.

*Mesquit (**Prosopis juliflora**)*

This species is native to west tropical and sub-tropical North and South America where climate ranges from the arid to semi-arid conditions. It was introduced in India through seed obtained from the Kew Botanical Garden, and the earliest records of its cultivation in the Indian subcontinent date back to 1877. Then Nawab of Radhanpur introduced it in the Rann area of Kachchh in 1900. State Forest Department started planting this species on coastal area in 1953 as part of the Desert Immobilization Programme. Plantations were carried out extensively for checking the spread of desertification towards mainland and for establishing a shelterbelt. Unexpectedly, this species invaded the vital grasslands in Banni and other areas that were grazing ground of chinkara, wild ass, bluebull and black buck as well as prime habitat of grassland birds including bustards and cranes. Within five decades, this invasive exotic has colonized progressively more areas in Saurashtra, Kachchh and North Gujarat. Remote sensing data show an area of around 43,000 ha occupied by mesquit in Little Rann of Kachchh (Singh *et al.*, 1999). Its colonization has brought major impact on the ecology of the region since its dense impenetrable cover does not permit the growth of other species underneath.

*The Congress Grass (**Parthenium hysterophorus**)*

Widely distributed in native America, this is one of fast spreading and most dreadful weeds in India. It is an annual, prolific seeder with high dispersal ability. Commonly referred to as 'Rag weed', 'Santa Maria', 'White top', 'Congress grass' or 'Carrot weed', it has become the greatest menace to natural flora in the plains. This weed, believed to be accidentally introduced in India through the import of foodgrains from USA and was first reported from Poona (Rao, 1956), has spread amazingly fast across agricultural fields, fallows, railway lines, roadsides, aquatic situations, forest-cleared areas and even forested areas. It is the most dominant and obnoxious weed today invading almost all habitats and supplanting the native flora.

Infestation of *Parthenium* is posing a serious problem in agricultural crops and vegetables, its spread being reportedly to be more in irrigated crops like sugarcane than under rainfed conditions (survey conducted by the Maharashtra State Government). Some host specific natural enemies of *Parthenium*, such as *Zizogramma bicolorata*, appear to be helpful in checking its growth in field trials. In some parts of Maharashtra and Karnataka states, a leguminous undershrub (*Cassia uniflora*) has been reported to have effectively replaced *Parthenium* by inhibiting its germination and preventing its establishment due to phenolic leachates and also because of its longer lifespan (Joshi, 1991).

Introduction of Exotic Trout Fishes and Carps

India is very rich in fish diversity with 2118 species documented from 8 aquatic ecosystems across the country. Over 350 species among them are considered to be of exotic origin. Introduction of tilapia, the Chinese carps (silver carp and grass carp) and the common carp have greatly helped the country in enhancing production in composite fish culture and adding substantially to the meager income of fish farmers. The larvicidal exotic fish, *Gambusia affinis*, has similarly helped in eradication of malaria.

Exotic fish stocks and species are still being introduced for increasing aquaculture production, boosting sport fishery and supporting aquaria and ornamental fish trade. Brown and rainbow trout fish, for example, were introduced in northern upland stream

(cold water) ecosystems in the beginning of 20th century to encourage amateur sport fishery combined with delicious food. These virgin streams accepted trout as welcome additions attracting thereby eager anglers from far and near.

Competing with the native species (like rohu, catla, mrigal and snow trout) for food and habitat niche, the exotic species appear to have negatively impacted upon the locally adapted indigenous species, often reducing their effective population size and causing genetic drift and loss of genetic variation in them. Other possible adverse genetic effects may arise from inter- and intra-specific hybridization among the native and exotic fish species resulting in introgression and contaimination/homogenization of the gene pool and ultimately the loss of adaptation to the local environment.

Accidental entry of silver carp in Govindsagar and its subsequent dominance over the native catla and mahseer fisheries is a shocking experience. Tilapia has similarly been reported to have adverse effects on indigenous species in Vaigai reservoir in Tamil Nadu. Another aquacultural species, the bighead carp, and a very recent intruder, the African catfish (also called Thai magur) seem to have posed even far greater threats to native fish fauna.

Key Actors and Major Stakeholders

A large number of primary and secondary stakeholders are concerned with the possible impact of invasive alien species that threaten ecosystems, habitats, species and natural base resources. Regeneration of renewable natural biological wealth, the pace of area development programmes and livelihoods security are also of immense interest. The Ministry of Agriculture of Government of India is the nodal governmental agency for dealing with this subject in the country and also for liaising with the FAO and other international/ regional organizations on relevant programmes and activities. There are several other union ministries/ departments that have jurisdiction over different components of this complex and cross-cutting thematic area. This subject is also of high priority to the state governments since agriculture and forestry are on the concurrent list of items. In addition, there are numerous other stakeholders including research organizations, developmental agencies and civil society organizations besides the farming and local communities who are the primary stakeholders but happen to be weak in asserting their rights. Their listing, though far from being exhaustive, is given as follows:

Nodal Central Ministry:

Agriculture

Departments:

Agriculture & Cooperation

Agricultural Research & Education/ ICAR Animal Husbandry & Dairying

Other major Central ministries/ departments:

Environment and Forests

Science & Technology/ Biotechnology

Health & Family Welfare

Commerce

Ocean Development

Mines

Tourism and Culture

Tribal Affairs

Finance/ Revenue (Customs)

Industry

Planning and Programme Implementation

State Ministries:

Agriculture

Forests

Environment

Other organizations:

State Agricultural Universities and Traditional Universities

ICAR and CSIR Research Institutes

Development Agencies

Non-Governmental Organisations

Farming and other local communities

Regulation of the Import of Plants and Animals

Authorities

Nodal Authority: Union Ministry of Agriculture

Plants (including seeds and propagation materials): Department of Agriculture & Cooperation, under advice of Plant Protection Advisor.

- Bulk Import for Commercial Use/Consumption: Directorate of Plant Protection, Quarantine & Storage, Faridabad.
- Samples for Research: National Bureau of Plant Genetic Resources, New Delhi.

Animals (including fish and other aquatic species):

Directorate General of Foreign Trade under advice of Animal Husbandry & Dairying

Department/Animal Husbandry, Commissioner to the Government of India.

Fishes (and other aquatic species)

Fisheries Development Commissioner to the Govt. of India

Animal Husbandry & Dairying Department

Plant Quarantine:

Plant quarantine is legal enforcement of measures that collectively aim to prevent the introduction of exotic pests through imported seeds, plants and plant material and to contain the spread of exotic pest that are accidentally got introduced to the country by implementing the provisions of The Destructive Insects & Pests Act, 1914 and the regulations issued there under. There is one National Plant Quarantine Station at New Delhi, 4 Regional Plant Quarantine Stations at Amritsar, Calcutta, Chennai, and Mumbai and 24 Plant Quarantine Stations (earlier referred as minor stations) functioning at various sea ports/airports and land borders.

Structure

Central Sector Scheme "Plant Quarantine Facilities in India"

Objectives:

- To prevent introduction of exotic pests inimical to Indian Fauna and Flora, and
- To assist the foreign Governments' as an international obligation, making arrangements for issuance of Phytosanitary Certificates for exportable plants/plant materials.

Salient features:

- Enforcement of Destructive Insects & Pests Act, 1914, and the Plant Quarantine Regulations entitled "The Plants, Fruits and Seeds (Regulation of Import into India) Order, 1989" issued thereunder, now revised as Plant Quarantine (Regulation of Import into India) Order, 2003.
- Regulation of import of plants and plant materials including seeds, fruits, soil, living insects, fungi, etc.
- Quarantine inspection/treatment and release of the imported materials if found free from exotic pests, or otherwise deport/destroy.
- Issuance of Phytosanitary Certificates for exportable agricultural commodities in compliance with the provisions of International Plant Protection Convention, 1951 of FAO.

Pattern of assistance:

100% grant by Ministry of Agriculture, Government of India

Implementation:

The statutory provisions under DIP Act, 1914 and Plant Quarantine (Regulation of import into India) Order, 2003 are implemented through 29 Plant Quarantine Stations situated at 10 international airports, 10 seaports and 9 land frontiers.

Person to be contacted:

The Joint Secretary
Plant Protection Division
Department of Agriculture & Cooperation
Krishi Bhawan, New Delhi 110001.

Date of start/duration: 1948

Implementation status:

The powers delegated under DIP Act, 1914 & Plant Quarantine (Regulation of import into India) Order, 2003 are implemented by the officers & staff of 29 Plant Quarantine Stations situated all over the country at all international airports/ seaports & land frontiers.

Issuance of Import Permit

No consignment shall be imported into India without a valid import permit issued by the Competent Authority as stated below.

(a) Bulk import of seeds / plant materials for sowing, planting and propagation:

Plant Protection Advisor to the Government of India

(b) Import of seeds/plant material for consumption:

Plant Protection Advisor to the Government of India

(c) Import of germplasm/ research and breeding materials:

The Director, National Bureau of Plant Genetic Resources (NBPGR) is authorised to issue permits for import of germplasm/ research and breeding material for public/ private sector in the country including institutions and organisations of Indian

Council of Agricultural Research (ICAR), State Agricultural Universities (SAU) and International Crop Research Institute for Semi Arid Tropics (ICRISAT).

Forest Research Institute, Dehradun: For forest plants.

Botanical Survey of India, Kolkatta: For the remaining plants of economic and general Interest.

Authority for Post Entry Quarantine

Plant materials:

Plant Protection Advisor for bulk imports

Director, NBPGR, for small samples imported for research

Animal materials:

Animal Husbandry Commissioner/ Animal Quarantine Unit

Domestic Plant Quarantine:

Under the DIP Act, Directorate of Plant Protection, Quarantine and Storage, Faridabad headed by the Plant Protection Advisor to the Government of India (under the Ministry of Agriculture) is responsible for enforcing domestic quarantine, regulating the inter-state movement of plant and plant materials to prevent the further spread of dangerous pests and pathogens still restricted in their distribution in the country. There is domestic qurantine regulations for nine pests and pathogens at present.

Institutional Support

Directorate of Plant Protection, Quarantine and Storage

The Directorate of Plant Protection, Quarantine and Storage (Dte of PPQS), established in 1946 with Plant Protection Advisor to Government of India as its head under the Ministry of Agriculture, is the apex plant protection organisation in the country having the following key functions:

- To enforce Plant Quarantine Regulations issued under The Destructive Insects and Pests Act, 1914 and amendments issued there under to prevent introduction & spread of exotic pests
- To implement the provisions of The Insecticides Act, 1968 and rules framed there under for effective control over use of pesticides
- To fulfill international commitment and obligations in respect of locust control and phytosanitary measures
- To introduce and popularize innovative plant protection technologies such as integrated pest management (IPM) practices
- To impart training in areas of plant protection technology, pesticide quality testing & pesticide residue analysis etc.
- To coordinate and liaise with State/Union Territory Governments in all matters relating to plant protection

The Directorate implements five central sector schemes in the area of plant protection viz., expansion of plant quarantine facilities, integrated pest management programmes, implementation of Insecticide Act, locust control and training in plant protection.

National Bureau of Plant Genetic Resources (NBPGR), New Delhi

NBPGR is the nodal institution for germplasm exchange in India at the national, bilateral and international levels. It has been authorized under PFS Order 1989 (now PQ Order, 2003) to undertake quarantine clearance of the germplasm of agri-horticultural crops imported in small quantities for research use. The NBPGR issues import permit for germplasm materials on application from both public and private sectors. This Bureau has a separate Division of Plant Quarantine for this purpose that is serviced by highly trained scientific and technical specialists working in well equipped laboratories with the latest technology. It has developed a national networking system that has insect-proof screen houses and environment controlled green houses located at New Delhi, Hyderabad and Bhowali (Khetarpal *et al.*, 2001).

Legal Backup

This section lists a number of the major legal authorities of the Government of India that deal with invasive species. It does not represent a complete or definitive list of all legal authorities on invasive species but includes those most relevant ones to this subject. Some international agreements are also briefly described that are concerned with the impact of IAS.

Legal Authorities Available to the Union Ministry of Agriculture:

- The Destructive Insects and Pests Act, 1914 (as amended upto 2001)
- The Plants, Fruits and Seeds Order, 1989 (and Amendments, 2001)

- The Seeds Act, 1966 (and the Seeds Rules, 1968)
- EXIM Policy 2002-2007
- Indian Livestock Importation Act, 1898 (and amendments, 2001)
- The Fisheries Act, 1897 (along with State Fisheries Acts)
- The Protection of Plants Varieties & Farmers Rights Act, 2001

Learning from the experience of other countries, a plant quarantine legislation was passed on 3 February 1914 by the Governor General of India, named "Destructive Insect and Pests Act 1914 (DIP Act)". This Act empowers the Central Government to:

- Prohibit or regulate the import into India of any article or class of articles likely to cause infection to any crop;
- Prohibit or regulate the export from a State or the transport from one State to another in India, of any article or class of articles likely to cause infection to any crop;
- Make rules prescribing the nature of documents which shall accompany any article or class of articles, the export or transport of which is subject to the conditions imposed or which shall be held by the consignor or consignee thereof, the authorities which may issue such documents and the manner in which these documents shall be employed.

This Act authorizes the State Governments to make rules for detention, inspection, disinfection or disinfestation of any article or class of articles in respect of which a notification has been issued and for regulating the powers of the officers whom it may appoint in this behalf. It also provides for penalty for persons who knowingly contravene the rules and regulations issued under this Act. Plant quarantine rules and regulations have been framed by the Government under the provisions of the DIP Act.

Responding to emerging requirements, a comprehensive Plants, Fruits and Seeds (Regulation of Import into India) Order 1984 was promulgated by the Government in exercise of the powers conferred by sub-section (1) of section 3 of the DIP Act. Following the announcement of the 'New Policy on Seed Development' by the Government of India in October 1988 liberalising the import of seeds and other planting materials for the benefit of Indian farmers, PFS Order 1989 was issued by the Government in suppression of the 1984 Order. The PFS Order 1989 works in conjunction with the DIP Act authorize the Union Ministry to regulate the importation and movement of field crop, pasture and forage, or vegetable seed that may contain noxious weed seeds. Provisions under these Acts authorize the government authorities to prohibit or restrict the importation or interstate movement of any plant, plant product, biological control organism, noxious weed if the Competent Authority, Plant Protection Advisor and others, determines that the prohibition or restriction is necessary to prevent the introduction into India, or the dissemination within India, of a plant pest or noxious weed. A plant pest is any living stage of any of the following that can directly or indirectly cause damage to, or cause disease in any plant or plant product: a protozoan, nonhuman animal, parasitic plant, bacterium, fungus, virus or viroid, infectious agent or other pathogen. A noxious weed is a plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture.

Plant Quarantine

The DIP Act and PFS Order emphasise the plant quarantine requirements and specifically authorize the Plant Protection Advisor (and others to whom the authority is legally delegated) to hold, seize, quarantine, treat, apply other remedial measures to destroy or otherwise dispose of any plant, plant pest, noxious weed, biological control organism, plant product that is moving (or has moved) into or through India or interstate, if the Ministry considers it necessary in order to prevent the dissemination of a plant pest or noxious weed that is new to or not known to be widely prevalent or distributed within or through out India.

These Acts also authorize the Ministry to order an owner, or an agent of the owner, of a plant, biological control organism, plant product, plant pest or noxious weed to treat, destroy, or otherwise dispose of those items. In addition, when a State is unable or unwilling to take the necessary action to prevent the dissemination of a plant pest or noxious weed, the Union Ministry has the authority to declare an extraordinary emergency and take appropriate actions. They also specifically authorize the Union Ministry to develop integrated

management plans for noxious weeds for the geographic region or ecological range where the noxious weed is found in India.

In addition, these Acts authorize the Union Ministry to cooperate with other Ministries, States, national governments, local governments of other nations, domestic or international organizations, domestic or international associations, and other persons to carry out their provisions.

Animal Quarantine

The Ministry's authority to regulate the importation and interstate movement of invasive animal species derives primarily from the "Livestock Importation Act 1898"(and its amendments upto 2001). The animal quarantine requirements under them authorize the Competent Authority (Animal Husbandry Commissioner/ Fisheries Development Commissioner/ Animal Quarantine Division) to promulgate regulations and take measures to prevent the introduction and dissemination of communicable diseases and pests of livestock and poultry. The animal quarantine rules authorize the Competent Authority to regulate the importation and interstate movement of all members of the animal kingdom, domestic and wild, except man, for the purpose of regulating communicable diseases and pests of livestock and poultry. Under these rules, the Competent Authority is authorized to seize, quarantine, and dispose of animals, animal products, or other material that can harbor disease or pests of livestock or poultry that are moving or are being handled, or have moved or have been handled, in interstate or foreign trade if they are infected with or exposed to a communicable disease of livestock or poultry.

Fishes are not included in the Wildlife (Protection) Act. The main available legal instrument covering fishes is the Indian Fisheries Act, 1897 that was enacted to protect aqua resources and also covered direct and indirect revenue earning. States have also enacted their Fisheries Acts and framed rules and regulations for implementation. Provisions of the Indian Livestock Importation Act, 1898 (and amendments, 2001) have been extended to cover fishes also.

Legal Authorities Available to the Union Ministry of Environment and Forests:

- The Forest Act, 1927
- The Wildlife (Protection) Act, 1972 (Amendment Act, 1991)
- The Forest (Conservation) Act, 1980
- The Wildlife (Protection) Act, 1972 and subsequent amendments up to 1993
- The Environment Protection Act, 1986
- The Coastal Regulation Zone Act, 1991
- The Environment Impact Assessment Notifications Act, 1994

The Ministry is required to develop and maintain a forest management plan for each administrative unit of the National Forest Management System. Forest plans establish forest-wide and area-specific management direction and may include management direction relating to the control of invasive species. The other Acts, pertaining to the protection of environment, also empower the Competent Authority to frame relevant rules and regulations and also to issue directions to States when necessary.

Legal Authorities Available to the Union Ministry of Commerce and Industry

- The Import and Export (Control) Act, 1947
- Foreign Trade (Development and Regulation) Act, 1992
- EXIM Policy 2002-2007

Provisions under these regulatory measures work in conjunction with the above -mentioned legislations enacted by different Ministries.

Leadership Role and Coordination

The Ministry of Agriculture is the nodal agency and is expected to provide the leadership and also coordinate the regulatory actions among all the concerned ministries and departments/ agencies in liaison with the State Governments. It is also the nodal Ministry regarding linkages with FAO, OIE, IPPC and other regional and international organizations concerned with genetic resources for food and agriculture. It is also responsible for quarantine operations in the country for plants and animals.

Ministry of Environment and Forests is the nodal agency for matters related to biodiversity, habitats and ecosystems and has links to CBD, CITES, CMS and Ramsar Convention. Ministry of Commerce and Industry, in cooperation with the Ministry of Agriculture, is the nodal ministry for implementation of the WTO-SPS Agreement on the Application of Sanitary and Phytosanitary Measures.

There is no clear focus on invasive alien species though several ministries and departments are primarily or partially dealing with them. Jurisdiction, authority and responsibilities seem to be overlapping with little accountability. Negotiations on this subject under the auspices of CBD are handled by the Ministry of Environment and Forests in association with the Ministry of Agriculture. Low priority is reflected in the National Report submitted to CBD on the implementation of Article 8h (Alien Species). There is an obvious need for perspective planning and proactive lead role, both at national and international levels.

An Operational Overview of the National System

Measures for Prevention

Actions to prevent or minimize the entry of unwanted alien organisms are preferred considering the technical difficulties and high costs of detecting, eradicating or containing the introduced species that become invasive. Hence, high priority is being accorded to prevention measures in India. Tools for prevention include prohibitions and permits (especially for deliberate introductions), quarantine measures (especially for incidental introductions on commodities), and destruction of the unwanted species through biological control and physical or chemical means. Since such controls are transboundary by nature, international cooperation is therefore vital. International instruments play an important role in providing a generally accepted regulatory framework for preventive measures taken at the national level.

The use of import and export controls to prevent introduction of pests is long established in India. National plant and animal health services and customs authorities play a key role in implementation of border controls, import restrictions and other quarantine measures.

Quarantine systems theoretically cover all introductions that can involve the transfer of pests but in practice there are wide variations in the scope and administrative working. Serious constraints are faced regarding legal authority, inspection facilities, taxonomic capacity, access to information, and human and financial resources. These controls are located in the Ministry for Agriculture but their implementation involves active participation of several other ministries/ departments/ agencies. Although all sectors involved in these operations are expected to be appropriately engaged and accountable, yet, the coordination between agencies remains far from being effective.

To sum up notwithstanding all the available regulatory provisions, the prevention and early detection measures for invasive alien species have not proved to be fully effective. The entire system works on the voluntarily disclosures at the designated ports of entry with hardly any strict checking system in place. The Directorate of Plant Protection, Quarantine and Storage, the nodal authority, does not have the powers of 'search and siege'. These powers rest only with the Customs authorities and if they intercept any seed/ planting materials noticed by them in the accompanied baggage of incoming passengers and pass them on to the quarantine officials for examination and due clearance. Regulatory system for the intentional introductions for research appears to operate effectively but this component forms just a small part of the total inflow of biological materials in the country. The national system has recently been strengthened under a UNDP Project and it remains to be seen how the entry of all plants and animals (including fish and other aquatic organisms) can be regulated under a unified, autonomous and statutory, national authority with assured funding and operational facilities.

Measures for Early Detection

The tools available for the early detection of invasive alien species include general surveillance or collation of information, site-specific surveys (for example, through trapping at likely entry points to ascertain the distribution of a known invasive or to detect a particular pest through trapping), monitoring, taxonomic identification, and public-awareness campaigns.

A significant and fast developing tool is the use of information systems for regulatory purposes. The series of publications, brought out by NBPGR, on plant pathogens and pests not known to occur in India is relevant here (Sharma *et al.*, 1990; Lal and Kapur, 1992). While there is consensus on the need to enlarge databases on known and potential invasive species and to make this information accessible as part of global capacity-building on invasive alien species, it must be recognized that some kinds of information may have commercial or political implications.

Infrastructure for the early detection of invasive alien species is being strengthened rapidly in India.

Monitoring for pests is particularly active programme. Early detection relies mostly on workers on the ground (farmers, extension staff), research organisations, field naturalists, NGOs and members of the public. Public-awareness schemes together with education and reporting mechanisms can contribute significantly to early detection and monitoring of alien species.

The IPPC, OIE and Codex Alimentarius support the establishment of surveillance systems as part of national frameworks and provide a basis for emergency action. Under the IPPC, elements include identification of pests already present and identification and surveillance of areas that are pest-free or from which a pest has been eradicated. In practice, national and regional capacity and also the funding are critical to effective surveillance.

Nationally, monitoring and early warning systems are still weak due largely to lack of information about species already present (baseline data) and lack of accessible information systems. Weak institutional linkages limit the ability of environment, veterinary, phytosanitary and health authorities to cooperate on prompt action.

To sum up, the lack of a national database on this subject is the major limitation. Access to information, held by the governmental system, is very limited and linkage with lead institutions and non-governmental agencies is weak. Surveillance at the field level for some prioritized species/ pathogens is in operation but its working and linkages need to be monitored and reviewed. Public education and awareness on this topic remains extremely low. Detection of species is weaker for lower taxonomic categories. Coverage of pathways is still inadequate, notably for the alien freshwater aquatic species. Finally, the networking and early warning systems leave much to be desired to be effective.

While terrestrial systems are mostly supported by the measures developed under agricultural conditions, particularly for weeds and insects, all major plant pathogens are not adequately covered by the existing capacities and merit greater attention. Awareness of some diseases and of certain taxa such as nematodes, flatworms and snails is gradually building up. Animal pathogens are well covered but only to the extent that the invading species is on the list of international notified diseases.

Aquatic weed control is now getting more attention because of public outcry. Likewise some progress has been made with invasive fish species and aquatic animal pathogens also. Best practices regarding introductions and transport of alien fish species need to be given more attention. The recent inclusion of aquatic animal (fish, shrimp and other) diseases among officially notified diseases are expected to reduce the spread of pathogens to natural populations surrounding aquaculture and adjacent processing sites.

Measures for Eradication and Control of IAS

Where an alien species has become invasive, options to prevent its establishment and spread include eradication (where feasible and cost-effective), containment or long-term control measures, and measures to mitigate the impacts of invasive alien species. Integrated pest management (IPM) technologies have been developed, most strongly for the management of insect pest problems in agriculture. These technologies have been directed for a complex of pests that affect a particular crop system. Good progress has been made in implementation but only for a few selected species.

Eradication requires prior effective surveillance on the distribution of the IAS, containment to prevent its spread, a good understanding of the biology of the target organism, and sufficient funding for training and follow-up measures to prevent re-invasion. Eradication is more likely to be successful in the early stages of invasion. Even so, total eradication of an established alien species is often difficult to achieve as experienced in several weedy species.

The aim of controlling invasive alien species has been either to contain the species within a geographical area or to suppress the overall abundance of the species to a level where it no longer causes any significant economic, social or ecological damage. Control measures for either containment or suppression fall into the following categories:

- Physical or mechanical (e.g., mechanical harvesters, hunting, trapping);
- Chemical (e.g., herbicides, insecticides);
- Biological [this includes a number of tools: the introduction, conservation or augmentation of natural enemies, the application of microorganisms as a biopesticide, host plant resistance (HPR), and

other tools such as behaviour modifying chemicals like pheromones, male sterile release and fertility control];

- Habitat management (e.g. crop rotation, nutrient management);
- Integrated pest management, utilizing combinations of the above four main measures.

To sum up the national legislative measures are weaker on eradication and control than on the prevention on the entry of exotics. Other constraints include poor institutional linkages, narrow mandates and lack of a strategic framework for remedial action. Prerequisites like surveillance on the distribution of the pest, proper understanding of the biology of the target organism and a risk analysis are found mostly wanting. Control measures for either containment or suppression of noxious weeds like Lantana, Parthenium and water hyacinth have not achieved notable success, primarily due to fragmented efforts that permit regeneration. While many tools exist for control of some invasive species, more work on generating technical knowledge and developing new methods is required for several other taxa. There is an urgent need for developing a national programme with identified institutional support.

Mitigation of Impacts and Adaptation Measures

Strategies to control the impacts of established invasive alien species have included reduction or elimination of the invasive species and their spread through mitigation measures, such as eliminating the invasive alien species completely, containment (keeping the invasive alien species within regional barriers); or suppression (reducing population levels of the invasive alien species to an acceptable threshold), that would curtail the extent, duration and impacts of the invasion (NISC, 2001).

It is now appreciated that the mitigation of impact would be most effective when it employs a long-term, ecosystem approach rather than an approach directed to controlling invasive species in isolation (Ramakrishnan and Vitousek, 1989).

Restoration may involve reintroduction or re-establishment of populations of native species and/or enhancement of native biodiversity and the structure and functions of the habitats or ecosystems that have been degraded as a result of invasion by alien species (Ramakrishnan, 1991). Restoration techniques, based on detailed information on invasive species biology and ecology, site assessments, beneficial plantings and monitoring of the effects of disturbances such as fire and flooding, have allowed the recovery of some terrestrial habitats/ecosystems to nearly their states before invasions (Sankaran *et al.*, 2001).

There is need to develop guidance for restoration work. This could be based on best practices for appropriate uses of native and desirable non-native species, the best available techniques for restoring habitats/ecosystems, as well as management practices that promote regeneration of native species and habitats/ecosystems (MSSRF-CABI, 2000).

To sum up attempts at predicting impacts have generally been unsatisfactory. There is a need for better and wider quantification and measurement of what invasive species do. In the context of preserving biodiversity, such studies are urgently needed. Data from countries where a species has previously invaded and been controlled can provide useful information on approaches to management. In addition, best practices for restoration of degraded ecosystems with the help of native species need to be documented and promoted.

Critical Gaps

Policy Support

Overall policy support to deal with the challenges posed by the invasive alien species in India is weak, particularly considering that this country is more vulnerable due to its vast porous borders, diverse agro-ecological zones and rich native biodiversity. This general perception is reflected by the low key at which India participates in international inter-governmental negotiations on this subject. This inference also emerges from India's national report submitted to CBD on the implementation of Article 8(h): Alien Species. Three one-page sketchy case studies contributed by India with a view to sharing knowledge in this area have made a poor impression as they seem to ignore the wealth of information available in the country. Other developing countries expect India to play a lead role in these negotiations in view of the enormous scientific expertise and also experiences available here on this topic.

Setting of Priorities

Programmes and activities bearing on the prevention (including regulation of introductions and quarantine measures), containment, control and management of

invasive alien species and also on mitigation of their impact require a more balanced approach and prioritization, particularly in terms of responsibilities and fund allocation.

Database

The major limitation to work on IAS is the lack of national database on intentional and accidental introductions in the country and their distribution. Access to information on different key aspects is restricted, particularly from the governmental sources. Several websites developed by some government departments, in an effort to promote awareness about their activities, are of limited help as most of them are either not updated or remain inaccessible.

Lines of Command

Authority to deal with different components of biodiversity (plants, animals, aquatic species, insect pests and pathogens) is fragmented in tight compartments with weak linkages and ineffective coordination and monitoring mechanisms. This leaves serious gaps and also leads to unavoidable overlaps.

Legal protection

There is no legal power of search and seize delegated to the quarantine staff as these entirely rest with the customs staff who often work with little orientation training or even proper briefs on invasive species. For example, not much effective actions have been taken to prevent unauthorized introduced fishes and punish the person/ organization violating the provisions of the Livestock Importation Act. Strengthening of State Fisheries Acts to include authority to prohibit sale of illegally introduced exotic fishes is needed.

Structural Limitations

Massive effort to strengthen the plant quarantine system with assistance from the UNDP notwithstanding, the quarantine component covering animal and aquatic species appears to have limitations of effective networking with the plant side. There is an obvious need for developing a unified national system with strong linkage with the relevant State Departments. Leadership role appears to be missing in this subject of national importance. There is also an imbalance in programmes since major focus of import regulation and quarantine operations remains on crop weeds, insect pests and pathogens of agricultural importance.

Quarantine Effectiveness

Enforcement of quarantine regulations at all the major disembarking ports needs to be improved and streamlined to make them more effective. Role of the Designated Inspection Authorities is very crucial and requires coordination and monitoring. A separate 'Living Organisms Quarantine Declaration Card', like the one used for 'Customs Declaration Card', needs to be introduced for the passengers disembarking in India enabling them to declare any plant materials/ seeds/ animals/ aquatic organisms brought by them as accompanied baggage. All these items should then be subjected to quarantine check and clearance. All State Governments should have separate quarantine wings/ units to effectively implement the domestic quarantine regulations.

Domestic Quarantine

Only nine insect pests/ pathogens have been covered at present under domestic plant quarantine regulations. There are, however, a number of other serious pests/ diseases that are still localized and not covered under these regulations. Even in the case of these nine pests, domestic quarantine is not being enforced properly with the result that these pests continue to spread to more areas/ states in the country. There appears to be no serious concern as yet on alien species invading and dominating public places, forest areas, freshwater systems and wastelands.

Awareness

The level of awareness on this subject remains low, particularly among the political leadership, policy makers and managers. There is an urgent need to organize public opinion and undertake campaigns on a war footing towards eradication/control/ management of top 10 invasive species in the country and restoration of the affected habitats/ecosystems. This requires collection and analysis of data on socio-economic impact of the alien species in major areas of their occupation so as to relate the problem to local people/ communities.

Law Enforcement Problems (The Case of Bighead Carp and African Catfish/ Thai Magur):

Based on the reports of various State Governments, state fisheries departments and followed by detailed field studies and a survey of fish farmers and fish traders, the National Bureau of Fish Genetic Resources

concluded that the culture of two unauthorized exotic fish species, namely, the Bighead Carp and Thai magur (also called African Catfish), was spreading under captivity in different parts of the country.

This survey also revealed that the Bighead carp, believed to arrive illegally from Thailand via Bangladesh more than 15 years back, was becoming more popular than even the widely cultured Silver Carp (one of the Chinese Carps) that was introduced legally earlier to boost fish production and fish farmers' income.

Since its introduction in 1975 at the Thu Duck Aquaculture Station in South Vietnam, the African catfish (also called Thai magur in India) has spread to Cambodia, Laos, China, Thailand, Bangladesh and India covering a large part of Asia. Deep concerns expressed about its negative impact on the indigenous fish fauna notwithstanding, the fact remains that culture of this species and its hybrids is also spreading rapidly.

Although the Indian scientists, environmentalists and NGOs decry the unauthorized introduction of these two invasive alien species in the country, yet, the way to stop their entry and spread into Indian waters is yet to be found.

The National Committee to oversee and regulate Introduction of Exotic Aquatic Species in Indian Waters discussed the issue of "unauthorized introduction of exotic magur and bighead carp" in its first meeting held on 9 October 1997, under the Chairmanship of Joint Secretary (Fisheries), and recommended as follows:

"The Ministry of Agriculture should write to all the States/ UTs to take immediate steps to destroy the existing stock of exotic magur and bighead which have been introduced into the country without official sanctions. All hatcheries may be identified and destroyed by the concerned States. It was stressed that exotic magur (*Clarias gariepinus*) should not establish in the natural environment and cross with the endemic species *Clarias gariepinus*. A strict controlling measure should also be adopted to avoid spread of exotic disease(s) from *Clarias gariepinus* to the endemic fishes."

The Fisheries Development Commissioner wrote to the Secretary (Fisheries), State Governments vide DO No.31016/1/96-FY dated 19 December 1997 requesting that necessary action may be taken immediately on this recommendation.

This order was challenged by C. Sebastian and others before the Hon'ble High Court of Kerala claiming that the two exotic fishes were very high yielding and commonly cultured throughout India for the last 15 years and destroying their stocks would bring losses to fish farmers. The Hon'ble Court directed the Government to provide all available relevant scientific data. This direction has been complied with and the matter stands there.

This case illustrates some of the problems encountered in implementation of the measures aimed at prevention, detection, eradication and mitigation of the impact of invasive alien species offers lessons to be learned.

Recommendations

The challenges posed by invasive alien species in India are enormous, both in dimensions and intensity. In marked contrast to this alarming situation, level of preparedness and response of the Central and State Governments appears to be inadequate. There is no unified national system geared to address the problems created by biological invasives and the authority/ responsibilities dealing with plants, animals, fishes and other aquatic species are rigidly compartmentalized. A holistic approach to face the prevailing and impending threats is missing and, above all, participation of key players and major stakeholders in decision making and problem solving is either lacking or ineffective. There are, however, examples of good work done in some areas but they do not seem to be part of a planned national effort. Some suggestions are offered here with a view to stimulating fresh thinking on this subject and drawing attention to some pivotal aspects of the national system that require re-orientation.

Role of the Central Government

- Overall authority regarding regulation of imports (of plants and livestock) and quarantine;
- Leadership, perspective planning, coordination and monitoring;
- National system development, infrastructure, database, institutional support, linkages;
- Early Warning and Watch: Detection, containment, quick response and monitoring;
- Legislation and enforcement;
- Capacity building and research support (Developing technologies to manage IAS);
- Education and public awareness;
- Fund mobilization; and

- Regional and international cooperation (also inter-governmental negotiations/ national reporting).
- **Establishing 'Unified Command for Plant and Animal Quarantine':**

A proposal for establishment of an autonomous Quarantine Authority of India.

Authority for import and quarantine of plants and seed materials is presently with the Plant Protection Advisor to the Govt. of India, Department of Agriculture & Cooperation, who heads the Directorate of Plant Protection, Quarantine & Storage. Director, National Bureau of Plant Genetic Resources, working under ICAR, shares the delegated responsibility for import of germplasm of agri-horticultural crops. Authority for import and quarantine of livestock (including fishes and aquatic species) rests with the Department of Animal Husbandry & Dairying with technical advice of the Animal Husbandry Commissioner and Fisheries Commissioner.

The plant quarantine activities in the country are presently regulated through implementation of Plant Quarantine (Regulation of Import into India) Order, 2003 (implemented from 1.1.2004) notified under the DIP Act, 1914 while the animal quarantine is regulated through implementation of the provisions under the Livestock Importation Act 1898 (as amended upto 2001).

Being the signatory to the International Plant Protection Convention (IPPC), India is obliged to have a National Plant Protection Organisation (Central Regulatory Agency) responsible for meeting international obligations relating to phytosanitary measures. Effective functioning of such a regulatory agency enjoins upon its necessary financial and administrative flexibility. Hence, an urgent need has been felt to establish an autonomous authority under the Government of India to undertake the scientific requirements of pest risk analysis, development of national standards, domestic and national quarantine, etc. A proposal to establish a **Plant Quarantine Authority of India** for this purpose is under discussion but it needs to be made more comprehensive covering quarantine measures in respect of animals and aquatic organisms (including fish) also. Accordingly, a recommendation is being made here to enact legislation for establishing an autonomous Quarantine Authority of India.

- **Setting up 'National Invasive Species Advisory Committee': A Proposal**

Considering that the scope of dealing with invasive alien species is multi-dimensional and requires multi-disciplinary inputs, there is an urgent need for establishing a broad-based National Invasive Species Advisory Committee to advise the Government on this subject and to work for the following objectives:

- To provide national leadership on invasive species;
- To see that the Central efforts are coordinated and effective;
- To promote action at local, State and ecosystem levels;
- To identify recommendations for international cooperation;
- To facilitate a coordinated network to document and monitor invasive species;
- To develop a web-based information network;
- To provide guidance on invasive species for Central Government agencies; and
- To prepare the National Invasive Species Management Plan.

Role of State Governments

- Assert their partnership right in preparation of the National Action Plan on IAS;
- Play the Area Commander's role in all Central Government's field programmes dealing with invasive alien species;
- Establish Surveillance, Early Warning and Quick Response System dealing with IAS;
- Strengthen their plant quarantine capacity and assist the Central Government in enforcing regulations of domestic quarantine;
- Enlist progressively greater involvement of *Panchayati Raj* (local self-government) institutions with capacity building activities;
- Mobilize funds based on proposals for field programmes and preparation of Case Studies;
- Involve local institutions and consultants in demonstrative restoration of the ecosystems;
- Organise Bio-Security Campaigns for disinfestation of the invaded areas;
- Support socio-economic studies, monitoring work and public awareness campaigns in partnership

with civil society organizations and self-help groups.

Role of Institutions

- Providing expertise, research backup and policy inputs;
- Extending research, technical and technological support;
- Developing and strengthening linkages;
- Conducting socio-economic studies;
- Developing case studies;
- Organising workshops and discussion meetings;
- Providing consultants/ subject matter specialists;
- Leading the effort on restoration of ecosystems and mitigation of negative impacts; and
- Project based mobilization of funds, particularly from international funding agencies.

Regional and International Cooperation

International Agreements and Authorities:

India cannot succeed in facing its invasive species problems unless it plays a leadership and proactive role in regional and international cooperation, and also in intergovernmental negotiations on this subject in different international forums.

Conclusions

India is highly vulnerable to the invasions of aggressive alien species in view of its vast ('porous') borders, wide spectrum of climatic and soil conditions, rich native biological wealth, endemic repository of wild relatives of cultivated plants, weak enforcement of biodiversity and environmental protection laws, ineffective implementation of regulatory measures for import of living organisms (plants, livestock, fishes and other aquatic species, insects and accidental introduction of virulent pathogens), expanding tourism and liberalization of trade. National system to respond to the prevalent and impending threats of IAS is still weak with notable shortcomings and gaps. It has, however, the scientific strength and capability to face these challenges provided that the priorities are set rightly at various levels, required funds are mobilised and the actions are taken without further delay with full administrative support and political will. The Central and State Governments and various ministries/ departments must work together for this purpose in active partnership with lead research institutions and civil society organizations and with effective involvement of local people and *Panchayati Raj* institutions. It is also desirable that campaigns for clearance of already heavily infested areas and restoration of invaded ecosystems be linked to Government's 'Food for Work' Programme in case a real headway is to be made in this direction.

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Important Crop Germplasm Introduced into India During 2003

RV Singh, Deep Chand, Vandana Tyagi, AK Singh, SP Singh and Surender Singh
Germplasm Exchange Division, National Bureau of Plant Genetic Resources, IARI Campus, New Delhi-110012

The paper contains the information about introduction of important promising introductions made for various biotic, abiotic stresses and other value added traits during 2003 and in this process overall 33,312 accessions of germplasm in 117 crops were introduced from 41 countries/International Agricultural Research Institutes.

Key Words: Introductions, Quality Traits, Agronomic Traits

The introduction of exotic germplasm has played a vital role in the development of varieties of different crops and given an impetus to Indian agriculture. In recent years, WTO and globalization of the market have raised the issues related to quality aspects particularly in cereals, pulses, oilseeds, fruits and floricultural crops, therefore our products should be at par in quality and meet the standards required for export purposes in the world market. On the other hand most of the high yielding varieties are more prone to diseases and insect pests resulting in the deterioration in quality as well as production. Moreover, India also has a sizeable area under saline and alkaline soils and the crops cannot be grown successfully in such problematic areas. Therefore, the emphasis is given for the introduction of germplasm having good quality traits for value addition and also sources of resistance for various diseases, insect pests and abiotic stresses. In this process germplasm having quality traits such as low content of erucic acid and glucosinolate lines in *Brassica*, low neurotoxin lines in *Lathyrus*, low gossypol lines in cotton, high protein lines in pulses and cereals and biotic and abiotic resistant sources in rice, wheat, maize, barley, pearl millet, french bean, pea, soybean, mustard, sunflower, sesame, chilli and tomato have been introduced. For the exploitation of heterosis, diverse sources of CMS and GMS lines in rice and pearl millet were also introduced. Some new crops, which are economically important and nutritionally rich like kiwi fruit, rambuttan, durian, pawpaw, mangosteen, seabuckthorn, broccoli, and brussel's sprout including improved varieties having good quality in temperate and tropical fruits have further been introduced for diversification of Indian agriculture. About 891 wild relatives of different crop plants were also introuduced to broaden the genetic base of the existing varieties through interspecific hybridization.

During January-December 2003, a total of 33,312 (thirty three thousand three hundred and twelve) accessions of germplasm representing of 117 crops were introduced from 41 countries/ International Agricultural Research Centres (IARC's). The information on the germplasm genes for specific traits that has been introduced by NBPGR is presented in Table 1.

Table 1. Promising introductions made during 2003

Crop. name	Acc. No./ Country	Sailent features	Distribution
		A. Biotic stress resistant	
Triticum aestivum (Wheat) Var. Zak	EC 524892 USA	Tolerant to hessian fly (*Mayetiola destructor*) biotypes E, F and GP	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var. Tara	EC 527045 USA	Tolerant to hessian fly (*Mayetiola destructor*), resistant to stripe rust (*Puccinia striformis*) and leaf rust (*Puccinia triticina*)	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var. Sisson	EC 533525 USA	Tolerant to hessian fly (*Mayetiola destructor*), resistant to powdery mildew (*Blumeria graminis*), *Barley yellow dwarf virus* and glume blotch (*Stagonospora nodorum*)	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var. Sabbe	EC 528127 USA	Resistant to powdery mildew (*Blumeria graminis*), septoria leaf blotch (*Septoria tritici*), soil borne *Wheat Mosaci Virus* and stripe rust (*Puccinia striformis*)	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.

Crop. name	Acc. No./ Country	Sailent features	Distribution
Var.-Intrada	EC 533532 USA	Resistant to leaf rust (*Puccinia triticina*) and stem rust (*Puccinia graminis*) and wheat soil borne mosaic virus	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var.-Wahoo	EC 533533 USA	Resistant to stem rust (*Puccinia graminis*), leaf rust (*Puccina triticina*) and hessian fly (*Mayetiola destructor*)	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Zea mays (Maize) Var.-N 547	EC 520260 USA	Resistant to European corn borer (*Ostrinia nubilalis*)	• Directorate of Maize Research, IARI, New Delhi. • NBPGR, New Delhi.
GM-MP 716	EC 523377 USA	Resistant to western corn borer (*Diatrae grandiosellta*) and fall armyworm (*Spodoptera frugiperda*)	• Directorate of Maize Research, IARI, New Delhi. • NBPGR, New Delhi.
	EC 514655-60 USA	Mould resistant varieties	• Bhabha Atomic Research Centre, Mumbai, Maharashtra.
Hordeum vulgare (Barley) Var.-AC Ranger	EC 523339 USA	Resistant to common root rot (*Cochlibolus sativus*)	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var.-Trochu	EC 532634 USA	Resistant to covered smut (*Ustilago hordei*) and intermediate reaction to barley leaf scald (*Rhynchosporium secalis*) and net blotch (*Pyrenophora teras*)	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var.-Farmington	EC 527044 USA	Resistant to stripe rust (*Puccinia striformis*)	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var.-Drummond	EC 533523 USA	Resistant to net blotch (*Pyrenophora tears*), spot blotch (*Cochliobolus sativus*) and stem rust (*Puccinia graminis* sp.*tritici*)	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var.-6 NDRPG-1	EC 533524 USA	Resistant to fusarium head blight (*Fusarium gramineraum*)	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Triticale Var. TCLF AN 31 Var. TCLF AN 34	EC 537921 EC-537922 Mexico	Resistant to stem rust (*Puccinia graminis* ssp. *tritici*), yellow rust (*Puccinia striformis*), fusarium head blight (*Fusarium* sp.)	• Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh.
Var. NE 422 T	EC 534274 USA	Resistant to prevalent races of stem rust (*Puccinia graminis* sp. *tritici*), leaf rust (*Puccinia recondita* sp. *tritici*), Wheat Streak Mosaic Virus and ergot (*Claviceps* sp.)	• Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh.
Phaseolus vulgaris (French bean)	EC 528359 AVRDC	Resistant to rust (*Uromyces appendiculatus*)	• Horticultural and Agroforestry Research Programme, Ranchi, Jharkhand. • NBPGR Regional Station, Shimla, Himachal Pradesh.
Var. MAB 84	EC 530832 USA	Resistant to angular leaf spot (*Phaeoisariopsis griseola*)	• GB Pant University of Agriculture and Technology, Pantnagar, Uttranchal. • NBPGR Regional Station, Shimla, Himachal Pradesh.

Crop. name	Acc. No./ Country	Salient features	Distribution
	EC 530891	Resistant to rust *(Uromyces appendiculatus)*	• GB Pant University of Agriculture and Technology, Pantnagar, Uttranchal. • NBPGR Regional Station, Shimla, Himachal Pradesh.
	EC 530898 CIAT, Columbia	Common bacterial blight *(Xanthomonas campestris* pv. *phaseoli)* resistant	• GB Pant University of Agriculture and Technology, Pantnagar, Uttranchal. • NBPGR Regional Station, Shimla, Himachal Pradesh.
	EC 528616-618 USA	Resistant to Curly Top Virus (CTV) and Bean common Mosaic Virus (BCMV)	• Horticultural and Agroforestry Research Programme, Ranchi, Jharkhand. • NBPGR Regional Station, Shimla, Himachal Pradesh.
Brassica napus (Rapessed)	EC 520224 USA	Broad adaptation ability	• National Research Centre for Rapessed and Mustard. Bharatpur, Rajasthan. • NBPGR Regional Station, Shimla, Himachal Pradesh.
Glycine max (Soybean)	EC 528619-629 AVRDC, Taiwan	Rust *(Phakopsora pachyrhizi)* resistant lines	• Nirmal Agricultural Research and Development Foundation, Jalgaon, Maharashtra.
Helianthus annus (Sunflower)	EC 524065-070 Bulgaria	Resistant to alternaria blight *(Alternaria helianthi)* and head rot *(Sclerotina scleotiorum*	• Directorate of Oilseeds Research, Hyderabad, Andhra Pradesh.
Sesamum indicum (Sunflower)	EC 519382 Bulgaria	Resistant to Antigastra, powdery mildew (*Microsphaera diffusc.*), wilt and bacterial blight *(Ralstonia solanacearum)*	• PC (Sesame and Niger), JNKVV, Jabalpur, Madhya Pradesh. • NBPGR Regional Station, Akola, Maharashtra.
Lycopersicon esculentum (Tomato)	EC 515140-5141 AVRDC Taiwan	Resistant to Tomato Yellow Leaf Curl Virus (TYLCV), bacterial wilt (*Ralstonia solanacearum*) and Tobacco Mosaic Virus (TMV)	• M/s Manjushtree Plantation Ltd., Tamil Nadu.
	EC 515144-5155 AVRDC Taiwan	Resistant to bacterial wilt (*Ralstonia solanaceraum), Tobacco mosaic virus* (TMV) and race F1 of fusarium wilt	• M/s Manjushree Planation Ltd, Tamil Nadu.
	EC 528360-369 AVRDC Taiwan	Resistant to Whiefly Transmitted Gemini virus (WTG), bacterial wilt *(Ralstonia solanacearum)*, tomato yellow leaf curl virus (TYLCV), Fusarium wilt race-(F1), race-2 (F 2) and Stemphyllium grey leaf spot	• Indian Institute of Vegetable Research Varanasi, Uttar Pradesh. • NBPGR, New Delhi.
Lycopersicon peruvianum	EC 532633 USA	Resistant to Tomato Leaf Curl Virus	• Indian Institute of Horticultural Research, Bangalore, Karnataka.

Crop. name	Acc. No./ Country	Sailent features	Distribution
Capsicum annuum (Chillies)	EC 533896-901 USA	Resistant to southern knot nematode *(Meloidogyne incognita)*	• Indian Institute of Horticultural Research, Bangalore, Karnataka.
Capsicum sp.	532396-89 AVRDC, Taiwan	Resistant to bacterial wilt *(Ralstonia solanacearum)* and poty virus-Y	• Punjab Agricultural University, Ludhiana, Punjab. • Indian Institute of Vegetable Research, Varanasi, UP.
Citrullus sp.	EC 531947-532028 USA	Resistant to anthracnose race II, Mosaic Virus II, powdery mildew, downey mildew	• Pradham Biotech Pvt. Ltd., Hyderabad, Andhra Pradesh.
Nicotiana tabacum (Tobacco)	EC 516587-586 USA	Resistant to black shank root knot nematode, granville wilt, Tobacco Mosaic Virus (TMV), southern root knot nematode *(Meloidogyne incognita)*	• Central Tobacco Research Institute, Rajahmundry, Andhra Pradesh.
		B. Abiotic stress tolerant	
Oryza sativa (Rice)	EC 517348-401 IRRI, Philippiness	Salinity tolerant lines	• Pt. Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Kerala.
	EC 526554-561 IRRI, Philippiness	Submergence tolerant lines	• Narendra Dev University of Agriculture and Technology, Faizabad, Uttar Pradesh.
	EC 526562-614	Salt tolerant lines	• Narendra Dev University of Agriculture and Technology, Faizabad, Uttar Pradesh.
	EC 526615-620 IRRI, Philippines	Zinc deficiency tolerant lines	• Narendra Dev University of Agriculture and Technology, Faizabad, UP.
Triticum aestivum (Wheat) Var.Sabbe	EC 528127 USA	Good Winter hardiness	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
	EC 533526-531	Drought resistant populations	• Birsa Agricultural University, Ranchi, Jharkhand. • Banaras Hindu University, Varanasi, Uttar Pradesh. • Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Zea mays (Maize)	EC 517308 USA	Lodging tolerant	• Sher-e-Kashmir University of Agricultural Science and Technology (K), Jammu and Kashmir. • Directorate, of Maize Research, IARI, New Delhi.
Hordeum vulgare (Barley)	EC 523339 Canada	Lodging tolerant	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var. Farmingtion	EC 527044 USA	Lodging tolerant	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Triticale Var. TCLF AN 31 Var, TCLF AN 34	EC 537921-22 CIMMYT, Mexico	Low pH tolerant lines	• Indian Grassland and Forage Research Institute, Jhansi, Uttar Pradesh.

Crop. name	Acc. No./ Country	Sailent features	Distribution
Cicer arietinum (Chickpea)	EC 519355-9381 Australia	Cold tolerant lines	• Punjab Agricultural University, Ludhiana, Punjab. • Indian Institute of Pulses Research, Kanpur, UP.
	EC 530806-808 Australia	Chilling tolerant lines	• Punjab Agricultural University, Ludhiana, Punjab. • Indian Institute of Pulses Research, Kanpur, UP.
Phaseolus vulgaris (French bean)	EC 530819 CIAT, Columbia	Heat tolerant	• GB Pant University of Agriculture and Technology, Pantnagar, Uttranchal. • NBPGR Regional Station, Shimla, Himachal Pradesh.
	EC 530858 CIAT, Columbia	Drought resistant	• GB Pant University of Agriculture and Technology, Pantnagar, Uttarachal. • NBPGR Regional Station, Shimla Himachal Pradesh.
Pisum sativum (Pea)	EC 530809-819 USA	Heat tolerant lines	• Horticultural and Agroforestry Research Programme, Ranchi, Jharkhand.
Seasmum indicum (Sesame)	EC 520261-62 Sri Lanka	Excessive moisture tolerant types	• Project Coordinator (Seasame and Niger), JN Krishi Vishvavidyalaya, Jabalpur, Madhya Pradesh. • NBPGR Regional Station, Akola, Maharashtra NBPGR, New Delhi.
Salix alba (Willow)	EC 515105 Hungary	Flood tolerant line	• YS Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh.
		C. Quality traits	
Triticum aestivum (Wheat) Var. Intrada	EC 533532 USA	Good bread making quality	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var.- Wahoo	EC 533533 USA	Good milling and baking quality	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var.-Explorer	EC 523376 USA	Excellent baking quality	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Zea mays (Maize)	EC 531818-30 CIMMYT, Mexico	Germplasm having high amylose, high oil content with good protein quality	• Directorate of Maize Research, IARI, New Delhi. • NBPGR, New Delhi.
	EC 531831-834 CIMMYT, Mexico	White and yellow grained quality protein maize (QPM)	• Directorate of Maize Research, IARI, New Delhi. • NBPGR, New Delhi.
	EC 517102-106 Bulgaria	High protein content	• Directorate of Maize Research, IARI, New Delhi. • NBPGR, New Delhi.
Hordeum vulgare (Barley) Var. Drummond	EC 533523 USA	Superior malting quality, plump kernels	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var. Farmington	EC 527044 USA	Semi-dwarf, two rowed; spring feed barley, plump kernels, and good malting quality, high grain protein (11%)	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.

Crop. name	Acc. No./ Country	Sailent features	Distribution
Var. AC Ranger	EC 523339 Canada	Six rowed, spring forage barley with superior forage quality	• Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh.
Phaselous vulgaris (French bean)	EC 530828 CIAT, Columbia	High iron content	• GB Pant University of Agricultrue and Technology Pantnagar, Uttranchal. • NBPGR, New Delhi.
Macroptilium atropurpureum (Horse gram)	EC 533895 Australia	Forage type	• Indian Grassland and Fooder Research Institute, Jhansi, UP. • NBPGR Regional Station, Jodhpur, Rajasthan.
Helianthus annuus (Sunflower)	EC 517095-96 Bulgaria	High oil content type	• Directorate of Oilseeds Research Hyderabad, Andhra Pradesh. • NBPGR, New Delhi.
	EC 524065-070 Bulgaria	High oil type (>48-50%) with high oletic acid (>60%) content	• Directorate of Oilseeds Research Hyderabad, Andhra Pradesh. • NBPGR, New Delhi.
Linum usitatissimum (Linseed)	EC 537910 Canada	Germplasm having low linolenic acid	• Punjab Agricultural University, Ludhiana, Punjab. • Project Coordinator, Linseed, CSAUA&T, Kanpur, Uttar Pradesh. • NBPGR RS, Akola, Maharashtra.
	EC 537911-12 Canada	Germplasm having high linolenic acid	• Punjab Agricultural University, Ludhania, Punjab. • Project Coordinator Linseed, CSAUA&T Kanpur, Uttar Pradesh. • NBPGR RS, Akola, Maharashtra.
Carthamus tinctorius (Safflower)	EC 523375 USA	High oil content type (>40%)	• Directorate of Oilseeds Research, Hyderabad Andhra Pradesh. • NBPGR RS, Akola, Maharashtra.
Gossypium hirsutum (Cotton)	EC 516301-02 USA	Good fibre quality	• Paras Extra Growth, Hyderabad, Andhra Pradesh.
Hibiscus cannabinus (Roselle)	EC 532034-52 USA	Good fibre quality	• CRIJAF, Barrackpore, West Bengal. • NBPGR, New Delhi.
Lycopersicon esculentum (Tomato)	EC 515142-43 AVRDC, Taiwan	Contains ten times more beta carotene than a red fruited tomato	• Manjushree Planation Hosur, Karnataka.
Lycopersicon esculentum var *cerasiforme*	EC 531800-801 AVRDC, Taiwan	High beta carotene, fresh market use cherry type	• Indian Institute of Vegetable Research, Uttar Pradesh. • NBPGR, New Delhi.
Opuntia ficus indica (Cactus)	EC 527043 CIMMYT, Mexico	Edible cactus	• Central Institute of Arid Horticulture, Bikaner, Rajashtan.
Nicotiana tabacum (Tobacco)	EC 517324-25	Flue cured variety	• Central Tobacco Research Institute, Rajahmundry, AP.

Crop. name	Acc. No./ Country	Sailent features	Distribution
	EC 519004-06	Hybrid barley type	• Central Tobacco Research Institute, Rajahmundry, AP.
		D. Agronomic traits	
Oryza sativa (Rice)	EC 512353-361 IRRI, Philippines	New plant types (NPT), less tillering, all tillers bear panicle, more no of grains per panicle and high harvest index	• Tamil Nadu Agricultural University Coimbatore, Tamil Nadu.
	EC 513198-237 IRRI, Philippines	New plant types (NPT), less tillering, all tillers bear panicle, more no. or grains per panicle and high harvest index	• Directorate of Rice Research, Hyderabad, Andhra Pradesh.
	EC 518781-820 IRRI, Philippines	New plant types (NPT), less tillering, all tillersbear panicle, more no. or grains per panicle and high harvest index	• Shere-e-Kashmir University of Agriculture Science and Technology (K) Shalimar, Srinagar, Jammu & Kashmir.
Triticum aestivum (Wheat) Var.-Sisson	EC 533525 USA	Early maturing high yielding	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var.-Tara	EC 527045 USA	High grain yield	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var.-Sabbe	EC 528127 USA	Excellent straw strength and yield potential	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var.-Intrada	EC 533532 USA	High yielding, high weight	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Var.-Zak	EC 524892 USA	High grain yield, semi dwarf	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Hordeum vulgare (Barley) Var.-Trochu	EC 532634 Canada	High yielding	• Directorate of Wheat Research, Karnal, Haryana. • NBPGR, New Delhi.
Triticale Var.-TCLF AN 31 Var-TCLF AN 34	EC 537921 Mexico EC 537922 Mexico	Hexaploid triticale, good forage quality	• Indian Grassland and Fodder Research Institute, Jhansi Uttar Pradesh.
Var.-NE 422 T	EC 534274 USA	High yielding, superior forage quality	• Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh.
Vicia villosa	EC 517311 USA	Ealy flowering and high yielding	• Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh. • NBPGR Regional Station, Bhowali, Nainital.
Capsicum sp.	EC 532386-89 AVRDC, Taiwan	Cayenne type	• Punjab Agricultural University, Ludhiana, Punjab. • Indian Institute of Vegetable Research Varanasi, Uttar Pradesh.

Crop. name	Acc. No./ Country	Sailent features	Distribution
Gossypium hirsutum (Cotton)	516300 USA	Early maturing	• Paras Extra Growth, Hyderabad, Andhra Pradesh.
Salix alba (Willow)	EC 515100-105 Hungary	High yielding, fast growing	• YS Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh.
		E. Lines for heterosis exploitation	
Oryza sativa (Rice)	EC 51691-235 IRRI, Philippines	CMS, maintainers and restorer lines	• Vibha Agrotech Ltd., Hyderabad, Andhra Pradesh.
	EC 523464-486 IRRI, Philippines	CMS, maintainers and restorers	• Pt. Jawaharlal Nehru College of Agriculture and Research Institute Karaikal, Kerala.
	EC 523487-489 IRRI, Philippines	TGMS lines	• Pt. Jawaharlal Nehru College of Agriculture and Research Institute Karaikal, Kerala.
	EC 523487-489 IRRI, Philippines	TGMS lines	• Pt. Jawaharlal Nehru College of Agriculture and Research Institute Karaikal, Kerala.
	EC 523490-91 IRRI, Philippines	Wide compatibility genes	• Pt. Jawaharlal Nehru College of Agriculture and Research Institute Karaikal, Kerala.
Pennisetum glaucum (Pearl millet)	EC 516577-83 USA	CMS and restorer lines	• All India Coordinated Research Project on Pearl Millet, Mandor, Rajasthan. • NBGPR Regional Station, Jodhpur, Rajasthan.

The NBPGR is continuing its efforts to identify promising germplasm through literature search and personal contact; and to introduce the same for utilization by Indian plant breeders.

Diversity of Bael (*Aegel marmelos* Corr.) in East Central India

Vishal Nath, Devendra Pandey* and Bikash Das
Horticulture & Agro Forestry Research Programme, Plandu, Ranchi-834010, Jharkhand
** Central Institute for Subtropical Horticulture, Rehmannkhera, Kakori, Lucknow, Uttar Pradesh*

The east and central India has rich genetic diversity of bael. To collect the existing genetic diversity, exploration programme was undertaken in parts of Jharkhand and Bihar during 2002. A total of 33 genotypes of bael having economically important horticultural traits have been identified from the diverse gene pool spread over six districts of Jharkand and ten districts of Bihar. The genotypes showed variability with respect to tree morphological characters, intensity of bearing and fruit characters. The physico-chemical constituent in different genotypes also varied greatly. The fruit weight in different genotypes varied from 0.5-2.6 kg whereas the fruit length varied from 16.8-30.5 cm. The skull thickness which is a negative character for a quality bael fruit, varied from 0.17-0.4 cm in different genotypes collected during the exploration. On the basis of fruit characters and bearing behavior five promising genotypes has been identified.

Key Words: Bael, *Aegle marmelos*, Diversity

Introduction

Bael (*Aegle marmelos* Corr.) is one of the underutilized native fruits of Indo-Malaysian region (Anon., 1985). It is found in wild state in sub-Himalayan tract and dry deciduous forest of central and southern region (Anon., 1985); a large number of genotypes are available in different diversity regions. Bael has great mythological significance and medicinal value in which almost all parts of the plant are used in preparation of different medicines (Pathak *et al.*, 2002). The pulp contains marmelosin, which acts as laxative, diuretic and in strong doses a cardiac depressant. The plateau region of Jharkhand and plains of Bihar have wide distribution of bael particularly in degraded land. Although, there is no systematic plantation of bael, a fair quantity of fruits are made available from forests and grooves in marginal lands of Bihar, Jharkhand and Uttar Pradesh where it matures at different time. As a result, bael fruits are sold in market from March to July. Owing to seed propagation of the species no standard variety of bael is available. Recently a few genotypes of bael collected and evaluated by different research institutions have been found useful for commercial cultivation. NB-5 and NB-9 cultivars have been evolved at NDUAT Faizabad (Pareek and Vishal Nath, 1996) and CISH-B1 and CISH-B2 at CISH Lucknow (Pathak *et al.*, 2002). Bael gene pool growing in different ecological regions has enormous variability with respect to qualitative and quantitative characters (Singh and Roy, 1984). Some superior genotypes are at the verge of extinction (Roy, 1984) and need to be conserved (Rai *et al.*, 1991). East-Central India has high potential of bael diversity and therefore, an urgent need for fine field survey and exploration was felt and thus, conducted in high variability region of Jharkhand and Bihar with a view to identify the superior genotype for various traits.

Material and Method

A joint exploration to identify and collect potential bael germplasm was undertaken by Horticulture and Agro Forestry Research Programme, Ranchi and Central Institute for Sub-tropical Horticulture, Lucknow in parts of Ranchi, Hazaribagh, Bokaro, Giridih, Deoghar and Koderma districts of Jharkhand and Jamui, Lakhisarai, Begusarai, Samastipur, Muzaffarpur, Vaishali, Motihari, Patna, Nalanda and Nawada districts of Bihar located between 83-87°E longitude and 23-26°N latitude during April, 2002. Five fruits were randomly collected in each genotypes to record the quantitative and qualitative characters. Tree height was estimated while spread and trunk girth was measured with the measuring tape. The information about age of the plant was gathered from local people whereas other vegetative characters were recorded visually. Yield of the tree was calculated on the basis of average weight of the fruit and total number of fruits on the tree. Population density was prepared by observing the plant population at a particular site. Range, mean and standard error for five characters were also calculated.

Results and Discussion

Bael is a drought hardy fruit plant, which grows in most degraded and marginal lands with varying soil types. In present exploration, it was observed that bael plants are widely growing in different parts of Jharkhand and Bihar.

Diversity in Plant Density

Population density of bael ranged low to high at different locations surveyed (Table 1). The highest densities of plants were observed at Khelari, Ranchi; Chitrapur, Bokaro; Sariya, Giridih; Chakai, Jamui; Dularpur, Begusarai; Bhikharia Mathia, Siwan and Jhumari-Tillaia, Koderma.

Diversity in Morphological Characters

Considerable variability was observed in the identified germplasms with respect to different morphological characters such as plant growth, leaf characters, thorniness on the stem and branches (Table 2). The tree height ranged from 6 m (IC 436503) to 22 m (IC 436475). Similarly, the trunk girth in these genotypes ranged from 0.5 m in IC 436503 to 1.5 m in IC 436505, IC 436492 and IC 436486. North-South canopy spread was the maximum (11.0 m) in genotype IC 436486 whereas the East-West canopy was highest (13.0 m) in case of IC 436507. Throns on the branches also varied from less to very high in different genotypes as reported by Rai *et al.*, (1991).

Diversity in Fruit Yield

The identified genotypes had wide diversity with respect to number of fruits per plant. During the exploration it was observed that the plants in backyard or at religious places had more number of fruits than those of disturbed and barren lands. In different genotypes, the yield ranged from 30 fruits/plant (IC 436494) to 500 fruits/plant (IC 436489). Rai *et al.* (1991) had earlier reported 60-3000 fruits per plant in different genotypes of bael.

Table 1. Population density of bael in parts of Jharkhand and Bihar

Location	Population Density	Location	Population density
Khijri, Ranchi	+	Musri Gharai, Samastipur	+
Ratu, Ranchi	+	Chak Salem, Samastipur	++
Khellari, Ranchi	+++	Kamalpur, Vaishali	+
Ramgarh, Hazaribagh	++	Meenapur, Muzaffarpur	++
Sandi, Hazaribagh	++	Phatuha, Patna	+
Chitarpur, Bokaro	+++	Biharsharif, Nalanda	-
Vishnugarh, Hazaribagh	+	Nawadah	+
Sariya, Giridih	+++	Jamui Tillaia, Koderma	+++
Mahua, Giridih	++	Barhi, Hazaribagh	+
Lataki, Giridih	++	Chakai, Jammui	+++
Jasidih, Deoghar	++	Deoghar Local	++
Jhajha, Jamui	++	Dularpur, Begusarai	+++

+ low, ++medium, +++ high

Variation in Fruit Characters/Fruit Size

Fruits of different genotypes varied in different physico-chemical characters (Table 3). The maximum fruit weight (2.6 kg/fruit) was recorded in genotype IC 436485, whereas the minimum (0.41 kg/fruit) was in IC 436476. Fruit length and breadth in different bael genotypes varied from 16.75 cm (IC 436476) to 30.50 cm (IC 436485) and 13.50 cm (IC 43694) to 29.00 cm (IC 436483), respectively. Botanically, bael is an Amphisarca. The outer hard skin, called skull, contains mini sacs. The number of sacs in different genotypes varied from 8-17 (Table 3). The skull weight in different genotypes varied from 28.1 g (IC 436476) to 480 g (IC 436499), whereas the skull thickness varied from 0.17 cm (IC 436486) to 0.50 cm (IC 436481). Pareek and Vishal Nath (1996) noted 0.26 cm to 0.32 cm skull thickness in different cultivars of bael whereas Pathak *et al.* (2002) and Rai *et al.* (1991) mentioned that papery skull in bael is a desirable horticultural trait. Fibre content in bael is considered to be negative character particularly with respect to pulp quality, whereas for medicinal point of view, fibre and mucilage content is desirable trait. The bael genotypes collected also varied with respect to fibre content. The maximum values of fibre (935.2g/fruit) was recorded in genotypes IC 436477. Data presented in Table 3 reveal that the number of seeds per fruit in different genotypes varied from 20 (IC 436488) to 165 (IC 436503). Pareek and Vishal Nath (1996) reported 46-108 seeds per fruit in different bael genotypes whereas Rai *et al.* (1991) noticed 46-120 seeds in different genotypes of bael from Eastern Uttar Pradesh.

On the basis of different desirable traits, following five elite genotypes have been identified.

IC 436483: Plant medium in height (8.0 m), medium spreading (7.8 x 8.5 m), leaves vigorous, healthy green, which persist up to end of April. Grown up plant bears 150-175 fruits weighing 2.0-2.5 kg fruit. Fruit round (29.0 cm diameter) with flat stylar end. Skull thin (0.26 cm) pulp has less seeds (40) and fibre and has pleasant aroma.

IC 436486: Plant tall (20.0 m) with thick trunk (1.5 m girth), more spreading (11.0 x 10.5 m), leaves healthy green, which persist up to mid of May. Well grown plant (50-60 years) has thorns and bears 300-400 fruits weighing 0.6 – 1.0 kg fruit. Bright yellow fruits are oblong in shape with 19.5 cm length and 18.5 cm diameter. Skull papery (0.17 cm) pulp has less seeds (52) and fibre content and has pleasant aroma.

Table 2. Diversity in morphological characters of bael land races in parts of Jharkhand and Bihar

Genotype (IC Number)	Tree height (m)	Trunk Girth (m)	Canopy spread (m) (N-S)	(E-W)	Leaf Characters	Spines on Tree	General Health	Age of tree (years)	Plant Location	Yield (No. of Fruits)	Remarks
IC436475	22	1.3	10.5	10.5	Early leaf fall	Medium	Medium	70-75	Barren land	100	–
IC436476	13	0.9	8.5	7.3	Vigorous	Less	Medium	50-55	Threshing flour	300	Die back of twigs
IC436477	10	0.7	6	5.5	Early leaf fall	Medium	Medium	30-35	Closed backyard	150	Less branches
IC436478	12	1.1	–	–	Vigorous, healthy	Less	Good	50-60	Barren land near house	150	Disease free
IC436479	12	0.9	9.5	9.5	Early leaf fall	Very less	Very good	30-35	Closed backyard	350	Heavy yield
IC436480	8	0.6	5.5	4.5	Early leaf fall	More	Good	10.15	Closed fencing boundary	60	Disease free
IC436481	12	0.9	7.5	7	Healthy, Vigorous	Very leass	Very good	25-30	Open backyard	150	Heavy bearing of uniform
IC436482	15	1.2	8	8.5	Smaller leaf	Less	Good	60-70	Closed backyard	250	Disease free pest free
IC436483	8	0.8	7.8	8.5	Vigorous. healthy leaf	Very less	Very good	35-40	Bund of field	175	Disease free pest free
IC436484	11	1.3	9	8.3	Early leaf fall	Very less	Very good	80-90	Field boundary	225	Heavy bearing disease free
IC436485	7	0.6	5.5	6	Early leaf fall	Medium	Good	20-22	Field boundary	100	Heavy yield disease free
IC436486	20	1.5	11	10.5	Healthy green leaf	Less	Very good	50-60	Open back yard	400	Heavy fruiting disease free
IC436487	18	1.1	8	7	Early leaf fall	More	Medium	40-45	Closed back yard	250	Heavy bearing pest free
IC436488	10	0.9	6.5	7	Early leaf fall	Very Less	Medium	20-25	Field boundary	250	Heavy bearing pest free
IC436489	12	1.2	8	7.9	Healthy vigorous leaf	Less	Good	60-70	Community place	500	Heavy bearing
IC436490	10	1	7.5	7.9	Healthy vigorous leaf	Less	Very good	30-35	In front of house	300	Heavy fruiting disease free
IC436491	8	0.8	6	6.4	Early leaf fall	More	Good	25-27	In front of house	200	Disease pest free
IC436492	11	1.5	8	8.5	Early leaf fall	Very less	Poor	100-125	Closed backyard	400	Old age symptom
IC436493	15	1.3	9	8.5	Healthy green leaf	Less	Very good	90-100	Community land	350	Disease free
IC436494	7	0.7	–	–	Early leaf fall	Less	Medium	100-150	Uncared backyard groove	30	Affected with black mould
IC436495	13	1.1	8.5	9.5	Healthy green	Less	Good	60-65	Closed back yard	200	Disease free
IC436496	10	Multi-stem	6.5	7.5	Early leaf fall	Very less	Poor	75-80	Single plant in mango orchard	400	Old age symptom
IC436497	9	0.8	6.7	6	Healthy leaf	Less	Medium	25-30	In front of office near bamboo clamp	100	Dieback symptom
IC436498	7	0.8	6.8	–	Early leaf fall	Less	Medium	30-40	Community land	100	Dieback symptom
IC436499	10	0.9	5	5.5	Early leaf fall	Less	Poor	40-45	Closed back yard	75	Dieback symptom
IC436500	7	0.7	6	6.5	Healthy green leaf	Less	Very good	20-25	In front of house	150	Orange flavour type fruit
IC436501	9	1	5.5	6	Green, vigorous leaf	Less	Poor	40-50	Field boundary	75	Attack of pest and dieback symptom
IC436502	7	0.6	5	5.5	Early leaf fall	Medium	Medium	10-15	Single plant in banana orchard	35	Pest and disease free
IC436503	6	0.5	6	5.5	Healthy green vigorous leaf	Less	Very good	20-25	Closed boundary in front of house	125	Dwarf type
IC436504	8	0.7	7.5	7.8	Early leaf fall	Less	Good	15-20	Open back yard	200	Disease and pest free
IC436505	13	1.5	9.5	7.5	Healthy green vigorous leaf	Less	Very good	25-30	Open back yard	175	Disease and pest free
IC436506	8	0.8	8	6.5	Vigorous, early leaf drop	Very less	Good	32	Open back yard	150	Large fruits with shining skull disease free
IC436507	15	1	12	13	Healthy green	Less	Very good	30	Open back yard	250	Medium size, shining fruit

IC436488: Plant medium tall (10.0 m), medium spreading (6.5 x 7.0 cm) leaves broader but falls by mid of April. Grown up plant has very few thorns and bears 250-275 fruits weighing 0.9-1.2 kg fruit. Pale yellow oblong fruits have 22.0 cm length and 19.5 cm diameter. Fruit has very thin papery skull (0.19 cm) and less seed, mucilage and fibre in its pulp. It also possesses very good aroma.

IC 436501: Plant medium tall (9.0 m), less spreading (5.5 x 6.0 m) with healthy green leaves. Well grown up plant bears 50-75 fruits weighing 1.4-1.8 kg fruits. Oblong fruits having 23.0 cm length and 22.0 diameter. Fruit contains papery skull (0.20 cm), less seeds (26) and mucilage.

IC 436507: Plant tall (15.0) with well spreading canopy (12.0 x 13.0 m) healthy green leaves. Grown up plants bears 200-250 fruits weighing 1-1.4 kg fruit. Round fruit with flat stylar end has 20.8 cm length and 23.2 cm diameter. At ripening fruit becomes yellow. It contain less seeds, and mucilage has good aroma.

Conclusion

The available variability for various traits in bael genotypes can be utilized for improvement of this underutilized fruit. Five genotypes described with desirable characters can be directly selected for commercial cultivation. Genotypes having less seeds and mucilage content, papery

Table 3. Diversity in fruit characters of bael genotypes

Genotype (IC Number)	Fruit weight (kg)	Fruit length (cm)	Fruit breadth (cm)	No. of Sacs in fruits	Weight of skull (g)	TSS (^{0}brix)	No. of seeds per fruit	Weight of seed per fruit (g)	Thickness of skull (cm)	Weight of fibre (g)
IC 436475	0.50	19.50	16.57	10	175.2	36.5	48	7.5	0.32	3.6
IC 436476	0.41	16.75	16.10	12	098.1	30.0	45	7.9	0.34	9.7
IC 436477	0.96	23.25	20.60	12	265.3	34.5	69	39.5	0.31	35.2
IC 436478	0.96	23.25	20.60	12	265.3	34.5	69	39.5	0.31	35.2
IC 436479	1.30	25.00	23.75	12	204.3	36.0	40	12.0	0.26	10.0
IC 436480	0.95	20.25	17.85	10	228.7	34.0	140	20.0	0.28	20.0
IC 436481	1.00	21.00	23.00	10	218.5	35.0	80	20.0	0.50	10.0
IC 436482	0.90	18.00	18.65	10	158.6	37.0	70	10.0	0.33	7.5
IC 436483	2.50	29.00	29.00	14	410.5	35.0	54	10.0	0.37	25.0
IC 436484	2.05	28.50	27.50	12	478.9	36.0	70	10.0	0.35	20.0
IC 436485	2.60	30.50	28.00	12	448.2	36.0	71	10.0	0.30	10.0
IC 436486	0.60	19.50	18.50	12	208.7	37.0	53	10.0	0.17	10.0
IC 436487	1.40	25.75	25.50	12	200.1	32.0	50	20.0	0.35	15.0
IC 436488	0.90	22.00	19.50	12	209.8	36.0	20	5.0	0.24	30.0
IC 436489	1.25	22.30	26.50	11.5	289.9	34.0	60	13.8	1.90	20.0
IC 436490	1.90	25.00	26.50	13	318.7	39.0	73	15.0	0.25	25.0
IC 436491	1.10	24.50	19.25	11	219.5	35.0	70	5.0	0.33	15.0
IC 436492	1.00	22.25	19.00	12	249.1	36.0	63	110	0.30	20.0
IC 436493	1.70	23.50	27.50	12	417.5	35.0	120	20.0	0.40	10.0
IC 436494	0.60	18.50	13.50	8	130.2	30.0	100	15.0	0.25	15.0
IC 436495	1.25	21.00	21.50	12	304.1	29.0	51	15.0	0.34	10.0
IC 436496	1.85	27.00	25.00	12	430.0	35.0	64	10.0	0.35	10.0
IC 436497	1.15	22.50	24.00	14	380.0	34.0	112	15.0	0.36	20.0
IC 436498	2.50	30.00	28.50	14	2480.0	34.0	49	20.0	0.36	30.0
IC 436499	2.50	30.00	28.50	14	480.0	34.0	49	20.0	0.36	30.0
IC 436500	1.15	21.20	22.50	12	175.0	35.0	110	17.5	0.28	11.0
IC 436501	1.40	23.00	22.00	17	180.0	36.0	26	5.0	0.20	10.0
IC 436502	2.50	26.30	28.00	12	450.0	39.0	112	15.0	0.30	30.0
IC 436503	0.80	17.80	18.50	12	180.0	35.0	165	20.0	0.20	30.0
IC 436504	1.05	20.50	18.50	11	160.0	38.0	40	10.0	0.32	10.0
IC 436505	1.40	24.50	23.50	15	210.0	35.0	90	15.5	0.20	26.2
IC 436506	2.25	26.50	27.90	15	450.0	31.0	85	20.0	0.30	60.0
IC 436507	1.10	20.75	23.15	13	180.0	28.0	140	30.0	0.20	20.0

skull pulp content, less fibre in pulp and better aroma can be used for improvement of this native fruit.

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Non-hierarchical Euclidean Cluster Analysis in Aromatic Rice

Dharmendra Singh, VK Sharma and VK Shahi
Department of Genetics, Rajendra Agricultural University, Bihar, Pusa, Samastipur-848125 Bihar

The present investigation is an attempt to classify forty-six entries comprising advanced breeding lines, local and exotic collections and cultivars of aromatic rice into well characterized groups. Results revealed significant differences among the entries for seventeen agromorphological and quality characters under consideration in this study. With the exception of days to 50% flowering, days to maturity, panicle length and kernel elongation ratio, all characters had moderate to high estimates for genotypic and phenotypic coefficients of variability. By following the method of non-hierarchical Euclidean cluster analysis, the entries could be divided into five distinct, compact and well characterized groups. The distinctness of clusters was proven by distance matrix as inter-cluster distances were greater than all the intra-cluster distances. Some of the entries showed greater diversity despite having common parentage. Further, the distribution pattern of entries was not necessarily related to geographical diversity. Analysis based on cluster means suggested the importance of plant height, number of grains per panicle, kernel length before and after cooking and volume expansion ratio for selection of parents from distantly related clusters for hybridization. The entries with exceptionally good performance were identified in five clusters for their use as base material.

Key Words: Rice, Aromatic Lines, Cluster Analysis, Genetic Diversity, Grain Quality

Introduction

Presence of wide genetic variation provides a greater scope for genetic improvement and making progress in crop breeding. Although intensive breeding of improved cultivars in recent times has enhanced the availability of natural variability in rice, much emphasis has not been laid on systematic programme of developing semi-dwarf high yielding aromatic varieties with superior quality characteristics. With the consumers becoming more quality conscious, emphasis on quality breeding has assumed greater significance in recent years. Precise information on the nature and extent of genetic divergence and on the relative importance of characters in terms of their contribution to total divergence is crucial in any crop improvement programme as it helps in choosing the parents for hybridization. The method of non-hierarchical Euclidean cluster analysis is a powerful tool in classifying the entries into distinct groups and in discerning divergence among groups based on actual expression of multiple characters. Using this method in the present study, an attempt was made to classify the advanced breeding lines, local and exotic accessions and standard cultivars of aromatic rice into well characterized groups and to quantify the magnitude of genetic divergence for their further use in recombination breeding with expectation of getting potential transgressive segregants.

Materials and Methods

The experimental materials of the present study consisted of fourty-six entries comprising advanced breeding lines, local and exotic collections and cultivars of aromatic rice. The entries were evaluated in randomized complete block design with three replications at the research farm of Rajendra Agricultural University, Pusa, Bihar during *kharif*, 2002. Seedlings of each entry were transplanted to the field in three rows spaced at 20 cm and inter-plant distance within a row was maintained at 10 cm. While raising the crop, recommended agronomic practices were followed. The observations for seventeen agromorphological, physical grain quality and cooking quality characters with the exception of phenological characters were recorded on five plants per entry in each replication and their mean values were subjected to statistical analysis. Genotypic and phenotypic coefficients of variation were estimated as per standard statistical procedure (Johnson *et al.*, 1955). Using a computer program (Doshi and Gupta, 1991), the non-hierarchical Euclidean cluster anlaysis (Beale, 1969; Spark, 1973) was conducted to group the entries into different clusters and to estimate the inter-cluster and intra-cluster distances.

Results and Discussion

Analysis of variance revealed significant differences among the entries for each of the seventeen characters under consideration in the present study, suggesting adequate variability among the genotypes. A wide range of variability was noticed for different agronomic and quality traits. The estimates of genotypic coefficient of variation were found to be lower than

respective phenotypic coefficient of variation. However, a relatively higher magnitude of difference between genotypic and phenotypic coefficient of variation was noticed in respect of number of panicles per plant, uncooked kernel breadth, kernel elongation index and grain yield per plant. While days to 50% flowering, days to maturity, panicle length and kernel elongation ratio had lower estimates, the remaining characters recorded moderate to high genotypic and phenotypic coefficients of variability in the present study.

Using correlation matrix based on mean values of entries, all the metric characters were transformed into a single index of similarity in the form of principal components, which yielded seventeen eigen roots and corresponding eigen vectors. Principal component analysis was used prior to cluster analysis to determine the relative importance of classification variables. Only first ten principal component scores were used further for clustering purpose as these accounted for 96.01 percent variation. Eigen values from the first ten principal component axes accounted for 28.63, 20.78, 13.74, 9.90, 5.63, 5.04, 4.02, 3.85, 2.86 and 2.47 per cent of the total variance present, respectively.

Non-hierarchical Euclidean cluster anlaysis was conducted and a series of cluster solutions with seven, six, five, four and three clusters were obtained. The sequential F-ratio tests for comparison of cluster solutions, however yielded the highest and significant F-value for making comparison between cluster solutions with five and four clusters. This indicated that going from five clusters to four clusters was inadequate to describe the data fully (Katyal *et al.*, 1985). Taking this into consideration, the cluster solution with five clusters was accepted for further study. Thus, fourty-six genotypes were classified into five separate and well characterized groups on the basis of their observed characteristics (Table 1), revealing the presence of considerable amount of genetic diversity in the material. Cluster A was dominated by traditional basmati varieties. The seven entries included in this cluster were characterized by superior grain and cooking quality characteristics. Cluster B was the largest group which consisted of fourteen entries, a majority of them being local collections possessing comparatively inferior grain quality attributes. Most of the entries included in this cluster were advanced breeding lines. Cluster D consisted of twelve entries including indigenous and exotic accessions and advanced breeding lines having better grain quality. Cluster E accommodated seven entries. This cluster was dominated by entries from indigenuous collections and characterized by superior grain and cooking quality attributes. It was interesting to find that some of the entries showed greater diversity as they were accommodated into distinct clusters, despite having common parentage. Further, the pattern of distribution of entries into different clusters was not observed to be necessarily related to geographical diversity as genotypes selected under diverse locations clustered together in consonance with the earlier reports (Singh *et al.*, 1999; Raju *et al.*, 2002; Shukla and Pandey, 2003; Datt and Mani, 2003). The results were in agreement with the earlier observations that the factors like history of selection, genetic drift and selection under diverse environments may cause greater genetic diversity than the geographical distance (Sardana *et al.*, 1997). Thus, it appeared that it is important to ascertain the level of parental divergence, since genetic diversity can not be taken as synonymous with geographical divergence when an initial choice of the parents has to be made in the hybridization programme for getting wide range of variability in segregating generations.

Statistical distances between the clusters represent the extent of diversity amongst the entries which are accommodated into different clusters. As it is evident from a perusal of distance matrix (Table 2), the inter cluser distance was maximum between B and E (5.30) reflecting greatest diversity between genotypes belonging to these two clusters. Similarly, the entries in clusters D and E (5.08) followed by those in clusters B and C (5.07) and clusters A and B (4.74) were much diverse to each other. The inter-cluster distance between A and

Table 1. Distribution of aromatic rice genotypes into five clusters

Cluster A : Type-3, Pakistani Basmati, Taroari Basmati, Katarni, PRR78, Seond Basmati, Basmati Sathi; **Cluster B:** Sugandha, Kamini, BR 9, BR 10, Kalanamak, BR 26, Sona Chur, Kamod-1, Chandan Chur, Shyma Jeera, Mallida, Laxman Bhog, Kariya Kamur, Gamkaua Dhan; **Cluster C:** RPS 1, Champaran Local-1, Pusa 1347-2, Pusa 1280-1, Pusa 1280-4, Pusa 1297-2; **Cluster D:** Kasturi, Champaran Local-2, Champaran Local-6, Basmati 385, RPS local, Kamod 2, BK 843-7, Azucena, Binam, Pusa 1347-3, Pusa 1347-1, Pusa 1280-3; **Cluster E:** Tilak Chandan, Haryana Basmati, RAU-SCT-13, RAU-SCT-14, RPS 2, Champaran Local-1, Champaran Local-4.

Table 2. Estimates of average intra and inter-cluster distances based on non-hierarchical cluster analysis

Cluster	A	B	C	D	E
A	2.72	4.74	3.67	4.49	3.32
B		3.11	5.07	4.06	5.30
C			3.08	3.54	4.30
D				2.73	5.08
E					2.64

Diagonal values represent intra-cluster distances

E (3.317) was smallest. However, it was greater than all the intra-cluster distances indicating that the five clusters obtained by non-hierarchical cluster analysis were distinct and more or less compact. While cluster E with the lowest value for intra cluster distance was most compact, the clusters A and D seemed to be relatively more compact than clusters B and C which had comparatively greater intra cluster diatance. Thus, the genotypes in clusters B and C were relatively more heterogenous, that is, diverse among themselves. The genotypes belonging to the clusters separated by high estimated distance could be utilized in hybridization programme for obtaining wide variation among the segregarits (Singh *et al.*, 1996; Gupta *et al.*, 1999).

The data on cluster wise mean values for different characters also indicated substantial variation among different clusters as well as superiority of different clusters for different characters (Table 3). None of the clusters contained genotypes with all the desirable characters which could be directly selected and utilized. The entries of cluster A appeared to be superior than others in respect of kernel length, kernel L/B ratio, cooked kernel length, cooked kernel L/B ratio and volume expansion ratio. In addition, cluster A also had the second highest man value for 100-grain weight, number of grains per panicle, kernel elongation ratio and kernel elongation index. The entries forming cluster B had more plant height and number of grains per panicle, least 100-grain weight, higher grain yield per plant, delayed flowering behaviour, late maturity and lower values for grain and cooking quality characteristics. The entries of cluster C were characterized by lower mean values for plant height, grain yield per plant, number of panicles per plant and number of grains per panicle, superior grain quality but relatively inferior cooking quality characteristics. The higher mean values for grain yield per plant, 100-grain weight and number of panicles per plant, moderately high plant height and number of grains per panicle, superior grain quality attributes, whereas lower mean values for cooking quality characteristics appeared to be the features of entries which were accommodated in cluster D. Similarly, the lower mean values for days to flowering, days to maturity, number of panicles per plant, number of grains per panicle and grain yield per plant, whereas higher mean values for grain and cooking quality components were the characteristics of the entries which were included in cluster E. Based on cluster means for different characters, plant height, number of grains per panicle, kernel length before and after cooking and vlume expansion ratio appeared to be the main factors responsible for differentiation among the lines evalutated in the present study. The importance of these characters as main contributors to genetic diversity in rice has also been emphasized earlier (Pandey *et al.*, 1999; Raju *et al.*, 2002; Roy *et al.*, 2002; Shukla and Pandey, 2003) supporting the observations that the greatest contributors to genetic diversity in grain crops are flowering time, plant height, primary branches or tiller number per plant (Murty and Arunachalam, 1966).

Considering individual genotypic performance as the basis for selection, three genotypes which registered exceptionally good performance were identified in each

Table 3. Cluster wise mean values for seventeen characters in aromatic lines of rice

Character	A	B	C	D	E
Days to 50% flowering	106.38±2.67	112.31±2.57	108.50±3.27	107.39±3.31	93.29±6.24
Days to maturity	131.67±6.25	138.98±3.67	133.11±5.47	132.67±4.92	122.14±4.21
Panicles per plant	6.03±0.90	6.09±0.96	4.86±1.04	5.71±1.13	4.85±0.98
Panicle length	22.03±1.54	23.84±2.02	20.93±1.72	21.86±1.46	21.53±0.95
Grains per panicle	123.84±47.98	147.13±49.64	92.48±50.65	103.50±31.80	82.70±10.85
100-grain weight	2.13±0.41	1.60±0.37	2.06±0.27	2.30±0.42	2.01±0.38
Grain yield per plant	10.45±2.22	12.84±1.64	8.22±3.83	13.24±1.40	9.88±2.84
Plant height	124.91±27.66	138.39±9.18	96.51±23.76	117.44±24.12	114.19±12.72
Kernel length	7.09±0.47	4.96±0.74	7.04±0.64	6.80±0.60	6.13±0.90
Kernel breadth	1.79±0.16	1.91±0.31	1.78±0.13	2.07±0.26	1.86±0.16
Kernel L/B ratio	4.00±0.40	2.64±0.59	3.82±0.75	3.35±0.50	3.19±0.62
Cooked kernel length	13.46±0.93	8.92±1.59	10.96±1.42	10.60±1.17	11.71±1.39
Cooked kernel breadth	2.29±0.34	2.52±0.39	2.21±0.34	3.01±0.26	2.28±0.31
Cooked kernel L/B ratio	5.92±0.81	3.62±0.83	5.08±1.00	3.58±0.53	5.22±0.83
Kernel elongation ratio	1.90±0.08	1.79±0.15	1.56±0.17	1.57±0.14	1.92±0.08
Kernel elongation index	1.49±0.21	1.38±0.22	1.33±0.12	1.09±0.09	1.67±0.24
Volume expansion ratio	3.82±0.18	3.57±0.30	2.88±0.34	2.99±0.40	3.81±0.19

Table 4. Superior genotypes selected from different clusters

Cluster	Genotypes with desirable characters
A	Type-3, Pakistani Basmati, Taroari Basmati
B	Kamod-1, Gamkaua Dhan, Kariya Kamur
C	Pusa 1347-2, Pusa 1280-4, Pusa 1297-2
D	Binam, Azucena, BK 843-7
E	RAU-SCT-13, RAU-SCT-14, Champaran Local-4

of the five distinct and well characterized clusters (Table 4). These entries can serve as parents to generate desirable segregarits in breeding programmes. The hybridization among genetically diverse parental genotypes may be helpful in bringing the new gene pool in population and producing a wide spectrum of variation in the segregating progeny.

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Cultivation and Utilization of Grain Sorghum and Small Millets from Nandurbar District of Maharashtra State

HM Patil[1] and VV Bhaskar[2]

[1] *V.N. College, Shahada, Dist. Nandurbar, Maharashtra*

[2] *Department of Botany, P.S.G.V.P. Mandal's, A.S.C. College, Shahada, Dist. Nandurbar, Maharashtra*

Landraces of sorghum and small millets were collected from a newly constituted tribal district Nandurbar in Maharashtra state. The collections includes 61 accessions of 13 sorghum landraces, 11 of proso millet, 11 of little millet, 28 of foxtail millet, 18 of barnyard millet, 11 of finger millet and 8 of kodo millet. The accessions show variability in morphogenetic characters. The tribals of Nandurbar district utilize these millets in nine different cooking styles and prepare as many as 72 items. But there is a gradual decline in the area of cultivation of these crops. Measures for evaluation and conservation of the rich genetic diversity of these millet crops are urgently required. The scope for bringing more area under their cultivation is also discussed.

Key Words: Sorghum, Small millets, Germplasm utilization, Biodiversity, Tribal district

Millet is a prominent group among rainfed crops. India is the largest producer of many kinds of millets. Among these, sorghum and small millets are grown in diverse soils, varying rainfall regimes, different altitudes and areas with varying thermo and photoperiods. Due to this reason, they are indispensable to tribal and hill agro ecosystem. Food security involves focusing research on neglected crops such as small millets which can perform in times of environmental stress (Paroda, 1996).

Recently, Kimata *et al.*, (1997 and 2000) reported the cultivation and utilization of small millets in hill regions of Uttar Pradesh, Himachal Pradesh and South India. Similar reports from hill and dry regions of Maharashtra are not found.

Tribals of Nandurbar district traditionally grow some small millets and certain landraces of sorghum. The hill farmers have developed methods of cultivation to suit to the prevailing environmental factors and also evolved ways and means of utilizing these millets to fulfill their food requirements.

In the present paper we report, for the first time, the cultivation of certain sorghum and some small millet crops and their utilization as food by the native people in a predominately tribal district Nandurbar.

Materials and Methods

Study area: Nandurbar is a newly constituted district in Maharashtra State, and is declared by the Government as a tribal district. It is situated in the North West part of the state, bordering Gujarat and Madhya Pradesh (M.P.). It has six talukas of which three are mostly in the Satpura hill ranges. Toranmal in Dhadgaon taluka is the second highest peak among Satpura hills, next only to Panchmari in M.P. Due to the poor developmental activities and the hilly terrain, most of the villages of Dhadgaon, Akkalkuwa and Navapur talukas are accessible only with great difficulty. Certain villages like Chulvad, Khadki can be reached only after a few hours of walking. Shahada and Nandurbar talukas are a bit developed. They are totally in the plain region at 200 m. above sea level. Two westward flowing rivers Narmada and Tapi take their course through the district. While Narmada passes through the hills along the border, Tapi flows in the plains making the valley region very fertile. The soil in the plains is clay with good water holding capacity. Agriculture in the district falls into three main agro ecosystems viz irrigated, dryland and hill agro ecosystems. Sorghum is grown in all three systems while small millets are grown only in dryland and hill agro ecosystems.

Pawra, Bhil and Konkni are the tribes inhabiting the district. Dhadgaon is dominated by Pawra tribe while Navapur and Akkalkuwa talukas have more population of Bhil and Konkni tribes. The Pawras are believed to be descendants of Rajputs as their ancestors have migrated to this region from Rajasthan about 400 years ago.

Methodology

The areas under the cultivation of sorghum landraces and different small millets were visited during 2001-2002. The farmers were contacted on form. Observations on their cultivation practices and utilization of grains

* *E-mail for correspondence: v_bhaskar_v@yahoo.com*

as food were noted from several consultations. Plants and their grains were collected mostly from the standing crop. Important morphological observations of all landraces were recorded. Passport information of every collection was prepared and the collections were deposited at Botany department P.S.G.V.P. Mandal's A.S.C. College, Shahada. Their detailed evaluation studies are yet to be carried out. The data from the preliminary survey are presented in this paper.

Results and Discussion

Table 1 shows the number of accessions of sorghum landraces and small millets collected from each taluka of Nandurbar district. Among the Sorghum cultivars Lal chikni was collected earlier by Bhaskar (2000) from Shahada taluka. He reported that it was not found among the 28000 and odd sorghum germplasm collections of ICRISAT. It is a popular *kharif* crop of the district. This is evident from the large number of (24) accessions collected in the present study. Safed Chikni was collected only from Navapur taluka. Gopal Reddy and Varma (1996) collected Pivli Chikni from the same taluka but they did not mentioning its making quality. Safed buri dadar, Kaliburi dadar, Pivli dadar, Safed dadar & Lalburi dadar are *rabi* cultivars and grown only in Shahada taluka. Rajwadi was collected from plains under rainfed ecosystem of Taloda taluka. The cultivars Satpani and Badi jawar are *kharif* crops and grown only on hills. Badi jawar is also a late maturing variety and resistant to diseases. Andheri dadar was reported earlier from Shahada taluka by Bhaskar (2000). It is a popular *rabi* sorghum cultivar of the taluka. Mani is the second popular landrace of sorghum (16 accessions) in the district.

Table 2 shows the morphogenetic characters of sorghum landraces collected from Nandurbar district. There are seven *kharif* varieties and six *rabi* varieties. Of these, the *kharif* varieties show more plant height and longer panicles than *rabi* varieties. Only Lal chikni and Safed chikni cultivars have drooping (bent) panicles while the remaining cultivars have straight panicles. There is a great variation in the distance between flag leaf and the panicle. It varied from 5 cm (in dudhmogra) to 36 cm (in Lalburi dadar). Variation was also observed in grain colour and glume colour.

Table 3 shows the morphogenetic characters of landraces of small millets. Proso millet, little millet and kodo millet have only one landrace while two landraces each of foxtail millet, barnyard millet and finger millet are cultivated in the district. Foxtail millets show variation in awnness, tillers and pigmentation. Of these, the cultivar rala is taller with longer panicles. Barnyard millets are also distinguished from the plant height and panicle length as they are referred as lahan (small) barti and mothi (big) barti. They also differ in stem characters like tillers, pigmentation and shape. The landraces of finger millet are named after the shape of their panicles. Pekri cultivar bears panicle with open and straight fingers while goliv cultivar bears compact and inwardly curved fingers. The colour of their grains is also different.

Table 4 shows the utilization of sorghum landraces by the people of Nandurbar district. Three landraces are used for making flakes; of these, Andheri dadar is the most popular variety. It is also a bird proof variety. Murthy *et al.,* (1982) screened 9862 accessions for popping quality and found only 36 to be better. Hence, these three landraces from Nandurbar district may provide valuable genetic resource for this character. According to the natives of Shahada the bhakri of Andheri dadar is good for diabetic patients. On the other hand the bhakri prepared from the flour of Mani cultivar is sweet in taste. We observed ants crawling over the stem of mani at the time of flowering. This indicates that this landrace must be a sweet sorghum type. Lal chikni and Safed chikni are consumed in five and six cooking styles respectively. They are, however, most preferred for their papad making quality. It is for this reason that the Lal chikni is cultivated in large areas both under irrigated and rainfed conditions during *kharif* season in the entire district while the affluent families of this region prepare sweet dishes like laddu and halwa from wheat flour. These items are prepared from the flours of chikni and Dhudh mogra cultivars of sorghum by tribals.

The popular items prepared from the flours of these landraces show good processing characteristics, acceptable quality and storability. Flours of hybrid and local variety of sorghum differ in their fermentation characteristics as determined by swelling volume of the batter (Subrahmanyan and Jambunathan, 1992). Hence, the collected sorghum germplasm from Nandurbar district should be evaluated for morphological, physiological and biochemical characters to determine their utility in future breeding programme. At the same time *in situ* conservation steps must also be taken up to save their biodiversity.

Table 1 shows that more than 70 percent of accessions of small millets are collected from Akkalkuwa, Dhadgaon and Navapur talukas. These three talukas are hilly areas and predominately tribal and also receive maximum

Table 1. Accessions of grain sorghum and small millets germplasm collected from different talukas of Nandurbar district in Maharashtra State

Name cultivar	No. of accessions						
	Akkalkuwa Taluka	Dhadgaon Taluka	Nandurbar Taluka	Navapur Taluka	Shahada Taluka	Taloda Taluka	Total No. of accessions
Sorghum:							
Lal chikni	05	06	03	04	03	03	24
Safed chikni	–	–	–	02	–	–	02
Satpani	01	01	–	–	–	–	02
Dudh mogra	02	01	–	–	–	–	03
Rajwadi	–	–	–	–	–	01	01
Badi jawar	01	02	–	–	–	–	03
Mani	04	03	02	03	02	02	16
Safedburi dadar	01	–	–	–	02	–	03
Lalburi dadar	–	–	–	–	01	–	01
Kaliburi dadar	–	–	–	–	02	–	02
Andheri dadar	–	–	–	–	02	–	02
Safed dadar	–	–	–	–	01	–	01
Pivli dadar	–	–	–	–	01	–	01
Total	14	13	05	09	14	06	61
Millet							
Proso millet: kalimor	03	05	–	02	01	–	11
Little millet : badimor	03	05	–	02	01	–	11
Foxtail millet:							
Bhadi	03	04	–	02	02	03	14
Burali rala	–	–	–	02	–	–	02
Rala	02	04	–	03	02	01	12
Barnyard millet :							
Lahan barti	04	04	01	02	01	02	14
Mothi barti	–	01	–	02	01	–	04
Finger millet :							
Pekhri	–	–	–	04	–	–	04
Goliv	01	–	02	04	–	–	07
kodo millet–kodra	02	03	–	03	–	–	08
Total	18	26	03	26	08	06	87
Grand Total	32	39	08	35	22	12	148

Table 2. Some morphogenetic characters observed in sorghum landraces from Nandurbar district in Maharashtra State

Name of cultivar	*Kharif/Rabi*	Plant height(cm)		Panicle length(cm)		Panicle	Grain	Glume colour	Flag leaf distance from panicle (cm)	
		Min.	Max.	Min.	Max.				Min.	Max.
Sorghum :										
Lal chikni	*Kharif*	251	325	17	30	Bent	Red	Red	25	30
Safed chikni	*Kharif*	267	279	16	28	Bent	White	Reddish	15	28
Satpani	*Kharif*	225	270	18	26	Straight	White	White	10	17
Dudh mogra	*Kharif*	215	256	22	26	Straight	White	White	5	8
Rajwadi	*Kharif*	270	320	23	38	Straight	White, bold	White	12	25
Badi jawar	*Kharif*	215	277	20	30	Straight	White	White	21	32
Mani	*Kharif*	127	171	39	62	Straight	Bright, white	Black	8	18
Safedburi dadar	*Rabi*	165	210	18	23	Straight	White	White	14	20
Lalburi dadar	*Rabi*	175	215	13	18	Straight	White	Red	30	36
Kaliburi dadar	*Rabi*	170	212	16	19	Straight	White	Black	16	19
Andheri dadar	*Rabi*	147	179	13	17	Straight	White, small	Brown	18	21
Safed dadar	*Rabi*	161	205	13	17	Straight	Bright, White, small	White	13	18
Pivli dadar	*Rabi*	160	208	10	14	Straight	Yellowish	Yellow	12	17

Table 3. Some morphogenetic characters observed in small millet collections from Nandurbar district in Maharashtra State

Millet	Plant height (cm) Min.	Max.	Panicle/Finger length (cm) Min.	Max.	Grain colour	No. of fingers Min.	Max.	Other morphological characters
Proso millet:								
Kalimor	45	80	9	18	Black			Tillers 2-3, pigmentation present
Little millet:								
Badimor	81	105	21	31	White			Tillers 2-3, pigmentation present
Foxtail millets:								
Bhadi *(S. glauca)*	23	59	4	9	White			Awns absent, tillers 1-2
Buralirala *(S. italica)*	50	61	8	10	Brownish			Awns present, tillers absent
Rala *(S. italica)*	115	130	15	24	White			Awns present, tillers absent, nodal pigmentation
Barnyard Millets								
Lahan barti	41	58	6	9	White			Tillers 2-5, pink pigmentation at nodal region stem cyclindrical
Mothi barti *(Echinocloa colonum)*	118	149	11	13	White			Tillers absent, pink pigmentation on stem, leaves and inflorescence, stem stout and angular
Finger millet								
Pekhri	93	105	9.0	9.5	White	4	5	Nodal tillers absent, green pigmentation present, ear with compact and curved fingers
Goliv	83	95	6.0	6.5	Copper brown	6	7	Nodal tillers present, green pigmentation present, ear with compact and curved fingers
Kodo Millet								
Kodra	50	64	6.0	7.1	Brown	2	3	Nodal pigmentation

Table 4. Different cooking styles followed for the consumption of sorghum and small millets as food in Nandurbar district in Maharashtra State (▲ – Seldom; ● – Often)

Ingredient	Bhat	Bhakri	Roti	Kheer	Laddu	Halwa	Papad	Drink	Flake	Total items
Sorghum										
Lal chikni		▲	▲		●	▲	●			05
Safed chikni		▲	▲		●	▲	●		▲	06
Satpani		●				▲				02
Dudh mogra		●			●					02
Rajwadi		●					●			02
Badi jowar		●			●					02
Mani		●					▲			02
Safedburi dadar		●					▲			02
Lalburi dadar		●					▲			02
Kaliburi dadar		●					▲			02
Andheri dadar		▲					▲		●	03
Safed dadar		▲					●		▲	03
Pivli dadar		▲					●			02
Total	00	13	02	00	04	03	10	00	03	35
Millet										
Proso millet: kalimor	●	▲		▲	▲					04
Little millet : badimor	●	▲		▲						03
Foxtail millet										
Bhadi	●	▲	▲	▲		▲				05
Burali	●	▲	▲	▲		▲				04
Rala	●		▲		▲	▲				04
Barnyard millet										
Lahan barti	●	●		●	▲					04
Mothi barti	●	●		●	▲					04
Finger millet										
Pekhri		▲					●	▲		03
Goliv		▲					●	▲		03
Kodo millet: Kodra	▲	▲						▲		03
Total	08	08	03	06	04	03	03	03	00	37
Grand Total	08	21	05	06	08	06	21	03	03	72

rainfall (900-1000 mm). Barti *(Echinocloa colonum* var. *frumentacia)* was collected from all the talukas. It is a popular small millet in the entire district. Every tribal family stores its grain to prepare bhat in dinner. A sweet dish called kheer is also prepared with barti (Table 4) on special occasions. We could not collect nagli (finger millet) from Shahada and Taloda talukas, which comprise the most fertile black cotton soils of Tapi valley basin. Surprisingly, it was not found in cultivation even in Dhadgaon taluka. The papad prepared from nagli is very famous in the entire district and used even in snacks. Kimata *et al.,* (1997) reported the utilization of finger millet as bhat and also in preparing a fermented and distilled alcoholic drink in hill regions of Uttar Pradesh. But, hill tribes of Nandurbar district do not know these preparations. The flour of nagli is mixed in butter milk and given to lactating mothers in Navapur taluka. Two accessions of rala (foxtail millet) were collected from Shahada and Taloda talukas. The people grow them due to their food habit of eating bhat prepared from rala as dinner. Millets are utilized in two forms; Flour foods and grain foods. The small millets are mostly utilized as grain foods in preparing bhat (Table 4). Such grain foods are new variations that have appeared in rather recent times (Kimata *et al.,* 2000). The authors also showed in case of *S. glauca* (bhadi) that as the variations of cooking increased, the genetic landraces did so too. In Nandurbar district also this crop is utilized in five different cooking styles and we could collect 15 accessions of the crop. The cultivation practices of *S. glauca* in Nandurbar district are also similar to those observed by the above authors in dry arid areas of South India.

The cultivation practices followed for small millets were shown in Table 5. Akkalkuwa, Dhadgaon and Navapur talukas represent maximum diversity of small millets. kalimor (proso millet) and badimor (little millet) are very popular in these talukas. They are short duration crops but require plenty of water. They are sown immediately after receiving first showers and harvested during September-October. Kalimor is sown in more or less even land while badimor is grown is undulating land and along the hill slopes. Rala and bhadi are also cultivated in the same way. Line sowing or broadcasting method is used to raise the crops. Fertilizer is not used for any of these crops grown in hills. Organic manure is however used in Navapur, Taloda and Shahada talukas (Table 5). Finger millet is always grown by transplantation method. This may be a reason for it not being under cultivation in hilly Dhadgaon taluka. The cultivation of kodra (Kodo millet) is also confined to hills. It is today least preferred small millet in the region. The reason, tribals tell, is that the preparation of bhat from kodra grains is time-consuming process. The grains are not cooked directly as they contain a hazardous substance to health. So the grains are first soaked in tamarind juice for 8-12 hours during which time harmful substances leach out. Later the grain is cooked.

Table 5. Cutivation practices of small millets in Nandurbar district in Maharashtra state

Cultivation practices	Proso millet (Kalimor)	Little millet (Badimor)	Foxtail millet (Rala)	Foxtail millet (Bhadi)	Barnyard millet (Barti)	Finger millet (Nagli)	Kodo millet (Kodra)
Sowing Time	Aug.-Sept.	May–June	June–July	Sept.–Oct.	June–July or Sept.-Oct.	June-July	June-July
Sowing Method	Broadcasting/ Line sowing	Broadcasting	Broadcasting/ Line sowing	Broadcasting/ Line sowing	Broadcasting/ Line sowing	Broadcasting	Broadcasting/ Line sowing
Cropping system	Mixed with Proso millets	Mixed with Proso millets	Mixed with Proso millets	Mixed with Little millets	Mixed with Jawar/Tur	Mixed or Pure cropping	Mixed with Jawar, tur or pure cropping
Cultural practices	Weeds are cleared and burnt before tilling the land No manuring	Grown along hill slopes Weeds are burnt	Organic manure	Organic manure	Organic manure	Organic manure	–
Harvesting time	Sept.-Oct.	Oct-Nov.	Oct.	Oct-Nov.	Oct.-Nov.	Nov.-Dec.	Nov.-Dec
Harvesting Method	Ear heads cut for grain, Base cutting for fodder	Ear heads cut for grain; base cutting for fodder	Whole plant by sickle	Ear head cutting for grain	Whole plant by sickle	Ear head cutting for grain	Whole plant by sickle
Threshing	Trumpling by cattle	Trumpling by cattle	Trumpling by cattle	Trumpling by cattle	Trumpling by cattle	By Threshing stick	By Threshing stick
Rainfed/Irrigation	Rainfed	Rainfed	Rainfed/ Irrigation	Rainfed/ Irrigation	Rainfed/ Irrigation	Rainfed/ Irrigation	Rainfed/

The report of all India coordinated small millets improvement project reveals that efforts are being made to produce improved varieties in all these small millet crops (Sitaram *et al.*, 2001). They conducted front line demonstrations (FLD) in different states to encourage farmers to grow HYV of small millets and increase the area under their cultivation. But, their FLDs were mostly in Karnataka, Andhra Pradesh, Tamil Nadu and Orissa while in Maharashtra state they could only cover just 6.6 hectares in Konkan region that too of only finger millet crop. There was no mention of either cultivation or collection of small millets from Maharashtra state by them. The publications of ICRISAT, which is a major sorghum and small millet collection centre, also do not mention any collection of small millets from Nandurbar region. The NBPGR regional station at Akola is yet to be contacted. The divisional office of the Department of Agriculture at Nandurbar maintains the records of area under cultivation of sorghum, bajra and maize crops grown every year. It, however, does not have record of cultivar wise crop area. For small millets, the records do not even show crop wise area under cultivation. The figures are for total area of all small millet crops grown in the year. These figures of area under cultivation in all the six talukas of the district for sorghum and small millets are given in Table 6. Mangala Rai (2002) observed that the statistics published by Ministry of Agriculture Government of India gave information about only three coarse cereals viz. maize, sorghum and pearl millet and nothing with respect to small millets. Among these three major millets also only maize showed a gradual increase in the area under cultivation. The author demanded appreciation and propagation of coarse cereals owing to their dual importance as nutritious as well as life supporting crops for sustainable production from frazil ecosystem. In fact, these coarse cereals are referred as nutricereals. The problem of pest and diseases is also negligible in small millets thus they are eco friendly crops and preferred crops for sustainable and green agriculture (Sitaram *et al.*, 2001). The tribals of Nandurbar have been conserving the biodiversity of sorghum and small millets *in situ* by their cultivation practices, food preferences, prevailing agro climatic conditions and their socio-economic status. But the scenario is fast changing. The agri-silvi plots distributed by forest department to tribals of Shahada, Nandurbar and Taloda talukas in 1970s were entirely converted into agriculture lands. There are no trees in these plots now. The traditional landraces cultivated in these lands are being replaced by the HYV. With the gradually improving socio-economic status, the principles and belief of the tribals are also changing. They no longer prefer bhat made of coarse cereals in dinner. Instead, they prepare roti of bajra and jawar. Thus flour foods are being increasingly preferred over grain foods. They started using chemical inputs to grow HYV. Some tribals have started cultivating cotton, chilli and sugarcane in their originally agri-silvi plots. This is evident from the fact that out of a total of 87 collections just 3, 8 & 6 small millets are available from Nandurbar, Shahada and Taloda talukas respectively (Table 1). The area under cultivation of small millets in these talukas is also very less (Table 6). It is extremely important to conduct a detailed survey of the district to estimate the area under cultivation of sorghum landraces and small millet crops in different agro-ecosystems. It should be followed by collection and conservation of the cultivars of these crops and the evaluation of their genetic diversity for use as potential genetic resources in future. The farmers of Nandurbar district especially tribals should be encouraged to grow improved varieties of small millets. This is possible only when our food industries and beverage industries launch the production of different weaning foods, fermented products, adjuncts and other food items with good shelf life from sorghum and small millets. Reports of such utilization of these grains at industry level are just appearing (Sitaram

Table 6. Area (in hectares) under cultivation for sorghum and small millets in Nandurbar district during 2003–2004

Taluka	Sorghum		Finger Millet	Other small millets	
	Kharif	*Rabi*		*Kharif*	*Rabi*
Nandurbar	5500	4500	50	300	–
Navapur	6000	8575	200	1500	–
Shahada	6250	1300	–	125	10
Taloda	3050	6300	–	200	50
Akkalkuwa	4100	6550	70	1205	10
Dhadgaon	4100	–	–	3020	25
Total	**29000**	**27225**	**320**	**6350**	**95**

Source: Divisional Office, Department of Agriculture, Nandurbar

et al., 2001 and Kazmi 2003). It may take some more time for the emergence of good demand for these so called coarse cereals from the industry.

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Genetic Diversity, Variability and Correlation Studies in Sesame (*Sesamum indicum* L.)

A Mothilal
Regional Research Station, Tamil Nadu Agricultural University, Vriddhachalam-606001, Tamil Nadu

Thirty genotypes of sesame were evaluated for seven quantitative characters to assess the genetic diversity, variability and correlation. The genotypes were grouped into seven clusters. Cluster I had largest number of genotypes. Fruiting stem length accounted for 26.6% of total diversity. The extent of variability was high in all the traits studied. The PCV and GCV values were higher for number of capsules and seed yield per plant. Heritability and genetic advance were higher for plant height, fruiting stem length, number of capsules, number of seeds per capsule, 1000 seed weight and seed yield per plant and it indicates that these characters are under the control of additive gene action and selection for these traits will be effective. The association of seed yield was found to be positive and significant with plant height, fruiting stem length, number of capsules, number of seeds per capsule and 1000 seed weight.

Key Words: Sesame, *Sesamum indicum*, Diversity, Correlation

Introduction

Crop improvement depends on the magnitude of genetic variability and the extent of transmission of traits in successive generations. Yield, being a complex polygenic trait is highly influenced by the environmental factors. Therefore, it is essential to partition the variability into its heritable and non-heritable components which will enhance the precision of selection. Beside the quantum of variability, the information on the nature of association between yield and its components helps in simultaneous selection for many characters associated with yield improvement. Present study was aimed (1) to study the diversity among 30 sesame genotypes collected from different parts of the country (2) to assess the quantum of variability and (3) to examine the association between yield and its components in the available germplasm.

Materials and Methods

Based on the seed coat texture, 30 genotypes comprising smooth and rough seed coat each numbering 15 genotypes representing diverse geographical regions of the country were selected for this study. All the genotypes were raised in randomized block design with three replications at the Regional Research Station, Vriddhachalam during Kharif 2000. The details of pedigree and origin of the cultures/varieties involved in this study are given in Table 1. Each genotype was raised in five rows of 5 metre length spaced 30 cm apart maintaining 30 cm between plants within row. Data were recorded on five plants chosen at random per replication for seven economic traits and mean of 15 plants over three replication was used for analysis. The D^2 values corresponding to all possible pairs of genotypes were calculated to determine group constellations. The genetic diversity was assessed using Mahalanobis D^2 technique and the genotypes grouped on the basis of minimum generalized distance using the Tocher's method as suggested by Rao (1952). The genetic parameters *viz.*, PCV, GCV, heritability and genetic advance were computed following the standard procedures. Genotypic and phenotypic correlation coefficients are calculated using the method proposed by Johnson *et al.* (1955).

Results and Discussion

(i) Genetic Diversity

Analysis of variance revealed highly significant difference among the genotypes for all the seven characters studied, indicating thereby the existence of genetic variability. On the basis of diversity, 30 genotypes have been grouped into seven clusters (Table 2). Cluster I, being the largest, possess 20 genotypes; while, cluster II consists of three genotypes. Only two genotypes are present in each of cluster III and V, whereas cluster IV, VI and VII had only one genotype each. The clustering pattern revealed that geographical diversity was not related to genetic diversity. Similar observations were recorded by Dikshit and Swain (2000), Ganesh and Thangavelu (1995), Mahapatra *et al.* (1993), Manivannan and Nadarajan (1996), Manivannan and Ganesan (2000), Gupta *et al.* (2001) and Patil and Sherief (1994).

The largest cluster I was comprised of 20 genotypes of which nine were from Tamil Nadu, five from Haryana, two from Kerala, one each from Karnataka, Andhra Pradesh, Maharashtra and Israel. Such grouping of genotypes from different locations may be attributed to free flow/exchange of breeding material from one place

Table 1. Details of pedigree and origin of the cultures/varieties.

S.No.	Name of the culture/variety	Type of genotype	Pedigree	Origin
1	Si 1721	Local	Not known	Andhra Pradesh
2	Si 1671	Local	Not known	Israel
3	S 0651	Local	Not known	Tamil Nadu
4	SVPR 1	Improved variety	Selection from westernghat white	Tamil Nadu
5	Si 320	Local	Not known	Haryana
6	Si 9087	Local	Not known	Haryana
7	Si 97	Local	Not known	Haryana
8	Si 1576	Local	Not known	Haryana
9	Si 1618	Local	Not known	Haryana
10	S 0626-NL-4	Local	Not known	Karnataka
11	Si 102	Local	Not known	Kerala
12	TC 328	Local	Not known	Gurdaspur
13	TMV 6	Improved variety	Selection from Andhra Local	Tamil Nadu
14	TMV 4	Improved variety	Pureline selection from Sattur Local	Tamil Nadu
15	Si 0613	Local	Not known	Tamil Nadu
16	TMV 3	Improved variety	Derivative of South Arcot local X Malabar variety	Tamil Nadu
17	S 0530	Local	Not known	Tamil Nadu
18	VS 9104	Improved culture	TMV 3 X VS 345	Tamil Nadu
19	Si 0480	Local	Not known	Tamil Nadu
20	Si 53102	Local	Not known	Kerala
21	Si 1711	Local	Not known	Andhra Pradesh
22	Si 3012	Local	Not known	Not known
23	Si 917	Local	Not known	Not known
24	AUS 9105	Improved culture	Not known	Tamil Nadu
25	TNAU 72	Improved culture	Not known	Tamil Nadu
26	Si 3214	Local	Not known	Assam
27	RT 46	Improved variety	T 12 X Pb.Til.No.1	Mandore
28	Si 1160	Local	Not known	Tamil Nadu
29	CO 1	Improved variety	(TMV 3 X Si 1878) X Si 1878	Tamil Nadu
30	VRI SV 1 (VS 117)	Improved variety	Pureline selection from Thirukkattupalli Local	Tamil Nadu

Table 2. Distribution of sesame genotypes into different clusters

Cluster	Number of genotypes	Genotypes
I	20	Si 1721, Si 1671, S 0651, SVPR 1, Si 320, Si 9087, Si 97, Si 1576, Si 1618, Si 0626-NL-4, Si 102, TC 328, TMV 6, TMV 4, Si 0613, TMV 3, S 0530, VS 9104, Si 0480, Si 53102
II	3	Si 1711, Si 3012, Si 917
III	2	AUS 9105, TNAU 72
IV	1	Si 3214
V	2	RT 46, Si 1160
VI	1	CO 1
VII	1	VS 117

to another (Verma and Mehta, 1976; Jain *et al.*, 1981) and/or to the unidirectional selection practiced by breeders of different locations (Singh and Bains, 1968).

The intra and inter cluster values among the seven clusters are presented in Table 3. The intra cluster generalized distance was maximum for cluster II (32.72) and minimum for cluster IV, VI and VII (0.00). The highest inter cluster distance (508.17) was recorded between cluster I and VII, while the cluster II and III were the least divergent (42.26).

Cluster mean values for all the characters are depicted in Table 4. The difference between cluster means were substantially high for all the characters except for number of seeds per capsule. In general, cluster VI had high mean values for plant height, fruiting stem length, 1000 seed weight and seed yield per plant. Cluster III had high mean values for number of branches and number of capsules. Number of seeds per capsule recorded higher mean values in cluster VII.

Contribution of Characters to Diversity

The ranking technique was adopted to rank the characters in the order of contribution to total genetic diversity (Murthy *et al.*, 1965). Contribution of individual characters to the diversity (Table 5) revealed that fruiting stem length contributed maximum diversity (26.60%) followed by plant height (17.24%), seed yield per plant (15.63%),

Table 3. Intra cluster (in bold) and inter cluster distance for seven characters in sesame

Clusters	I	II	III	IV	V	VI	VII
I	**20.47**	47.12	121.42	277.27	182.19	445.39	508.17
II		**32.72**	42.26	144.63	111.27	348.65	435.06
III			**11.98**	56.57	94.62	242.62	377.98
IV				**0.00**	54.29	178.64	242.54
V					**17.16**	163.28	217.49
VI						**0.00**	205.43
VII							**0.00**

Table 4. Character means in different clusters of sesame genotypes

Clusters	Plant height	Number of branches	Fruiting stem length	Number of capsules	Number of seeds per capsule	1000 seed weight	Seed yield per plant
I	67.39	3.62	43.50	34.13	47.34	3.58	4.51
II	70.14	3.17	35.94	27.09	41.76	2.98	2.12
III	94.23	**4.80**	54.2	**51.20**	41.55	3.25	5.80
IV	53.93	2.20	39.86	18.13	47.46	3.37	1.90
V	67.09	4.19	41.73	41.92	49.44	2.94	3.14
VI	**96.33**	3.86	**59.73**	46.00	49.93	**4.33**	**7.68**
VII	52.00	3.06	34.26	21.73	**64.40**	2.09	4.52

number of seeds per capsule (13.79%), number of capsules per plant (11.26%), 1000 seed weight (10.34%) and number of branches per plant (5.05%). In contrast to the present findings, Manivannan and Nadarajan (1996) and Manivannan and Ganesan (2000) reported higher contribution of plant height followed by number of branches per plant.

Cluster means for seven characters indicated that the genotype in cluster VI had highest height, fruiting stem length, 1000 seed weight and seed yield per plant; whereas, genotypes of cluster III recorded maximum number of branches and number of capsules per plant. Therefore, hybridization between the genotypes of these two clusters, will lead to accumulation of favourable genes in a single variety. In view of this, it is suggested that for varietal development, the crosses between the genotypes of divergent clusters should be made rather than between the genotypes of those clusters which have the minimum diversity.

(ii) Variability and Correlation

Analysis of variance showed that genotypic difference were significant for all the characters studied, indicating the presence of considerable amount of genetic variability in the material selected for the study (Table 6). In general, PCV was higher than GCV for all the characters studied which indicates the variation observed in the genotype is not only due to genotype but also due to the influence of environment. The GCV was high for number of capsules and seed yield per plant. Govindarasu *et al.* (1990), Chandrasekhara and Ramana Reddy (1993), Sverup John and Gopinathan Nair (1993), Singh *et al.* (1997), Sadhakshari *et al.* (1992 & 1995), and Backiyarani *et al.* (1997) also reported high GCV for these traits. The characters like plant height, number of branches per plant, fruiting stem length, number of seeds per capsule and 1000 seed weight in that order registered moderate GCV. Similar observations were obtained by Chandra Sekhara and Ramana Reddy (1993), Sadhakshari *et al.* (1992 and 1995) and Backiyarani *et al.* (1997). Thus, it is evident from these observations that, all the said characters are amenable for improvement through simple selection.

Burton (1952) suggested that GCV together with heritability estimate gives the best picture of the extent of advance to be expected by selection. High heritability was observed for plant height, fruiting stem length, number of capsules per plant, number of seeds per capsule, 1000 seed weight and seed yield per plant. A similar trend was also reported by Mishra *et al.* (1995), Chandrasekara and Ramana Reddy (1993), Backiyarani *et al.* (1997), Shanmugavalli and Vanniarajan (1998), Shadakshari (1992 & 1995), Sverup John and Gopinathan Nair (1993), Govindarasu *et al.* (1990) and Umesh Kumar Reddy and Stephen Dorairaj (1990). Heritability shows the effectiveness of phenotypic performance for a character. High heritability along with high genetic advance render the selection more effective (Johnson *et al.*, 1955). The genetic advance as per cent of mean was found to be high for plant height, fruiting stem length, number of capsules, number of seeds per capsule, 1000 seed weight and seed yield per plant. This is in consonance with the findings of Umesh Kumar Reddy and Stephen Dorairaj

Table 5. Contribution of individual traits in the divergence among 30 genotypes of sesame

S.No.	Character	Contribution (%)
1	Plant height	17.24
2	Number of branches per plant	5.05
3	Fruiting stem length	26.66
4	Number of capsules per plant	11.26
5	Number of seeds per capsule	13.79
6	1000 seed weight	10.34
7	Seed yield per plant	15.63

(1990), Govindarasu *et al.* (1990), Sverup John and Gopinathan Nair (1993), Shadakshari *et al.* (1992 & 1995), Shanmugavalli and Vanniyarajan (1998), Backiyarani *et al.* (1997), Chandrasekhara and Ramana Reddy (1993) and Mishra *et al.* (1995).

If the heritability of a particular trait is mainly due to non-additive gene action, the genetic advance will be low, whereas if the heritability was due to additive gene effects it would be associated with high genetic advance. High heritability accompanied with high genetic advance observed for plant height, fruiting stem length, number of capsules, number of seeds per capsule, 1000 seed weight and seed yield per plant indicates that these characters are under the control of additive gene effects and selection for these traits will be effective. Low heritability along with low genetic advance was observed for number of branches indicates the influence of environment upon this trait and selection would be ineffective in such instances. Kandaswami *et al.* (1990) reported low heritability and low genetic advance for number of branches. Contrary to the present findings, Jayalakshmi *et al.* (1998) observed high heritability and genetic advance for primary branches. In general, a character with high genotypic variance and high heritability value coupled with a greater genetic gain would be responsive to selection in the positive direction.

Study of simple correlation indicated that plant height, fruiting stem length, number of capsules per plant, number of seeds per capsule and 1000 seed weight had significant phenotypic and genotypic correlation with seed yield per plant (Table 7). However the relationship between seed yield per plant with number of branches is significant in phenotypic correlation only. Vanisri *et al.* (1994) reported positive association of seed yield with number of capsules and 1000 seed weight. Rai *et al.* (1997) registered positive association of seed yield with number of capsules per plant and number of seeds per capsule. Singh *et al.* (1997) and Mishra *et al.* (1995) observed strong association among productive capsules and seed yield per plant. Shadakshari *et al.* (1992) noticed significant but strong association between seed yield per plant with total number of capsules per plant, plant height, total number of branches and 1000 seed weight. Backiyarani *et al.* (1998) reported positive and significant association of seed yield with number of capsules.

Variability studies clearly revealed that characters *viz.*, plant height, fruiting stem length, number of capsules, number of seeds per capsule, 1000 seed weight and seed yield per plant recorded high heritability coupled with high genetic advance, which indicates the involvement of additive gene action in the inheritance of these traits. The association of seed yield was found to be positive and significant with plant height, fruiting stem length, number of capsules, number of seeds per capsule and 1000 seed weight. Hence, selection of these yield components will simultaneously improve the seed yield.

From the foregoing results, it may be concluded that, the characters *viz.*, plant height, fruiting stem length, number of capsules, number of seeds per capsule and 1000 seed weight showed strong correlation with seed yield per plant. Hence, when selection is imposed upon these traits, seed yield can be improved ultimately. Crossing genotypes in the VI and III cluster may generate more variable segregants and it may be possible to fix a genotype with higher seed yield in the early generation itself, as most of the characters are under the control of additive gene action.

Table 6. Mean, genotypic and phenotypic coefficient variation and heritability for seven characters in sesame

Characters	Mean ±SE	Genotypic coefficient of variation	Phenotypic coefficient of variation	Heritability (broad sense)	Genetic advance	Genetic advance as per cent of mean
Plant height	70.05±4.18	15.88	17.48	82.49	20.81	29.71
Number of branches	4.01±3.00	14.94	92.81	2.59	0.199	4.95
Fruiting stem length	43.44±3.57	17.29	20.02	74.63	13.37	30.77
Number of capsules	35.14±6.01	29.10	35.86	65.83	17.09	48.63
Number of seeds per capsule	47.96±4.17	14.41	7.92	64.59	11.44	23.85
1000 seed weight	3.43±0.22	12.69	15.09	75.46	21.97	64.81
Seed yield per plant	4.40±0.86	37.19	44.35	70.31	2.82	64.09

Table 7. Correlation (r) coefficient between different characters in sesame

Characters		Plant height	Number of branches	Fruiting stem length	Number of capsules	Number of seeds per capsule	1000 seed weight	Seed yield per plant
Plant height	rP	1.000	0.5045**	0.7581**	0.7859**	-0.0565	0.2887**	0.6359**
	rG		0.1073	0.7544**	0.7388**	-0.0423	0.1855**	0.6100**
Number of branches	rP		1.000	0.4911**	0.1040	0.3328**	-0.2378**	0.1899**
	rG			0.1624**	0.3016**	-0.0427	0.0208	0.1057
Fruiting stem length	rP			1.000	0.7468**	-0.0456	0.4793**	0.6697**
	rG				0.6899**	-0.0855	0.3238**	0.6161**
Number of capsules	rP				1.000	0.2052**	0.1884**	0.7890**
	rG					0.1531*	0.1546*	0.7876**
Number of seeds per capsule	rP					1.000	-0.1872**	0.5136**
	rG						-0.1759**	0.4264**
1000 seed weight	rP						1.000	0.3905**
	rG							0.2483**
Seed yield per plant	rP							1.000
	rG							

rP, rG – Phenotypic and genotypic correlation coefficient; *, ** significant at 5% and 1% level respectively

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SHORT COMMUNICATION

An Under-Exploited Species Bankunari {*Solena amplexicaulis* (Lamk.) Gandhi}: Its Exploration and Preliminary Evaluation

D Ram, Mathura Rai, Sudhakar Pandey, B Singh, Hira Lal and AK Pal
Indian Institute of Vegetable Research, Varanasi-221005, Uttar Pradesh

Key Words: Bankunari, Dioecious, Collection, Conservation, Evaluation

Bankunari {*Solena amplexicaulis* (Lamk.) Gandhi} is a rare dioecious plant having good market potential due to high nutritional and medicinal value. Plant parts like fruits, leaves and fleshy roots are edible. In this genus, 88 species are reported worldwide, out of which 12 species occur in India (Ambasta, 2000). Among various species, Bankunari is more diverse in nature. It is a typical hilly crop, often surviving under stress conditions (Hooker, 1985). Non-availability of sufficient quality planting material (tubers) is a major drawback in popularizing the crop.

Total of 25 accessions were collected from the Rajmahal, Hazaribagh, Tikigora hills of Santhal Pargana, Lalmattia, Chandana and nearby forest area of Ranchi (Jharkhand) during the year 1996 to 2002 by adopting random sampling method (Panse and Sukhatme, 2000). All the accessions were evaluated at research farm of Indian Institute of Vegetable Research, Varanasi. A wide range of variability was observed in leaf size, leaf margin, fruit size, shape (round, oblong, long), base (round, conical), apex (narrowly round, conical round), fruit colour (light green, dark green and yellow), flesh content, seed content and taste of fruit. The mean performances of different parameters are presented in Table 1. Inter-nodal length of collected lines varied between 6.0-14.5 cm with the mean value of 9.48 cm. The lines that pertain maximum inter-nodal length are DR-05 (14.15 cm), DR-09 (12.45 cm), DR-02 (12.15 cm) and DR-10 (12.12 cm). Average fruit weight varied from 6.00 to 13.00 g with the mean value of 9.95 g. As yield per plant some of the lines were found high yielding viz. DR-12 (480.00 g), DR-02 (444.00 g), DR-03 (442.00 g) and DR-13 (432.00 g). Average length of the vine was observed to be 2.86 m. It was observed that shape and size of

Table 1. Characterization of Bankunari germplasm

Accessions	Inter-nodal length (cm)	Fruits /plant	Fruit diameter (cm)	Fruit weight (g)	Vine length (m)	Yield/ plant (g)
DR-01	10.24	18	3.5	10	2.34	340
DR-02	12.15	21	4.0	11	3.33	444
DR-03	9.35	16	3.2	10	3.00	442
DR-04	7.24	14	3.6	9	2.89	400
DR-05	14.15	18	3.0	6	2.62	280
DR-06	6.12	12	2.1	7	2.85	185
DR-07	8.45	15	2.8	8	3.31	168
DR-08	10.12	11	4.0	8	3.00	210
DR-09	12.45	17	4.3	11	3.32	218
DR-10	12.12	15	2.9	12	3.15	338
DR-12	11.16	12	3.0	12	3.26	480
DR-13	9.32	14	3.6	13	3.30	432
DR-14	8.75	13	3.2	9	3.00	385
DR-15	7.89	12	3.3	10	2.62	300
DR-16	8.28	14	4.0	11	2.00	285
DR/NKV-48	9.00	13	3.1	12	2.21	260
DR/NKV-58	8.00	12	2.6	13	2.92	290
DR/NKV-59	6.00	10	2.2	10	2.45	330
DR/NKV-65	9.00	14	2.8	9	2.82	340
DR/NKV-70	10.00	16	2.6	8	3.00	345
Mean	**9.48**	**14.35**	**3.19**	**9.95**	**2.86**	**323.60**
Range	6 -14.15	10-21	2.1- 4.3	6-13	2-3.33	168-480

Email: pdveg@up.nic.in

Table 2. Categorization of Bankunari on the basis of tuber size, weight and days taken to sprout

Tuber size	Tuber weight (g)	Sprouting (days after planting)	Root development	Plant growth	Accessions
Small	> 120.00	18-20	Good	Weak and slender	DR/NKV-56, 65, 67
Medium	120.00-140.00	15-16	Good	Vigorous	DR/NKV-58, 59
Big	< 180.00	10-12	Poor	Normal	DR/NKV-68, 69

the fruit has no effect on total yield, while, number of fruits per plant has positive correlation with total yield. Fruit diameter ranges between 2.10 to 4.30 cm. with the mean value of 3.19 cm. The most notable genotypes collected were DR/NKV-48, DR/NKV-62, DR/NKV-65 and DR/NKV-70, which bear attractive and bigger size fruit. More number of seeds in fruit is not a desirable character in Bankunari therefore genotypes having less seed and more flesh must be given priority in selection procedure.

On the basis of tuber size, days taken by these tubers to sprout after transplanting and sprouting habits, the collected samples were grouped into three categories (Table 2). Samples with big tuber size (more than 180.00 g) showed vigorous and early sprouting as compared with that of medium (120.00-140.00 g) and small (less than 120.00 g) tuber size. It was also observed that root development in the plants with big tuber size was poor as compared to medium and small tuber size. Medium size tubers took 15-16 days for sprouting and plant stand was quite vigorous as observed in the field conditions. Plants developed by medium tuber size showed early flowering and better fruiting. Small tubers start sprouting quite late (18-20 days) and sprouts were weak and slender. The total yield obtained from the plants of bigger size tubers was lower than medium and small tuber size plants. DR/NKV-58 and DR/NKV-59 were the most notable genotypes with respect to vigorous growth and yield.

Seed of Bankunari germinates within 40 days after dispersal from mature fruit. It is difficult to recognize the male and female plants at early stages (Ram *et al.*, 2001). Male flower occurs between 58-62 days while female in 65 days after seed dispersal. It attains edible fruit maturity in 95 days and seed maturity after 110-120 days. Tuberous roots sprout very early (20-22 days) and start flowering within 48-55 days, which attain the edible maturity within 80 days (Table 2). Observations indicate that medium size tubers are the best planting materials (Ram *et al.*, 2001).

Bankunari may be important for new agricultural systems and for expanding the productive area into marginal regions where few known vegetables are in cultivation. Adequate conservation and protection measures are required to safeguard the rich diversity of Bankunari.

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Plant Germplasm Registration Notice*

The Germplasm Registration Committee of ICAR in its XI[th] meeting held on 23[rd] October, 2003 at the National Bureau of Plant Genetic Resources, New Delhi approved the registration of following 55 germplasm lines out of the 171 proposals considered.

Cytoplasmic Male Sterile Lines of Paddy (*Oryza sativa* L.)

NT Hoan, MS Ramesha, EA Siddiq, BC Viraktamath, M Ilyas Ahmed, CHM Vijayakumar and NP Sarma
Directorate of Rice Research, Rajendra Nagar, Hyderabad-500 030, Andhra Pradesh.

Development of the cytoplasmic male sterility using new sources is important in rice to avoid outbreak of epidemics, because more than 95 percent of the commercial hybrids are based on a unitary source, wild abortive (WA).

DMS 4A (RPMS 1-4), DMS 4B, *(INGR No. 03048; IC 296572 & IC 296579)*

DMS 4A, a new diversified cytoplasmic male sterile (CMS) line developed through wide hybridization involving *O. rufipogon* (VN_1) as female and PMS 2B as male parent, followed by substitution backcrossing of the male sterile plants with the recurrent parent till BC_8 generation.

This new CMS line possesses very high proportion (71-81%) of round sterile pollen grains and about 19-29 per cent of typical abortive pollen grains as against high proportion of (80-85%) typical abortive pollen grains in 'WA' source (Ramesha *et al.*, 1999). Also, it does not restore fertility with IR 66 and IR 70, which are otherwise restorers of 'WA' system. Additionally, DMS 4A (RPMS 1-4A) possess better panicle exsertion (>94%), very high stigma exertion (>58%) and high out crossing ability (>46%) as compared to many 'WA' based CMS lines, like IR 58025A and IR 62829A (Ramesha *et al.*, 1999).

DMS 4A is a long duration (>140 days), non-aromatic, long slender grain type with desirable floral traits and ideal plant stature suitable for hybrid seed production. Good restorers for this source have been identified.

DMS 3A (RPMS 4), DMS 3B *(INGR No. 03049; IC 296580 & IC 296581)*

DMS 3A is a new diversified CMS line developed through wide hybridization involving *O. nivara* (DRW 21018) as female and IR 66 as male parent. The F_1 hybrid plants with less than 30 percent pollen fertility were backcrossed with IR 66 until BC_8 to obtain complete male sterile plants. The newly developed CMS line was characterized using pollen morphology (staining pattern with one percent I-KI solution), and interaction after a test cross with a set of maintainers and restorers of the 'WA' cytoplasmic male sterile stock.

The DMS 3A possesses 75-85 percent of typical abortive sterile and 15-25 percent of round sterile pollen grains with hundred percent spikelet female fertility (Hoan *et al.*, 1997 and Ramesha *et al.*, 1999). This line has a different spectrum of restoration and maintenance reaction as compared to the 'WA'. This CMS line possesses early maturity, non-aromatic and medium slender grains with ideal plant stature for hybrid seed production. After identification of good restorers, it may be used for developing a new generation commercial hybrids.

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* *Communicated by Dr Anurudh K. Singh, Member Secretary, Plant Germplasm Registration Committee, National Bureau of Plant Genetic Resources, ICAR. New Delhi-110 012*

High Protein Lines of Wheat (*Triticum aestivum* L.), MBL-2 (*INGR No. 03050; IC 405230) and MBL-5 (INGR No. 03051; IC 405231)*

Ratan Tiwari, RK Gupta, Rajender Singh and Jag Shoran
Directorate of Wheat Research, Karnal-132 001, Haryana

Among the important factors influencing the milling and baking qualities of wheat is the grain protein content (GPC) with direct effect (Bushuk, 1998), and hectoliter weight and 1000-kernel weight (TKW), with an indirect contribution. Increase in grain yield usually results in decreased GPC. However, there are reports of alleles of high grain protein content without any significant reduction in the TKW (Gross *et al.*, 2003). Two high grain protein content lines, MBL-2 and MBL-5 (3-4% higher over the best parent) with amber colour were developed through selection from cross NP4 x HB 208. Recombinant inbred lines with higher protein content than either of the parents were selected from cross, NP4 x HB 208. Of these selections, MBL-2 and MBL-5 gave consistently high protein content, coupled with acceptable 1000-grain weight. These two genotypes also showed increased hectoliter weight (7%) and sedimentation value (4.5%) over parents. Testing under Quality Component Screening Nursery across the wheat growing regions showed significantly higher protein content, higher bulk density (hectoliter weight) and no reduction in the 1000-grain weight in MBL-2 and MBL-5 compared to the check, P-5-3.

Grain protein content of MBL-2 ranged from 11.63 to 16.91 (av. 14.43) percent and of MBL-5 from 11.51 to 16.57 (av. 14.22) percent, compared to 11.59 to 15.63 (av. 13.55) percent for P-5-3. Hectroliter weight or test weight ranged from 73.0 to 83.0 (av. 81.02) for MBL-2, 78.3 to 83.6 (av. 81.21) for MBL-5 compared to 68.6 to 80.8 (av. 78.08) kg per hl for P-5-3. Thousand-grain weight ranged from 30.6 to 46.2 (av. 39.30) g for MBL-2, and 34.0 to 48.8 for MBL-5 (av. 41.05) and P-5-3 (av. 39.06) g. These result reflects increase in protein content without reduction in 1000-grain weight in MBL-2 and MBL-5.

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Grossd C, N Robert, E Bervas and G Charmet (2003) Genetic anlaysis of grain-protein content, grain-yield and thousand-kernel weight in bread wheat. *Theor. Apl. Genet.* **106:** 1032-1040.

Heterotic Pool Lines of Maize (*Zea mays* L.), MS Pool C4 (*INGR No. 03052; IC 296598) and Tux Pool C4 (INGR No. 03053; IC 296599)*

AS Khehra[1], BS Dhillon[2], VK Saxena[1] and NS Malhi[1]
[1] *Punjab Agricultural University, Ludhiana-14 004, Punjab*
[2] *NBPGR, Pusa Campus-110012,, New Delhi*

Heterotic pools, MS Pool C4 and Tux Pool C4 were developed with the objective of developing heterotic populations, which are genetically broad based, diverse, highly heterotic and have high performance *per se* and acceptable inbreeding tolerance (Khehra *et al.*, 1986; Dhillon *et al.*, 1997, 1998; Saxena *et al.*, 1998).

Makki Safed (MS) and Tuxpeno (Tux) pools have long duration and high yield potential (developed using Makki Safed 1-Diseases Resistant (MS1 DR) an improved indigenous flint landrace) and Tuxpeno Planta Baja C7 Ludhiana (Tux PBL), an improved dent Mexican race used as testers. MS1 DR and Tux PBL were the parents of a highly heterotic commercial hybrid Sangam (Khehra *et al.*, 1982). Initially, two cycles of reciprocal recurrent selection (RRS) were carried out in these populations to enhance the level of heterosis and *per se* performance. It was followed by two more cycles of RRS with introgression of germplasm from various sources. The material introgressed in the base populations included germplasm from US Corn Belt, and indigenous and some other germplasm. Lancaster and Stiff Stalk germplasm were assigned to Makki Safed Pool and Tuxpeno Pool, respectively. The materials contributing to the development of these pools are as follows.

MS Pool C4; Arun, Ageti 76 x (MO 17 x FR 13A), CM 104, CM 202, CM 202 x H 101, CM 202 x J 632, CM 600 x H 95, J 101, J 607, J 641, J 663, J 664, J 2006, J 660 x M 017, J 663 x FR Va 16, Kailpur Local Kalakh

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Local x MS P2, MSIDR, MSIDR x J617, MSIDR x M 017, MSDR yellow x J 617, MSDR C2, Navjot, Partap x (FR 619 x FR M 017), Partap x (M 017 x B 57), Partap x (M 017 x FR 13A), Sarhad x (FR 619 x FR 670), Tarun x MSI, Vijay and Vijay 444 x CM 202.

Tux Pool C4; CM 123, Cuba 11J, Exp. 10-5, H 104, J 1031, MC Nair Hybrid (EC 103838), Suwan 1, Suwan 1 x B 73, Suwan 1 x H 93, Suwan 2, TAD, Tuxpeno PBL, Tuxpeno C 16, Tuxpeno PBL C 1 x TAD, Tuxpeno C 17 x Suwan 1, Tuxpeno PBL x (Suwan 1 x B 73), Tuxpeno PBL x CM 206) x Tuxpeno PBL, (Tuxpeno PBL x CM 206) x Tuxpeno PBL, (Tuxpeno PBL x TAD) x Tuxpeno PBL and Z 216.

MS Pool C4 has thin long ears. The grains are mostly flint with very low frequency of semidents. Tux Pool C4 has thick ears. Its grains are flint with very low frequency of semi-dents. MS Pool C4 and Tux Pool C4 are highly heterotic to each other. They serve as reservoirs for genetic diversity and are subjected to inbreeding for derivation of inbreds. The first single cross hybrid of India, Paras, released in Punjab in 1995, had both the parental inbred lines derived from these pools.

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Inbred Lines of Maize (*Zea mays L.*) Post Flowering Stalk Rot (PFSR) Resistant Inbred Line, BPTTI 28 *(INGR No. 03054; IC 396382)*

S Shankar Lingam and R Vidyasagar

Agricultural Rsearch Station, Amberpet, Hyderabad-500013, Andhra Pradesh

Post Flowering Stalk Rot (PFSR) caused by a complex, comprising three fungi namely, *Cephalsporium acremonium, Macrophomina phaseolina, Fusarium moniliforme* and one bacterium *Erwinia carotovora* var. *zeae* causes severe yield losses in India. BPTTI 28 is a new ibred line resistant to PFSR, derived from the resistant pool synthesized through full-sib recurrent selection method, adopted for improving this pool prior to derivation of the inbred lines by the standard ear-to-row method. Inbreeding was carried out with toothpick screening in PFSR disease sick plot that is selfing accompanied by toothpick inoculation with causal organisms. The PFSR resistant pool included resistant hybrids, composite varieties and synthetics evaluated under All India Co-ordinated Maize Improvement Trails. Table 1 presents the morpho-agronomic characteristics of inbred line BPTTI 28.

BPTTI 28 is an orange seeded, yellow flinted type belonging to full season maturity. The PFSR disease rating of 2.2 classifies this inbred line as highly resistant. The ideal sowing time is first week of June to first fortnight of July in *kharif,* and October 15th to November 15th in *rabi.*

Reference

Payak MM (1983) "Premature Drying in Maize" Bulletin on Techniques of Scoring for Resistance to Important Diseases of Maize. All India Co-ordinated Maize Improvement Project, New Delhi, pp 96-100.

Table 1. Morpho-agronomic characteristics of inbred line BPTTI-28**

Inbred Genotype	Days to silk	Pl. ht. (cm)	E.H. (cm)	E.L. (cm)	E.G. (cm)	Kernel Rows	Kernel (row) (g)	100-kernel wt. (kg/ha)	Grain Yield (1-9)	Disease score*
BPTTI 28-1-2-1-1-2-bulk	74R	153	67	10	8	10	24	15.5	3300	2.2

*1=healthy, 9=highly susceptible: Disease rating of 5 and below is resistant
** Payak (1993)

Local x MS P2, MSIDR, MSIDR x J617, MSIDR x M 017, MSDR yellow x J 617, MSDR C2, Navjot, Partap x (FR 619 x FR M 017), Partap x (M 017 x B 57), Partap x (M 017 x FR 13A), Sarhad x (FR 619 x FR 670), Tarun x MSI, Vijay and Vijay 444 x CM 202.

Tux Pool C4; CM 123, Cuba 11J, Exp. 10-5, H 104, J 1031, MC Nair Hybrid (EC 103838), Suwan 1, Suwan 1 x B 73, Suwan 1 x H 93, Suwan 2, TAD, Tuxpeno PBL, Tuxpeno C 16, Tuxpeno PBL C 1 x TAD, Tuxpeno C 17 x Suwan 1, Tuxpeno PBL x (Suwan 1 x B 73), Tuxpeno PBL x CM 206) x Tuxpeno PBL, (Tuxpeno PBL x CM 206) x Tuxpeno PBL, (Tuxpeno PBL x TAD) x Tuxpeno PBL and Z 216.

MS Pool C4 has thin long ears. The grains are mostly flint with very low frequency of semidents. Tux Pool C4 has thick ears. Its grains are flint with very low frequency of semi-dents. MS Pool C4 and Tux Pool C4 are highly heterotic to each other. They serve as reservoirs for genetic diversity and are subjected to inbreeding for derivation of inbreds. The first single cross hybrid of India, Paras, released in Punjab in 1995, had both the parental inbred lines derived from these pools.

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Inbred Lines of Maize (*Zea mays L.*) Post Flowering Stalk Rot (PFSR) Resistant Inbred Line, BPTTI 28 *(INGR No. 03054; IC 396382)*

S Shankar Lingam and R Vidyasagar

Agricultural Rsearch Station, Amberpet, Hyderabad-500013, Andhra Pradesh

Post Flowering Stalk Rot (PFSR) caused by a complex, comprising three fungi namely, *Cephalsporium acremonium, Macrophomina phaseolina, Fusarium moniliforme* and one bacterium *Erwinia carotovora* var. *zeae* causes severe yield losses in India. BPTTI 28 is a new ibred line resistant to PFSR, derived from the resistant pool synthesized through full-sib recurrent selection method, adopted for improving this pool prior to derivation of the inbred lines by the standard ear-to-row method. Inbreeding was carried out with toothpick screening in PFSR disease sick plot that is selfing accompanied by toothpick inoculation with causal organisms. The PFSR resistant pool included resistant hybrids, composite varieties and synthetics evaluated under All India Co-ordinated Maize Improvement Trails. Table 1 presents the morpho-agronomic characteristics of inbred line BPTTI 28.

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Table 1. Morpho-agronomic characteristics of inbred line BPTTI-28**

Inbred Genotype	Days to silk	Pl. ht. (cm)	E.H. (cm)	E.L. (cm)	E.G. (cm)	Kernel Rows	Kernel (row) (g)	100-kernel wt. (kg/ha)	Grain Yield (1-9)	Disease score*
BPTTI 28-1-2-1-1-2-bulk	74R	153	67	10	8	10	24	15.5	3300	2.2

*1=healthy, 9=highly susceptible: Disease rating of 5 and below is resistant
** Payak (1993)

An Early Maturing Protogynous Maize Inbred Line, HKI 209 *(INGR No. 03055; IC 405277)*

Sain Dass, KS Dhanju and P Arora
Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Uchani, Karnal-132 001, Haryana

HKI-209 is an early maturing protogynous inbred line developed from an exotic material, CIMMYT population (Pool-10) by ear to row selection method. Desirable ears were selected and their progenies were subjected to inbreeding. After seven generations of inbreeding the line became uniform. One of the important distinguishing characters of this line is protogyny. In general, anthesis in maize is earlier than silking, but in this case it is reverse that is silking occurs earlier by a day. The data presented in Table 1 indicates the stability of protogyny across the season. Other important characters of this line are early maturity, tall erect narrow green leaves, green stem, lax-tassel erect, green anther; green glume, green prolific silk; husk cover-green, tight; ear cylindrical medium long, grain filling upto tip, straight kernel rows; flint grained light orange with white cap, round and medium bold. The line yields upto two ton per ha. It is resistant to Maydis Leaf Blight with a score of 2.0 on 9-point scale as compared to 4.8 of CM 600. Being protogynous, seed setting is least affected in this line as it escapes moisture stress during pollination period.

Table 1. Days to silking and tasselling of HKI-209

Kharif	2001	2002	2003	Mean
Days to 50% tasselling	46	46	48	46.7
Days to 50% silking	45	45	47	45.7
Rabi	2000-01	2001-02	2002-03	Mean
Days to 50% tasselling	134	134	136	134.7
Days to 50% silking	132	132	134	132.7

An Extra Early Maturing and Stay Green Maize Inbred Line, HKI-335 *(INGR No. 03056; IC 405279)*

Sain Dass, KS Dhanju and P Arora
Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Uchani, Karnal-132 001, Haryana

HKI-335 is an extra early inbred line with stay-green character, selected through ear to row selection method, followed by continuous inbreeding in an exotic germplasm, Pool-10 obtained from CIMMYT. The line possesses an extra early maturing character. Three years data revealed that it takes 43-44 days for 50 percent tasselling and 45-46 days for 50 percent silking. The hybrid developed from this line is extra early possessing stay-green trait, which confirms the inheritance of the trait. Other important characteristics of the line are-semi-dropping green leaf, dense tassel, few secondary branches, purple anther, green glume, green and tight silk, cylindrical, short ear filled upto tip, irregular kernel rows; flinted, semi-dent, orange, flat and bold grains (Annual Report, 1999-2001). It is resistant to Maydis Leaf Blight with a score of 1.3 on 9-point scale as compared to 4.8 of CM 600. Early character also expressed during winter.

Table 1. Days to silking and tasselling of HKI-335

Kharif	2001	2002	2003	Mean
Days of 50% tasselling	43	44	43	43.3
Days of 50% silking	45	46	45	45.3
Rabi	2000-01	2001-02	2002-03	Mean
Days of 50% tasselling	129	130	129	129.3
Days of 50% silking	131	132	132	131.3

Reference

Annual Report (1999-2001) Evaluation of selected/new inbred lines of maize against excess soil moisture. Directorate of Maize Research, Cummings Laboratory, Pusa Campus, New Delhi, pp 102-104.

An Early Maturing Protogynous Maize Inbred Line, HKI 209 *(INGR No. 03055; IC 405277)*

Sain Dass, KS Dhanju and P Arora
Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Uchani, Karnal-132 001, Haryana

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Reference

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Cytoplasmic Male Sterile Lines of Barley (*Hordeum vulgare* L.)

BN Dahiya, Dalvir Singh, VS Malik and Krishan Kumar
Chaudhary Charan Singh Haryana Agricultural University, Hisar-125 004, Haryana

BHMS 12A & 12B *(INGR No. 03057; IC 405267 & IC 405268)*

BHMS 12A is a six-rowed cytoplasmic genic male sterile line of spring barley developed through repeated backcrossing using *msm*-1 as source of male sterile cytoplasm and EC 382331 as recurrent parent. In early stages the plants have erect growth, good vigour, green foliage, and broad leaves. Ear-heads are parallel in shape, having medium density and long yellowish awns. Average plant height is 115 cm. It flowers after 90 days and matures in 128 days under Hisar conditions. The BHMS-12A has synchrony in flowering with its maintainer line BHMS-12B (IC 405268). Grains are hulled, plump, finely wrinkled and yellowish, having 1000-grain weight of 43.1 g.

BHMS 25A & 12B *(INGR No. 03058; IC 405271 & IC 405272)*

BHMS 25A a six-rowed cytoplasmic genic male sterile line of spring barley having short awns, developed by repeated backcrossing, using a male sterile cytoplasm source, two-rowed male sterile line *msm-2* and SxW 15-5 as recurrent parent. Plants of BHMS-25A in early stage have erect growth, good vigour, green foliage, and broad leaves. Leaf coleoptile and auricle are pigmented. Ear-heads are parallel in shape, dense, with short yellowish awns. Average plant height is 118 cm. It flowers after 107 days and matures in 144 days when sown in middle of November, under Hisar conditions. The line has synchrony in flowering with its maintainer line BHMS-25B (IC 405272). Grains are with hull, yellowish, finely wrinkled, long and narrow having 1000-grain weight of 38 g.

Novel Amaranth Germplasm (*Amaranthus tricolor* L.)

B Varalakshmi
Division of Vegetable Crops, Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bangalore-560 089, Karnataka

Type Amaranth, AV-31 (IIHR-31) *(INGR No. 03059; IC 395324)*

AV-31 (IIHR-31) is a *'Dantu'* type (thick stem) amaranth germplasm, was developed by pure line selection from the IIHR Acc. No. 16436. It has thick and tender stem suitable for pulling type of amaranth. It is 66 cm high with 9 branches, has light pink stem and petioles with green leaves and pink veins on the under surface, Leaf weight is 80 g per plant, stem weight 140 g per plant; stem girth 7 cm and total plant weight is 220 g. It takes 34 days flower.

White Rust Resistant Amaranth, AV-50 (IIHR-50) *(INGR No. 03060; IC 395327)*

AV-50 (IIHR-50), is a white rust [*Albugo bliti* (Biv. – Bern) Kuntze] resistant germplasm of amaranth. It is a high yielding (197 g/plant) germplasm line developed by the pure line selection from the IIHR Acc. No. 18385. The plants have a height of 53 cm with 8 branches. Leaf weight is 92 g per plant and stem weight is 105 g per plant. The stem is green with green petioles and green leaves. It takes 47 days to flower.

Chickpea (*Cicer arietinum* L.) Mutants

VK Gour and PM Gaur
Department of Plant Breeding, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur-482 004, Madhya Pradesh

Fasciated Stem mutant, Fasciata *(INGR No. 03061; IC 395465)*

Fasciata or Jawahar Gram Mutant-2 (JGM-2) is a fasciated broadened and flattened stem mutant developed through mutation breeding by treating the seeds of JG-315 with 0.4 percent of ethyl methane sulphonate for six hours. It was identified in M_2 generation. It has irregular leaf arrangement and clustering of pods at the stem tip with delayed maturity, larger seed size, having lesser yield than the parental cultivars. Inheritance studies have shown

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B Varalakshmi
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Chickpea (*Cicer arietinum* L.) Mutants

VK Gour and PM Gaur
Department of Plant Breeding, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur-482 004, Madhya Pradesh

Fasciated Stem mutant, Fasciata *(INGR No. 03061; IC 395465)*

Fasciata or Jawahar Gram Mutant-2 (JGM-2) is a fasciated broadened and flattened stem mutant developed through mutation breeding by treating the seeds of JG-315 with 0.4 percent of ethyl methane sulphonate for six hours. It was identified in M_2 generation. It has irregular leaf arrangement and clustering of pods at the stem tip with delayed maturity, larger seed size, having lesser yield than the parental cultivars. Inheritance studies have shown

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BN Dahiya, Dalvir Singh, VS Malik and Krishan Kumar
Chaudhary Charan Singh Haryana Agricultural University, Hisar-125 004, Haryana

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B Varalakshmi
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Chickpea (*Cicer arietinum* L.) Mutants

VK Gour and PM Gaur
Department of Plant Breeding, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur-482 004, Madhya Pradesh

Fasciated Stem mutant, Fasciata *(INGR No. 03061; IC 395465)*

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that fasciation is governed by a single recessive gene, which segregates independently of the loci *slv* (simple leaf), *mlv* (multipinnate leaf), *blv* (bronze leaf) and *B* (blue flower). Fasciation is an easily scorable morphological trait and can be a useful genetic marker for gene mapping. Comparative morphological features of Fasciata mutant and parent JG-315 (Gaur *et al.*, 1999) are given in the Table 1.

Reference

Gaur PM and VK Gour (1999) An induced fascinated mutant of chickpea (*Cicer arietinum* L.). *Indian J. Genet.* **59:** 325-330.

Table 1. Morphological features of JGM-2 (Fasciated mutant) and the normal plants of its parental cv. JG-315

Character	JGM-2 (Fasciata)	JG-315
Days to maturity	126±2.01	118±1.41
Plant height (cm)	34.2±0.62	42.6±0.51
Number of primary branches	3.6±0.05	4.5±0.05
Number of secondary branched	9.6±0.18	13.1±0.19
Number of pods/plant	31.0±1.70	53.0±2.10
Number of seeds/pod	1.22±0.01	1.20±0.01
Shelling turnover (%)	0.81±0.02	0.85±0.01
Harvest index	36.1±1.06	48.6±1.17
100-seed weight (g)	15.1±0.18	14.3±0.14
Grain yield/plant (g)	5.7±0.34	9.2±0.37

Broad Few Leaflet mutant, BFL *(INGR No. 0362; IC 395466)*

Broad Few Leaflet or Jawahar Gram Mutant-4 (JGM-4) is a chickpea leaf mutant with 5-9 large leaflets per leaf and 3-5 overlapping leaflets at the terminal end, in comparison to 11-17 leaflets per leaf in parent JG 315. It was developed under mutation breeding programme by treating the seeds of cultivar JG-315 with 0.3 percent ethyl methane sulphonate for eight hours. It was identified in M_2 generation. The inheritance studies indicated that a single resessive single gene designated as *bfl* governs the mutant trait (Gaur *et al.*, 2003) The mutant reported would be very useful in linkage mapping studies, as it would be easy to score.

Reference

Gaur PM and VK Gour (2003) Broad-few leaflets and outwardly curved wings: two new mutants of chickpea. Short communication. *Pl. Breed.* 192-194.

Outwardly Curved Wings mutant (OCW), JGM-5 *(INGR No. 03063; IC 395467)*

Outwardly Curved Wings or Jawahar Gram Mutant-5 (JGM-5) is a flower mutant with wings curved outwards, exposing the keel and petal. Normally, the wings in typical chickpea flowers are incurved and enclose the keel. It was developed under mutation breeding programme, by treating the seeds of cultivar, JGM-315 with ethyl methane suphonate. Genetic studies indicate that this trait is governed by single recessive gene, designated as *ocw* (Gaur *et al.*, 2003).

Reference

Gaur PM and VK Gour (2003) Broad-few-leaflets and Outwardly Curved Wings: Two new mutants of chickpea. Short communication. *Pl. Breed.* **122:** 192-194.

Cymose Infloresence Multiflower, Multipodded mutant *(INGR No. 03064; IC 395468)*

Cymose Inflorscence Multiflower, Multipodded is a mutant with one to nine flowers per flowering node arranged in a cymose inflorescence at many axes of the raceme. It was developed under interspecific breeding programme and was isolated from an interspecific cross involving ICC 5783 (*C. arietinum)* x ICCW 9 (*C. reticulatum).* Both parents are single flowered. Inheritence studies indicate that a single recessive gene *cym* is responsible for producing cymose infloresence with multiflowers and multiple pods. The genetic study conducted has revealed that the *cym* gene is not allelic to *sfl*, suggesting that two loci control the number of flowers per peduncle in chickpea (Gaur *et al.*, 2002). The established line exhibited one to nine flowers and pod set variation from 0 to 5 in each cyme in comparison commonly found one or two and rarely three flowers. It may be the result of a spontaneous mutation either in one of the two parents or F_1 hybrid. The plants have bronze foliage and produced reticulated or partly reticulated seeds.

Reference

Gaur PM and VK Gour (2002) A gene producing one to nine flowers per flowering node in chickpea. *Euphytica.* **128:** 231-235.

Cytoplasmic Male Sterile and Fertility Restorer Lines of Pigeonpea

SBS Tikka, RM Chauhan, PT Patel and LD Parmar
Main Pulse Research Station, Gujarat Agricultural University, Sardar Krushi Nagar-385506, Gujarat

GT 33A & B *(INGR No. 03065; IC 296582 & IC 296590)*

GT 33A is a stable cytoplasmic-genic male sterile line with red seed and indeterminate growth habit incorporating the cytoplasm of *Cajanus scarabaeoides* developed through interspecific hybridization between *Cajanus scarabaeoides* and *Cajanus cajan* (Pusa 33) followed by backcrossing with Pusa 33, up to eight generation. It showed 100 per cent pollen sterility with acetocaramine (2%) test. The plant is non-determinate spreading type and early in maturity (130-145 days) with green stem and yellow flowers. The plant height is 127 to 160 cm with an average of 5-9 branches and 100-130 pods per plant with spreading pod bearing habit. Average pod length is 3-5 cm with 4-5 seeds per pod, and 100 seed weight is 9.1g with 309 per plant. It is moderately resistant to wilt, Sterility Mosaic Disease (SMD) and *Phytophthora* blight disease. GT 33B is identified as mainainer of GT 33A.

GT 100A & B *(INGR No. 03066; IC 296590 and IC 296592)*

GT 100A is a stable cytoplasmic-genic male sterile line with white bold seeds and determinate habit, incorporating the cytoplasm of *Cajanus scarabaeoides* developed from a cross between *Cajanus scarabaeoides* and *Cajanus cajan* (GT-100) followed by backcrossing with GT-100 upto eighth generation. It showed 100-percent pollen sterility. It is a determinate type with green stem, yellow flower and pods in bunch. The plant height is 101 to 115 cm with an average of 5-6 branches and 120-170 pods per plant. It is early maturing (132-142 days) with an average pod length of 3-5 cm, 4-6 seeds per pod and 10.2 to 100-seed weight giving an average yield of 39 g per plant. It is moderately resistant to wilt, Sterility Mosaic Disease (SMD) and *Phytophthora* blight disease. GT 100B is identified as mainainer of GT 100A.

GTR-10 *(INGR No. 03101; IC 296588)*

GTR-10 is a fertility restorer line of stable cytoplasmic-genic male sterile line GT-288A, with orange seed, indeterminate habit and early maturity. It was developed through recurrent selection within line, with simultaneous confirmation of restorability from line ICP-9260. It showed 100 per cent fertility restoration of GT 288A. It has scattered pod bearing habit and early maturity (145-160 days). The plant height is 140-160 cm with green stem with an average number of 11-15 branches, yellow flower and 187-205 pods per plant. Average pod length is 4.5 cm with 4-4.5 orange seeds per pod, and 10 g 100-seed weight.

GTR-11 *(INGR No. 03102; IC 296589)*

GTR-11 is a fertility restorer line of stable cytoplasmic-genic male sterile line GT-288A with bold and white seeds, determinate habit and early maturity. It was developed through recurrent selection within line with simultaneous confirmation of restorability from line GT100. It showed 95.8 percent fertility restoration of GT 288A. It has pods in bunches and early in maturity (135-145 days). The plant height is 100 to 140 cm with green stem with an average number of 5-15 branches, yellow flower and 150-250 pods per plant. Average pod length is 4-5 cm with 3-4.5 white bold seeds per pod, and 10.5 g 100-seed weight. It is moderately resistant to sterility mosaic disease (SMD) and *Phytophthora* blight disease,

pod borer and pod fly.

Large Seeded, High Oil Content Groundunt (*Arachis hypogea* L.), PBS 29031 *(INGR No. 03096; IC 296913)*

P Manivel A. Bandyopadhyay, RK Mathur and MY Samdur
National Research Centre for Groundnut, Junagadh-362 001, Gujarat

PBS 29031 is a large seeded Virginia bunch type groundnut (*A. hypogaea* L. subsp. *hypogaea* var. *hypogaea*) with high oil content (52%) high yield, and low oleic/linoleic (O/L) ratio. It was developed following pedigree selection method from a cross between M13 x NCAc 17278. NCAc 17278 is a virginia bunch type. PBS 29031 has a decumbent-3 type (IBPGR and ICRISAT, 1992) growth habit (semi-erect) with alternate floweing and medium to small elliptic dark green leaves. It has 4 to 6 primary branches and 8 to 21 secondary branches. The average height of main axis is 27 cm with 62 cm wide canopy. It matures in 115 to 120 days in the rainy season and has a shelling turn over of 70 percent. It has bold attractive pods with slight reticulation, constriction and beak, predominately two-seeded. The seeds are tan coloured, with an average of 52 per cent oil, 20 percent protein, 9 per cent sucrose, 0.29 per cent free amino acids, and 0.35 per cent reducing sugars. It has an average of 46 percent pod and 60 percent seed yield superiority over the check B 95 (Table 1). It was also superior to Somnath and ICGV 89211 for both pod and seed yield (2700-3000 kg per ha at NRCG in 1998) and produced a 100-seed weight of 67 g as compared to 66 g, 71 g and 78 g of the checks B 95, Somnath and ICGV 89211 respectively.

It has moderate field resistance to gram pod borer (*Helicoverpa armigera*), tobacco caterpillar (*Spodoptera litura*), early leaf spot (*Cercospora arachidicola*) and late leaf spot (*Phaeoisariopsis personata*) (NRCG 1998).

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Table 1. Performance of PBS 29031 compared to checks (rainy season 1996-1999)

Year	Culture	Mean Yield Kg/ha*	Increase over the released large seeded cultivars (%)		
			Somnath	B 95	ICGV 89211
1996	PBS 29031	P 2058	64.6	34.2	71.4
		5 1379	67.2	40.3	67.0
1997	PBS 29031	K 1196	16.8	60.1	0.7
		K 853	21.2	90.2	8.7
1998	PBS 29031	K 2715	23.1	51.1	65.8
		K 1900	22.8	63.2	75.5
1999	PBS 29031	P 1379	67.2	40.3	82.2
		K 924	69.5	46.9	69.5
Average		P 1835	42.9	46.4	55.0
		K 1246	**45.2**	**60.1**	**55.2**

*P = Pod yield; K = Kernel yield

Curved Leaf Mutant of Groundnut (*Arachis hypogaea* L.), PBS 30138 *(INGR No. 03097; IC 296915)*

P Manivel, RK Mathur, A Bandyopadhyay and MY Samdur
National Research Centre for Groundnut, Junagadh-362 001, Gujarat

PBS 30138 (Girnar 1 CLM) is a Curved Leaf Mutant of groundnut identified in M_2 generation progenies of a Spanish bunch type (*Arachis hypogaea* ssp. *hypogaea* var. *vulgaris*) cultivar Girnar 1, whose seeds were treated with 0.10 percent ethyl methane sulphonate (Mathur *et al.*, 2000, NRCG 1995). The mutant bred true in subsequent generations (M_3 and M_4) and was designated as Girnar 1 CLM. Based on morphological characters (Table 1) it was classified into Virginia bunch type (*Arachis hypogaea* subsp. *hypogaea var. hypogaea).*

Table 1. Distinctive features of Girnar 1 CLM than its parent Girnar 1

Character	Girnar 1 CLM	Girnar 1
Leaf	Curved leaf	Normal leaf
Botanical group	Virginia bunch	Spanish bunch
Growth habit	Semi-erect	Erect
Branching pattern	Alternate	Sequential
Height of main stem	30 cm	20.30 cm
Number of primary branches	7	4
Number of secondary branches	14	1.3
Leaf length/width ratio	2.44	2.05
Pod reticulation	Deep	Moderate
Pod constriction	Absent	Slight
Pod beak	Absent	Slight
Pod length	Shorter (28.2 mm)	Longer (39.6 mm)
Pod width	Wider (12.4 mm)	Narrow (6.6 mm)
Seed shape	Button shape	Long/oblong
100-seed weight	34 g	29 g
Shelling percent	69%	64%
Maturity duration	Longer (120 days)	Medium (100 days)

Girnar 1 CLM has decumbent-3 (IBPGR and ICRISAT 1992) growth habit (semi-erect) with alternate flowering and medium to big obovate light green leaves. It has 6-8 primary branches and 12-16 secondary branches. The average height of main axis is 30 cm with 55-60 cm wide canopy. It matures in 115-120 days (rainy season) and has a shelling turn over of 69 per cent. The pods are of medium size with deep reticulation, no beak and no constriction, predominatly three-seeded. Seeds are ten in colour with a 100-seed weight of 34 g, containing 48.9 percent oil and 11.5 percent protein. The mutant yielded an average of 1800 q per ha, which was significantly higher than the Girnar 1 (1610 q/ha). It has 5 percent higher shelling turn over (69%) than its parent (64%). For rust and late leaf spot on 9-point scale (0 being highly resistant and 9 being highly susceptible), it scored less than three for both rust and LLS (NRCG, 1998 & 1999).

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A Pentafoliate Leaf Mutant of Groundnut (*Arachis hypogaea* L.) TCGS 635 *(INGR No. 03098; IC 296917)*

RP Vasanthi, N Rajagopal, J Ramachandra Reddy, K John, L Prasanthi and O Venkateshwarlu
Regional Agricultrual Research Station, Tirupati-517 502, Andhra Pradesh

Peripinnate leaves with two pairs of leaflets are unusual in groundnut. TCGS-635 is a pentafoliate leaf mutant of groundnut identified in F_3 generation of the cross, Tirupati-1 x ICGV 86398. It bred true in succeeding generations. The female parent, Tirupati-1 belongs to *Arachis hypogaea* subsp. *Fastigiata* var. *vulgaris*, while ICGV 86398 belongs to *Archis hypogaea* subsp. *Hypogaea* var. *hypogaea* both with normal four leaflets. TCGC-635 is an erect bunch type with thin stem and sparsely hairy five narrow and small leaflets. The fifth leaflet is apical and is slightly smaller than the other four leaflets. The pentafoliate leaves occur in a frequency of 33 to 40 percent starting from 5-6th node. It comes to flowering in 27 days and to full bloom in 33 days after sowing. It matures in 95 days in *kharif* and in 100 days in *rabi*. It gave an average pod yield of 1135 kg per ha in *kharif* and 2568 kg per ha in *rabi*. Pods are mostly two-seeded with slight beak, constriction and reticulation. Its 100-pod weight is 55 g, while 100-seed weight is 33 g with light rose testa. It has field tolerance to *Spodoptera* species (JL-24, a susceptible variety had 63 per cent damaged leaflets, while TCGS 635 had only 43 percent) and bud necrosis disease (JL-24, a susceptible variety had 24 percent affected plants while TCGS 635 had 5.6 per cent affected plants).

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Amphidiploid *Brassica tournefortii* x *Raphanus caudatus (INGR No. 03067; IC 296597)*

Chakresh Kumar
Agriculture Research Station, Navgaon, Alwar-301025, Rajasthan

Amphidiploid of an inter-generic cross between *Brassica tournefortii* and *Raphanus caudatus* was produced. *Raphanus caudatus* L. (RR=2n=18), a rattail radish is similar to common radish (*Raphanus sativus*) except for characteristic fleshy root and grown mainly for fruits long slender unilocular unripe pods for vegetable purpose. Whereas wild turnip, *Brasica tournefortii* gaunan (TT-2n=20) is a semicultivated species, cultivated for oil in arid regions and has been reported to be a good source of resistance for tolerance against *aphids* (*Lipaphis erysimi*), *Alternaria, Albugo candida, Leptosphaeria maculans* and drought (Ljungberg *et al.*, 1993). The inter-generic hybrids were male sterile. They were treated with one percent colchicine solution at apical meristem for production of an amphidiploid with non-dehiscent siliquae (Kumar, 1994 and 1995). This amphidiploid has pedicillate leaves and hairs on abaxial side. It is bushy in nature with upto 17 primary branches. Petals are white in colour and slightly smaller than those of *R. caudatus*. Its siliquare are 3.7 cm long, bicarpillary and non-dehiscent with caudate tip. Seeds are round in shape and blackish brown in colour with 1000-seed weight of 7.2 g Number of seeds per siliqua are upto eight. It is immune to white rust and moderately resistant to powdery mildew. It might be helpful in development of hybrids in olieferous Brassicas or used as bridge for introgression of desirable traits into cultivated species of tribe Brassicaceae.

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Salinity Resistant Mustard [*Brassica juncea* (L). Czern & Coss], RH 8814 *(INGR No. 03068; IC 401570)*

D Singh, ML Chhabra, NK Thakral, DC Nijhawan, SK Thakral, Parkash Kumar, JS Yadava, CD Kaushik and Naveen Chandra
Department of Plant Breeding, CCS Haryana Agricultural University, Hissar-125004, Haryana

Screening of *Brassica juncea* genotypes at Hisar, Karnal, Faizabad and Kanpur under All India Co-ordinated Research Programmed on Rapessed-mustard resulted in identification of RH 8814 with tolerance to salinity. Laboratory screening was done in trays using a calculated amount of salt viz., NaCl, $CaCl_2$, $MgSO_4$, $MgCl_2$ and Na_2SO_4 dissolved in water to provide $Cl:SO_4$ ratio of 4:1, Ca:Mg ratio 1.3:1 and Sodium Absorption Ratio between 10-12 in soil. Rate of emergence and final emergence was worked out as suggested by Maguire (1962). Percent reduction in emergence, root and shoot length, dry weight per 5 seedlings over control were used for assessment of salinity tolerance (AICRIPR & M, 2000, 2001). Testing of genotypes was also done at reproductive stage. For field screening, genotypes were sown in field having salinity between 10 to 12 dS/m depending upon location. RH-8814 (RH 765 x R-74-3) proved to be significantly tolerant to salinity both at seedling and reproductive stage (AICRIP R & M, 2000). It is medium in height with upright arranged broad leaves, creamish mid-rib, pale yellow flowers and semi-appressed arrangement of siliquae with medium bold seeds. It is also frost tolerant (AICRIP R & M, 2001).

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Fusarium Wilt Resistant Castor (*Ricinus communis* L.), RG 297 (*INGR No. 03069; IC 296578*)

K Anjani
Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, Andhra Pradesh

RG 297 is a castor germplasm resistant to *Fusarium* (*Fusarium oxysporum* f. sp. *ricini*) wilt selected from segregating population of germplasm collection RC 1194 obtained from Tindivanam, Tamil Nadu. The segregating population was initially screened at DOR, Hyderabad and uniform looking resistant plants were selected and sib-mated. Seeds from these plants were bulked. Later on, in the progeny generations selection was made for morphological traits to obtain reasonable uniformity. It was further screened in wilt sick plots at DOR, Hyderabad and Gujarat Agricultural University, S.K. Nagar under All India Co-ordinated Research Project for two years (Ann. Progress Report, Castor 200-01 and 2001-02). It was found resistant to *Fusarium* wilt in wilt sick plots where the incidence of wilt in susceptible checks ranged from 77-98 percent. Its resistance to wilt was further confirmed under very high disease pressure in pots by root-dip technique. It reaches 50 percent flowering in 40 days and maturity in 120 days from the day of sowing and yielded at par with the best check 48-1 (200 g seeds/ plant).

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Andro-Monoecious *Fusarium* Wilt Resistant Inbred Castor (*Ricinus communis* L.) JI-220, (*INGR No. 03070; IC 395312*)

PR Golakia, RH Kavani, CJ Dangaria, AB Patel and DB Patel
Oilseeds Research Station, Gujarat Agricultural University, Junagadh-362 001, Gujarat

JI-220 is an andro-monoecious line of castor with resistance to *Fusarium* wilt developed through hybridization followed by pedigree selection. The pedigree of this inbred is the double cross of VP-1 x 48-1 and VP-1 x TMV-5 in which 48-1 and TMV-5 were wilt resistant. The plants of JI-220 have medium tall stature, green stem, spiny capsules, 16 to 18 elongated internodes and compact spike with triple bloom. It yields 1682 kg seed per ha with oil content of 48.7 per cent and 100-seed weight of 26.3 g (average of 16 AICRP trials). It showed least incidence of wilt compared to check (Table 1). The development and diversification of wilt reistance andromonoecious inbred lines to different genetic background would be of help in hybrid breeding programme with resistance to wilt

Table 1. Percent wilt incidence in JI-220 compared to checks (1997-1999)

Entry	1997			1998			1999	Mean %
	SKN[1]	DOR[2]	PAL[3]	SKN	DOR	PAL	SKN	Incidence
JI-220	13.3	20.00	11.7	0.0	4.16	6.4	0.0	7.9 0 (7)
48-1	0.0	15.00	43.3	0.0	20.0	8.3	0.0	12.37 (7)
GCH-5	100.0	80.95	60.5	93.8	–	55.7	100.0	81.83 (6)
GCH-4	100.0	93.75	41.1	100.0	77.8	43.8	100.0	79.49 (7)
Aruna	–	90.00	65.4	73.4	38.9	56.0	80.0	67.28 (6)
GC-2	–	100.00	55.3	100.0	92.3	63.2	–	82.16 (5)

1. SKN = Sardar Krushinagar, Gujarat, 2. Directorate of Oilseeds Research, Hyderabad and 3. Palem (AP)

Fusarium Wilt Resistant Castor (*Ricinus communis* L.), RG 297 (*INGR No. 03069; IC 296578*)

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Andro-Monoecious *Fusarium* Wilt Resistant Inbred Castor (*Ricinus communis* L.) JI-220, (*INGR No. 03070; IC 395312*)

PR Golakia, RH Kavani, CJ Dangaria, AB Patel and DB Patel
Oilseeds Research Station, Gujarat Agricultural University, Junagadh-362 001, Gujarat

JI-220 is an andro-monoecious line of castor with resistance to *Fusarium* wilt developed through hybridization followed by pedigree selection. The pedigree of this inbred is the double cross of VP-1 x 48-1 and VP-1 x TMV-5 in which 48-1 and TMV-5 were wilt resistant. The plants of JI-220 have medium tall stature, green stem, spiny capsules, 16 to 18 elongated internodes and compact spike with triple bloom. It yields 1682 kg seed per ha with oil content of 48.7 per cent and 100-seed weight of 26.3 g (average of 16 AICRP trials). It showed least incidence of wilt compared to check (Table 1). The development and diversification of wilt reistance andromonoecious inbred lines to different genetic background would be of help in hybrid breeding programme with resistance to wilt

Table 1. Percent wilt incidence in JI-220 compared to checks (1997-1999)

Entry	1997			1998			1999	Mean %
	SKN[1]	DOR[2]	PAL[3]	SKN	DOR	PAL	SKN	Incidence
JI-220	13.3	20.00	11.7	0.0	4.16	6.4	0.0	7.9 0 (7)
48-1	0.0	15.00	43.3	0.0	20.0	8.3	0.0	12.37 (7)
GCH-5	100.0	80.95	60.5	93.8	–	55.7	100.0	81.83 (6)
GCH-4	100.0	93.75	41.1	100.0	77.8	43.8	100.0	79.49 (7)
Aruna	–	90.00	65.4	73.4	38.9	56.0	80.0	67.28 (6)
GC-2	–	100.00	55.3	100.0	92.3	63.2	–	82.16 (5)

1. SKN = Sardar Krushinagar, Gujarat, 2. Directorate of Oilseeds Research, Hyderabad and 3. Palem (AP)

disease.

Pistillate Line of Castor (*Ricinus communis* L.), M 619 *(INGR No. 03095; IC 296508)*

M Ramachandram[1], SK Chakrabarty[2] and C Lavanya[1]
[1] *Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500030 Andhra Pradesh*
[2] *Seed Technology Division, Indian Agricultural Research Institute-110 012, New Delhi*

M 619 is a mutant S-type pistillate line of castor with wilt resistance developed through seed treatment of VP-1 with 55 kR gamma rays and selection for early duration and wilt resistance through pedigree selection method and generation advancement in wilt sick plots of DOR (Lavanya *et al.,* 2000). It is a revertant type pistillate line with green stem, spiny capsules, dwarf plant type with condensed internodes, convergent branching, producing on an average 14.8 nodes, at primary spike and triple bloom. It has semi-compact spike with light chocolate coloured medium bold seeds and 41 percent oil content. It is a stable pistillate line producing 90 percent of the plants as pistillate in the entire spike order (Lavanya *et al.,* 2003). It is a good general combiner for seed yield and 100-seed weight (Chakrabarty, 1997; Lavanaya and Chandramohan, 2003). Also, it is resistant to *Fusarium* wilt, nematodes and root rot diseases.

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New Genetic Male Sterile Line of Cotton (*Gossypium arboreum* L.), MPKV GMS *(INGR No. 03071; IC 296576)*

SS Mehetre, VR Patil, GC Shinde and AS Mokate
Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar-413722 (Maharastra)

Recognising the importance of indigenous hybrids, efforts were made to develop genetic male sterile (GMS) and cytoplasmic genetic male sterile (CGMS) lines of *G. arboreum* cotton to enable production of hybrid seed in large quantities at cheaper rate. These efforts have resulted in isolation of new GMS line, MPKV-GMS with good combining ability for naked seed, high ginning percentage and good fibre properties in *G. arboreum* cotton during 2000 (Mehetre and Patil, 2001) from segregating populations of intra *arboreum* cross, Y-1 x Sanjay.

Two recessive genes ($gms^{arbns}{}_1$ $gms^{arbns}{}_2$) control GMS in the present line. Earlier identified GMS line in diploid cotton was controlled by a single recessive gene ams_1 (Singh *et al.,* 1998). Male sterile and fertile counterparts did not differ distinctly except for characters. It has normal chromosome behaviour and pollen abortion is caused due to vacuolation of pollens after tetrad stage and non-degeneration of anther tapetum. This new male sterile line has naked seeds, give best response for vegetative propagation, facilitating production of large number of GMS plants for hybrid seed production (Mehetre *et al.,* 2003). The technical properties of fibre of hybrids involving this male sterile line conform the modern textile requirements.

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Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar-413722 (Maharastra)

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Two recessive genes ($gms^{arbns}{}_1$ $gms^{arbns}{}_2$) control GMS in the present line. Earlier identified GMS line in diploid cotton was controlled by a single recessive gene ams_1 (Singh *et al.,* 1998). Male sterile and fertile counterparts did not differ distinctly except for characters. It has normal chromosome behaviour and pollen abortion is caused due to vacuolation of pollens after tetrad stage and non-degeneration of anther tapetum. This new male sterile line has naked seeds, give best response for vegetative propagation, facilitating production of large number of GMS plants for hybrid seed production (Mehetre *et al.,* 2003). The technical properties of fibre of hybrids involving this male sterile line conform the modern textile requirements.

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New Surgical Type Cotton (*Gossypium arboreum* L.), RH-arb-02-1 (W) *(INGR No. 03072; IC 296577)*

SS Mehtre, GC Shinde, VR Patil and AS Mokate
Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar-413 722, Maharashtra

RH-arb-02-1 (W) is a new cotton germplasm with surgical type fibre quality (less sinking and good water holding capacity) developed by selection during the year 2002 (Anonymous, 2003) and tested at the Central Institute for Research on Cotton Technology, Mumbai by using a single stage process method for conversion of short staple cotton or cotton waste into absorbent or surgical cotton (Nachane and Nagarkar, 2001). The absorbency is one of the most important components, which characterizes sample's suitability for surgical properties. A comparison of various traits indicated that for all the morphological characters of RH-arb-02-1 (W) were significantly lower than the control Y1, while, for number of bolls, boll diameter, seed per locule, seed index and ginning percentage, it was superior than Y1. Its boll opening is excellent and locule retention is 100 percent. After boll opening, if harvesting is delayed, there is hardly and fall of locule.

The data (Table 1) indicated that uncleaned samples of Y1 required more time (5.2 and 6.5) seconds) than those of RH-arb-02-1 (W) (1.9 second) for absorbency. Likewise, sinking time of un-cleaned and cleaned samples of Y1 (5.9 and 8.5 second) are more than RH-arb-02-1 (W) (2.9 and 2.0). This indicates that the absorbency and sinking time of RH-arb-02-1 (W) is superior to that of Y1. The water holding capacity of this line is also greater than Y1. The uncleaned and cleaned samples of RH-arb-02-1 (W) recorded 27.8 and 26.7 g per g water holding capacity, respectively. Superiority for these traits indicates RH-arb-02-1 (W) to be a better surgical type.

This genotype yields 66 percent higher (1942 kg/ha) than Y1 (1170 kg/ha) and was early in maturity (168 days) than Y1 (190 days). Dwarf habit (97 cm) and creamy flower with red spot are the other important features.

Table 1. Properties of surgical cotton RH-arb-02-1 (W)

Properties	Y1 Clean	Y1 Unclean	RH-arb-02-1 (W) Clean	RH-arb-02-1 (W) Unclean	Standard*
Moisture content (%)	6.8	6.7	6.6	6.7	<8%
Water-soluble matter (%)	0.29	0.37	0.14	0.15	<0.5%
Absorbency (sec)	6.5	5.2	1.9	1.9	10 sec
Brightness (%)	77	77	74	74	-
Solubility in 75% H_2SO_4 (w/w)	Soluble	Soluble	Soluble	Soluble	Soluble
Solubility in 4% NaOH (w/w)	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble
Sinking time (sec)	8.5	5.9	2.0	2.9	10 sec
Water holding capacity (g/g of cotton)	25.0	26.7	26.7	27.8	>23
Sulphated ash (%)	0.29	0.27	0.14	0.19	<0.5
Acidity	Nil	Nil	Nil	Nil	Nil
Alkalinity	Nil	Nil	Nil	Nil	Nil

*Minimum standard values of different properties for surgical grade cotton as given by Indian Pharmacopoeia.

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Heat Tolerant Upland Cotton (*Gossypium hirsutum* L.) Pusa 17-52-10 (*INGR No. 03073; IC 408236*)

RP Singh[1], Jagmail Singh[1], M Singh[1], GS Chahal[2] and CB Lal[1]
[1]*Division of Genetics, Indian Agricultural Research Institute, New Delhi-110012*
[2]*Department of Plant Breeding, Genetics and Biotchnology, Punjab Agricultural University, Ludhiana-141 004, Punjab*

Pusa 17-52-10 is a new tolerant genotype of cotton. In North India, cotton is grown in *kharif* from April to November. Cultivation of cotton during spring/summer could be one of the possible alternatives to increase production. However, the weather during spring/summer season is characterized by low temperature at the time of sowing, establishment and initial growth and unusually high diurnal temperature coupled with low humidity during flowering and boll development stages from April to June. Therefore, a heat tolerant and compact type genotype was developed from a cross between Pusa 595B and Pusa 734 followed by pedigree selection. Later in segregating generations, one more cycle of selective intermating was applied. The segregating progenies were tested for their performance in summer in addition to normal *kharif*, following the shuttle-breeding method. Under Delhi conditions yield of 662.3 kg per ha against 217.4 kg per ha of RS 875, which is more than three times the yield of RS 875. Under multilocation trial conducted at IARI New Delhi, SVBP Bullandshahar and PAU Ludhiana during spring summer season (2003), it was early with regard to germination, days to flowering and days to boll opening on the basis of mean of all 24 genotypes tested under trial. It outperformed in yield (mean yield 802 kg seed cotton/ha), the check, RS 875 (501 kg seed cotton/ha) at three locations.

It has compact plant type, early maturity (125-130 days), high boll weight and very high seed cotton yield with acceptable fibre quality. The leaf shape and orientation of the genotype helps in reducing the evapo-transpirational losses. During April to June, the day temperature ranged from 38.2°C to 43.4°C and the night temperature around 30.6°C. This genotype has the capacity to flower and set bolls under these conditions. It performed well during spring/summer season indicating tolerance to high and diurnal temperature variation.

Table 1. Heat tolerance of Pusa 17-52-10 as summer crop at Delhi during 2002 & 2003

Character	Pusa 17-52-10			RS 875			Superiority (%)
	2002	2003	Mean	2002	2003	Mean	over check
Days to germination	12.0	7.0	9.5	9.7	7.0	8.4	13.8
Days to Ist flower	66.3	62.3	64.3	69.3	63.3	66.3	3.0*
Days to Ist boll opening	100.0	97.0	98.5	100.0	99.3	99.7	1.2*
Ist fruiting node	4.1	4.2	4.2	4.9	4.3	4.6	9.8*
Plant height (cm)	76.0	49.9	63.0	107.7	56.3	82.0	23.2*
Monopodia/plant	0.3	0.2	0.25	0.4	0.2	0.3	16.7*
Sympodia/plant	24.6	16.8	20.7	24.9	20.1	22.5	8.0
Internode length (cm)	2.7	2.4	2.6	3.6	2.3	3.0	13.6*
Total boll (upto 30th June)	17.5	10.8	14.2	13.3	8.4	10.9	30.4*
Opened-ball (upto 30th June)	11.3	10.4	10.9	4.9	8.0	6.5	68.2*
Boll weight (g)	2.8	2.7	2.8	1.4	2.4	1.9	44.7*
Ginning out turn (%)	34.5	32.7	33.6	33.5	32.3	32.9	2.1*
Seed index	6.9	9.3	8.1	5.6	8.0	6.8	19.1
Lint Index	3.6	3.6	3.6	2.8	3.8	3.3	9.1*
Yield (kg/ha)	458.3	866.3	662.3	71.1	363.7	217.4	204.7*
Fibre quality character**							
Fibre length (2.5% S.L.)	25.5	25.5	25.5	26.0	25.6	25.8	1.2
Fibre uniformity ratio	50.4	50.8	50.6	50.1	49.7	49.9	1.4*
Fibre fineness	3.5	4.5	4.0	3.6	4.4	4.0	0.0
Fibre strength	17.3	20.3	18.8	22.5	19.5	21.0	-10.5
Fibre elongation (%)	5.40	6.00	5.7	5.2	6.40	5.8	1.7
Fibre quality index	236.00	244.40	240.2	308	238.0	273.0	-12.0

*Desirable
**Fibre quality traits were evaluated by Central Institute for Research on Cotton Technology CIRCOT (Mumbai).

High Fibre Quality and CLCV Resistant Cotton (*Gossypium hirsutum* L.) Pusa GH 95-33-47-2-2 *(INGR No. 03099; IC 296868)*

VP Singh[1], RP Singh[1], M Singh[1], CB Lal[1], DN Makwana[2] and VG Malthi[1]
[1] *Indian Agricultural Research Institute, New Delhi-110012*
[2] *Central Institute for Research on Cotton Technology, Mumbai-400 019, Maharastra*

Pusa GH 95-33-47-2-2 is a cotton germplasm with high fibre strength and elongation rate with resistance to Cotton Leaf Curl Virus (CLCV) developed through pedigree selection method. With the adoption of new efficient spinning technologies, the priorities for ranking of fibre properties for various spinning processes have changed to the order of fibre strength, fibre fineness and fibre length. Therefore, there is a need for improvement of fibre strength at 1/8 gauge (3.2 mm) for blending it with synthetic fibres. The fibre strength of this line is 26.4 g per tex at 3.2 mm gauge. The ginning out turn of this line is 30-31 percent with fibre length of 29-30 mm (2.5% SL) will fall in 'superior long' group. It also has desirable fibre fineness with micronaire value of 4.0. The Count Strength Product (CSP) value at 50s count for this line was reported to be 2780 against the standard CSP value of 2125 while the fibre quality index was in the range of 375 to 400 (Singh *et al.*, 2000). Also, it is characterized by seven percent elongation rate. All these fibre quality parameters of Pusa GH 95-33-47-2-2 make it highly suitable to modern textile industry.

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Photo-Thermo Insensitive Cotton (*Gossypium barbadense* L.), Pusa GB 11-135 *(INGR No. 03100; IC 296963)*

RP Singh, VP Singh, M Singh, BB Singh and CB Lal
Division of Genetics, Indian Agricultural Research Institute-110 012, New Delhi

Dastur (1949) reported than varieties of *G. barbadense* are sensitive to day length and night temperatures and susceptible to diseases and pests (specifically, the sucking pests) restricting their distribution. Pusa GB 11-135 is a photo-thermo insensitivity in Egyptian cotton adapted to north India. It was isolated from intervarietal crosses involving geographically and genetically divergent *G. barbadense* parents belonging to Egyptian, Russian and Sea Island cotton. Rigorous selections using pedigree method were made in the segregating generations for their performance under north Indian conditions. This line was found comparatively more tolerant to high diurnal temperature and dry hot weather conditions of spring season of north India (Singh *et al.*, 1999).

It is medium tall type (110 to 120 cm) and takes 60 days to flower, 105-110 days to Ist boll opening with average boll number 20-25 per plant. In maturity it is at per with *G. hirsutum* cotton varieties cultivated during *kharif* in north zone. The ginning out turn of this line is 30 percent with fibre length of 29.4 mm (2.5% S.L.), the fineness as measured by micronaire value is 3.6 and fibre strength (bundle tenacity) at 3.2 mm gauge is 24.3 g per tex. Inter-specific cotton hybrids involving Pusa GB 11-135 as male parent, gave the best fibre quality F_1's in the extra long staple category, with the mean fibre length (MFL value) of 34-35 mm at 2.5 percent SL, the fineness as measured in micronaire between 3.5-4.2, bundle tenacity of 24-25 g per tex at 3.2 mm gauge. The fibre of these F_1's could be spun at 80s count. Hence, it can be used as male parent to develop extra-long-staple inter-specific cotton hybrids (*G. hirsutum* L. x *G. barbadense* L.) suitable for general cultivation (Singh *et al.*, 2000).

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Bacterial Wilt Resistant Brinjal (*Solanum melongena* L.) IIHR 3 (96-2-1) *(INGR No. 03074; IC 395333)*

AT Sadashiva, TH Singh, KM Reddy, MK Reddy, MV Balaram, BC Narasimha Prasad, KM Prasanna, LR Naveen and SG Joshi

Division of Vegetable Crops, Indian Institute of Horticultural Research, Bangalore-560 089, Karnataka

Brinjal suffers from several diseases, of which the Bacterial Wilt (BW) caused by *Ralstonia solanacearum* is most serious. It has been reported to cause yield losses up to 90.6 percent (Baruah *et al.*, 2000; Ika *et al.*, 2001). IIHR-3 (96-2-1) is a BW resistant line of brinjal developed through pedigree selection from a cross between Arka Keshav (purple long) and IIHR-124 (green oval) (F_9). The performance of the resistance line for yield and yield contributing characters is given in Table 1. Evaluation of the lines was done in BW sick plot followed by artificial inoculations with bacterial ooze 107 cfu/ml (0.7 ID @ 600 mm) during *rabi* 2002-03. IIHR-3 has tall and spreading plant type with green foliage cover. Fruits are green long (21 cm), with 26 fruits per plant. It has the yield potential of 1.96 kg per plant with an average fruit weight of 43 g.

Table 1. Performances of BW resitant lines for yield and yield components (*Rabi* 2002-03)

Lines	Plant Height (cm)	No. of fruits/ plant	Avg. fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Yield/ plant (kg)	Percent BW incidence
IIHR-3	134.8	26.4	42.6	21.2	2.78	1.96	0
IIHR-7	123.2	30.8	47.8	17	2.90	1.56	0
SM6-6 (RC)	77.8	32.4	28.2	10.8	2.96	0.07	0
Arka Keshav (RC)	84.8	23.4	40.0	14.4	3.04	0.67	0
Arka Shirish (SC)	138	14.6	37.8	22.8	2.96	0.22	100
Arka Kusumarkar (SC)	102.2	22	32.0	13.4	3.32	0.78	100
SEm±	6.7	1.89	3.33	0.67	0.20	0.13	-
C.D. @ 5%	19.7	5.58	9.82	2	0.60	0.38	-
C.D. @ 1%	26.9	7.6	13.39	2.7	0.80	0.52	-

References

Baruah SJN, Binoy Mudiar, Rachid HA and Mudiar B (2000) Yield potentiality of some brinjal cultivars in severe bacterial wilt infected condition. *Vegetable Science.* **27:** 76-77.

Ika Mariska, Hobir, Karden Mulya, Ali Husnil, Suci Rahayu, Ragapadmi Purnamaningsih, Mia Kosmiatin and Darasinh silhackakr (2001) Improvement of bacterial wilt resistance of eggplant through protoplast fusion. *Journal of Litbang Pertanian.* **20:** 25-31.

Tomato Leaf Curl Virus and Bacterial Wilt Resistant Tomato (*Lycopersicon esculentum* Mill)

AT Sadashiva, KM Reddy, MK Reddy, TH Singh, MV Balaram, BC Narasimha Prasad, KM Prasanna, LR Naveen and SC Joshi

Division of Vegetable Crops, Indian Institute of Horticultural Research, Bangalore-560 089, Karnataka

Tomato Leaf Curl Virus (ToLCV) and bacterial wilt (BW) are serious production constraints. Saikia and Muniyappa (1989) reported 100 per cent infection with yield loss exceeding 90 per cent by ToLCV caused by a Gemini virus and BW caused by *Ralstonia solanacearum* is reported to cause up to 90.6 per cent loss in tomato (Ramkishun, 1987), needing development of variety/ hybrid with resistance to ToLCV and BW.

TLBR-1 (INGR No. 03075; IC 395328)

TLBR-1 is a tomato germplasm with resistance to ToLCV and BW, developed from a cross between a ToLCV resistant line H-24 (Hisar Anmol) and BW resistant line 15SBSB. Hybrids were raised and the seeds of both the back crosses and F_2 were produced. Parents, F_1, F_2 and backcrosses were field evaluated for ToLCV resistance. In the backcross population (BC_1F_1) involving 15 SBSB as recurrent

Bacterial Wilt Resistant Brinjal (*Solanum melongena* L.) IIHR 3 (96-2-1) *(INGR No. 03074; IC 395333)*

AT Sadashiva, TH Singh, KM Reddy, MK Reddy, MV Balaram, BC Narasimha Prasad, KM Prasanna, LR Naveen and SG Joshi

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parent, of the 25 ToLCV disease-free plants, three individual plants viz., H-24 x 15 SBSB BC_1F_1-36, H-36, H-24 x 15 SBSB BC_1F_1-56 and H-24 x 15 SBSB BC_1F_1-64 were advanced. Progeny of the selected back cross (BC_1F_2-36) were further screened for ToLCV resistance using virulent white files in the screenhouse. Fifty-nine ToLCV resistant plants from this population were further advanced in BW sick plot followed by artificial inoculations with bacterial ooze. Five individual plants with resistance to ToLCV and BW were identified, bulked and named as TLBR-1.

Plants of TLBR-1 are semi-determinate with good foliar cover. Fruits are medium sized (75 g), obvate round, and medium firm (4.23 kg/cm^2) with light green shoulder. It yields 2.03 kg per plant in 140 days (Table 1). Morphoagronomic details of TLBR-1 are summarized in Table 1.

Table 1. Morpho-agronomic details of TLBR-1

Lines	Season									
	April to September 2001					October 2001 to March 2002				
	Yield (kg/pl)	Average fruit weight (g)	Fruit firmness (kg/cm^2)	ToLCV (%)	BW (%)	Yield (kg/pt)	Average fruit weight (g)	Fruit firmness (kg/cm^2)	ToLCV (%)	BW (%)
TLBR-1	**2.38**	**73.0**	**3.40**	**0.00**	**0.00**	**2.16**	**80.00**	**5.06**	**0**	**0**
TLBR-2	1.96	50.0	4.34	0.00	0.00	1.28	46.00	4.56	0	0
TLBR-3	2.50	98.0	4.14	0.00	0.00	1.28	92.00	4.40	0	0
TLBR-4	2.24	79.0	3.74	0.00	0.00	0.86	66.00	4.84	0	0
TLBR-5	2.51	110.0	3.77	13.14	0.00	1.04	88.00	4.76	0	0
TLBR-6	2.59	86.0	3.04	0.00	0.00	0.90	83.00	4.24	0	0
Arka Saurabh	0.86	51.0	3.54	91.67	98.3	0.17	63.00	3.06	100	100
SEm±	0.08	6.95	0.01	-	-	0.18	6.10	0.25	-	-
C.D. @ 5%	0.21	19.32	0.03	-	-	0.50	16.93	0.69	-	-
C.D. @ 1%	0.27	24.82	0.04	-	-	0.63	21.17	0.89	-	-

IIHR-2195 ***(INGR No. 03076; IC 395457)***

IIHR-2195 is a tomato germplasm resistant to ToLCV and BW in different genetic background, developed through screening of advance breeding lines received from Asian Vegetable Research and Development Centre. During April to September 2001 eight-advance breeding lines were screened, all were resistant to ToLCV compared to check, Arka Saurabh (92% incidence). All the eight entries except IIHR-2196 (3.7%) were also found completely free from BW incidence compared to Arka Saurabh (98% incidence). IIHR 2195 (CLN2114DC1DF1-20-2-16-8-2-17-0) yielded of 2.24 kg per plant. The resistance was confirmed in subsequent season with a yield of 2.03 kg per plant and an average fruit weight of 19 g (Table 1). It has a determinate growth habit with round fruits of small to medium size (20-30 g); medium firm (2.55 kg/cm^2) and light green shoulder produced in 120 days (Table 1). It is suitable for summer cultivation.

Table 1. Agronomic details of the tomato line TLBR-1

Lines	Season							
	April to September 2001			October 2001 to March 2002				
Genotype	Yield (kg/pt)	ToLCV (%)	BW (%)	Yield (kg/pt)	Average fruit weight (g)	Fruit Firmness (kg/cm^2)	ToLCV (%)	BW (%)
IIHR-2195	**2.24**	**0.00**	**0.00**	**2.03**	**19.10**	**2.55**	**0.00**	**0.00**
IIHR-2196	2.50	0.00	0.00	2.73	29.46	3.75	0.00	0.00
IIHR-2197	2.20	0.00	0.00	1.73	29.52	2.40	0.00	0.00
IIHR-2198	2.88	0.00	0.00	2.40	38.77	3.43	0.00	0.00
IIHR-2199	2.99	0.00	0.00	1.96	2.00	38.10	3.13	0.00
IIHR-2100	3.19	0.00	0.00	0.50	56.51	2.90	100.00	100.00
Arka Saurabh	0.00	100.00	100.00	0.50	56.51	2.90	100.00	100.00
SEm±	0.21	-	-	0.03	2.13	0.03	-	-
C.D. @ 5%	0.63	-	-	0.09	6.39	0.08	-	-
C.D. @ 1%	0.86	-	-	0.13	8.80	0.13	-	-

Cytoplasmic Genetic Male Sterile Line MS 2 A & B OF Chilli (*Capsicum annum* L.) *(INGR No. 03077; IC 296318 & IC 296319)*

K Madhavi Reddy and AA Deshpande
Division of Vegetable Crops, Indian Institute of Horticulture Research, Bangalore-560 089, Karnataka

MS 2A is a new cytoplasmic genetic male sterile (CGMS) germplasm line of chilli. This malesterile plant was naturally observed in the experimental plot at IIHR, Bangalore. Profuse growth was observed in male sterile plant compared to fertile ones. The male-sterile plants had shrivelled anthers and were devoid of pollen grains. Crosses were made with its sister line and normal pod setting was observed. The F_1 plants were male fertile indicating recessive gene actions for male sterility. The fertile F_1's of the cross were backcrossed as pollen parent to corresponding fertile parent and through progeny testing two types of populations were identified from the cross.

Identified heterozygous progenies were selfed and the obtained progenies were crossed with male sterile parent. After evaluating the progency, corresponding maintainer (B line with normal cytoplasm and male sterile nuclear genes) was identified, which gave 100 percent male sterile progeny. The morphological characters of MS2 (A-line) and its mainainter (B line) are given in the Table 1. The plants of MS2A are more vigorous than maintainer, but for characters, such as fruit length, fruit width and 20 fruit weight, male-sterile lines had less mean values compared to their corresponding maintainer line.

Table 1. Details of MS A and B lines of Chilli

Line	Cross/Parent	Days to 50% flowering	Fruit Length (cm)	Fruit width (cm)	Fruit width (cm)	Plant height (cm)	Plant spread (cm)
MS-2	A line	36	3.33	1.03	23.85	80.84	65.50
	B line	36	4.13	1.06	33.00	58.33	51.65

Reference

Hundal JS (2000) Double chilli yield by growing hybrid varieties. Spice India. October 2000: 17-20.

Leafless Pea (*Pisum sativum* L.), PMR-21 *(INGR No. 03078; IC 395309)*

Yash Vir Singh and Hari Har Ram
Department of Vegetable Science, GB Pant University of Agriculture & Technology, Pantnagar-263 145, Uttaranchal

PMR-21 is a leafless pea genotype with only tendrils compared to normal pinnately compound leaf. It has resistance to powdery mildew (*Erysiphe polygoni)* and was developed through hybridization between Arkel and HEP-4 followed by pedigree selection method. The plant of PMR-21 is medium tall with light green foliage. Flowers are white. Pods are long and slightly curved at the tip. It belongs to the early mid season group of maturity. The seeds are yellow round with small dimple at dry stage. It has been tested for powdery mildew resistance in breeding nurseries and mid season pea varieties under All India Co-ordinated Vegetable Improvement Project (Table 1).

Table 1. Performance of PMR-21 in AICVIP trials (green pod yield q/ha and reaction to powdery mildew)

Entry/ Check*	Location					
	Solan	IIVR, Varanasi	Almora	IARI, N.Delhi	Pantnagar	Bangalore
PMR-21	**75 (R)**	**119 (R)**	**125(R)**	**139(R)**	**159(R)**	**38(R)**
FC-1*	70 (HR)	-	50 (R)	-	82(R)	-
IP-3*	100 (S)	-	106 (S)	-	116 (HS)	23 (S)
C.D. 5%	-	33	19	-	16	22
C.V. %	-	-	11	-	14	19

(Source: AIC VIP Annual Report 2001)
R=Resistant, HR=Highly resistant, S=Susceptible, HS Highly susceptible

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Identified heterozygous progenies were selfed and the obtained progenies were crossed with male sterile parent. After evaluating the progency, corresponding maintainer (B line with normal cytoplasm and male sterile nuclear genes) was identified, which gave 100 percent male sterile progeny. The morphological characters of MS2 (A-line) and its mainainter (B line) are given in the Table 1. The plants of MS2A are more vigorous than maintainer, but for characters, such as fruit length, fruit width and 20 fruit weight, male-sterile lines had less mean values compared to their corresponding maintainer line.

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Reference

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Yash Vir Singh and Hari Har Ram
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PMR-21 is a leafless pea genotype with only tendrils compared to normal pinnately compound leaf. It has resistance to powdery mildew (*Erysiphe polygoni)* and was developed through hybridization between Arkel and HEP-4 followed by pedigree selection method. The plant of PMR-21 is medium tall with light green foliage. Flowers are white. Pods are long and slightly curved at the tip. It belongs to the early mid season group of maturity. The seeds are yellow round with small dimple at dry stage. It has been tested for powdery mildew resistance in breeding nurseries and mid season pea varieties under All India Co-ordinated Vegetable Improvement Project (Table 1).

Table 1. Performance of PMR-21 in AICVIP trials (green pod yield q/ha and reaction to powdery mildew)

Entry/ Check*	Location					
	Solan	IIVR, Varanasi	Almora	IARI, N.Delhi	Pantnagar	Bangalore
PMR-21	**75 (R)**	**119 (R)**	**125(R)**	**139(R)**	**159(R)**	**38(R)**
FC-1*	70 (HR)	-	50 (R)	-	82(R)	-
IP-3*	100 (S)	-	106 (S)	-	116 (HS)	23 (S)
C.D. 5%	-	33	19	-	16	22
C.V. %	-	-	11	-	14	19

(Source: AIC VIP Annual Report 2001)
R=Resistant, HR=Highly resistant, S=Susceptible, HS Highly susceptible

It is a dual-purpose genotype that can be used both as vegetable and grain. Also, it is resistant to powdery mildew (*Erysiphe polygoni).* In north Indian conditions, it should be sown in first fortnight of November with a seed rate of 100 kg per ha.

Powdery Mildew Resistant Yellow Wrinkle Seeded Pea (*Pisum sativum* L.) DPP 62 *(INGR No. 03079; IC 397028)*

Pritam Kalia
Division of Vegetable Science, Indain Agricultural Research Institute, New Delhi-110 012

DPP 62 is powdery mildew (*Erysiphe polygoni)* resistant germplasm of pea with yellow wrinkled seeds and medium plant height developed at the Department of Vegetable Science, Himachal Pradesh Krishi Vishvavidyalaya (HPKV), Palampur through hybridization between germplasm 'Bonneville' and powdery mildew resistant stock P388. Individual plant selection for powdery mildew resistance and high yield from F_2 population, under artificial epiphytotic conditions was carried out. The selected plants were then advanced following pedigree breeding method. Selection of powdery mildew free plants was done until uniformity. The final selections were again screened under artificial epiphytotic conditions created by infector rows and dusting with fresh inoculum. It takes about 95 days for 50 percent flowering and 120 days for first picking. The availability of pods lasts for about 20 days. The plants attain medium height of 40-50 cm. It bears 12 pods per plant and each pod measures 7.5 cm in length, 5 cm in width with a shelling of 48 percent. The seeds contain 14.5 percent of total soluble sugar, 12 mg per 100 g ascorbic acid and 10.5 percent protein (Pathak, 1999). It gave an average green pod yield of 180.7 q per under dry temperate trans-Himalayan region (Sharma and Sharma, 2000). It is a mid season type. Its pod development stage coincides with the powdery mildew disease incidence in the field. It was also evaluated for pre and post-inflection changes in peroxidase, polyphenoloxidase and phenylalanine ammonia lyase (PAL) activity, which showed that post inflection activity of these phenol oxidinzing enzymes, 2-3 times higher than pre-infection activity (Table1), revealing their role in resistance to powdery mildew disease (Kalia, 1998).

Table 1. Change in pre- and post-powdery mildew inflection peroxidase, polyphenoloxidase and PAL activity in DPP 62

Phenol oxidizing enzymes	Pre-infection	Post-infection
Peroxidase activity (ΔO.D./min/mg)	113	360
Polyphenol oxidase activity (ΔO.D./min/mg)	0.12	0.25
Phenylalanine ammonia lyase (PAL) activity (μg-transcinnamic acid formed hr^{-1} mg^{-1})	133	238

References

Kalia P (1998) Enzymic association of powdery mildew resistance in garden pea. *Veg. Sci.* **25:** 166-168.

Pathak S (1999) Variability and Inter-relationships among horticultural traits in powdery mildew resistant genotypes of garden pea (*Pisum sativum* L.) M.Sc. Thesis, PHKV-Palampur (HP).

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Novel Cashew (*Anacardium* spp.) Germplasm

Bigger cashew kernels with ivory white colour fetch premium price in the international trade, hence there is a need to develop varieties with bigger size nuts and other desirable traits (Bhaskar Rao *et al.,* 1996).

NRC-59 (VTH 196/18) *(INGR No. 03080; IC 296552)*

KN Murthy, PM Kumaran, KRM Swamy, MG Bhat and EVV Bhaskara Rao
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC-59, bold nut and big apple type cashew (*Anacardium occidentale* L.) was obtained from the primary collection of the seedling progency of tree No. 196/18 collected from 8/8 Avivelu, Venkatapuram and maintained at the

It is a dual-purpose genotype that can be used both as vegetable and grain. Also, it is resistant to powdery mildew (*Erysiphe polygoni).* In north Indian conditions, it should be sown in first fortnight of November with a seed rate of 100 kg per ha.

Powdery Mildew Resistant Yellow Wrinkle Seeded Pea (*Pisum sativum* L.) DPP 62 *(INGR No. 03079; IC 397028)*

Pritam Kalia
Division of Vegetable Science, Indain Agricultural Research Institute, New Delhi-110 012

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Powdery Mildew Resistant Yellow Wrinkle Seeded Pea (*Pisum sativum* L.) DPP 62 *(INGR No. 03079; IC 397028)*

Pritam Kalia
Division of Vegetable Science, Indain Agricultural Research Institute, New Delhi-110 012

DPP 62 is powdery mildew (*Erysiphe polygoni)* resistant germplasm of pea with yellow wrinkled seeds and medium plant height developed at the Department of Vegetable Science, Himachal Pradesh Krishi Vishvavidyalaya (HPKV), Palampur through hybridization between germplasm 'Bonneville' and powdery mildew resistant stock P388. Individual plant selection for powdery mildew resistance and high yield from F_2 population, under artificial epiphytotic conditions was carried out. The selected plants were then advanced following pedigree breeding method. Selection of powdery mildew free plants was done until uniformity. The final selections were again screened under artificial epiphytotic conditions created by infector rows and dusting with fresh inoculum. It takes about 95 days for 50 percent flowering and 120 days for first picking. The availability of pods lasts for about 20 days. The plants attain medium height of 40-50 cm. It bears 12 pods per plant and each pod measures 7.5 cm in length, 5 cm in width with a shelling of 48 percent. The seeds contain 14.5 percent of total soluble sugar, 12 mg per 100 g ascorbic acid and 10.5 percent protein (Pathak, 1999). It gave an average green pod yield of 180.7 q per under dry temperate trans-Himalayan region (Sharma and Sharma, 2000). It is a mid season type. Its pod development stage coincides with the powdery mildew disease incidence in the field. It was also evaluated for pre and post-inflection changes in peroxidase, polyphenoloxidase and phenylalanine ammonia lyase (PAL) activity, which showed that post inflection activity of these phenol oxidinzing enzymes, 2-3 times higher than pre-infection activity (Table1), revealing their role in resistance to powdery mildew disease (Kalia, 1998).

Table 1. Change in pre- and post-powdery mildew inflection peroxidase, polyphenoloxidase and PAL activity in DPP 62

Phenol oxidizing enzymes	Pre-infection	Post-infection
Peroxidase activity (ΔO.D./min/mg)	113	360
Polyphenol oxidase activity (ΔO.D./min/mg)	0.12	0.25
Phenylalanine ammonia lyase (PAL) activity (μg-transcinnamic acid formed hr^{-1} mg^{-1})	133	238

References

Kalia P (1998) Enzymic association of powdery mildew resistance in garden pea. *Veg. Sci.* **25:** 166-168.

Pathak S (1999) Variability and Inter-relationships among horticultural traits in powdery mildew resistant genotypes of garden pea (*Pisum sativum* L.) M.Sc. Thesis, PHKV-Palampur (HP).

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Novel Cashew (*Anacardium* spp.) Germplasm

Bigger cashew kernels with ivory white colour fetch premium price in the international trade, hence there is a need to develop varieties with bigger size nuts and other desirable traits (Bhaskar Rao *et al.,* 1996).

NRC-59 (VTH 196/18) *(INGR No. 03080; IC 296552)*

KN Murthy, PM Kumaran, KRM Swamy, MG Bhat and EVV Bhaskara Rao
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC-59, bold nut and big apple type cashew (*Anacardium occidentale* L.) was obtained from the primary collection of the seedling progency of tree No. 196/18 collected from 8/8 Avivelu, Venkatapuram and maintained at the

Cashew Research Station (CRS), Baptala, Andhra Pradesh.

The trees of NRC-59 are tall (4.1m in height) with a spread of 4.9 m^2 in the 10th year of planting. Trees are extensively branched with small to medium leaves (66.8 cm^2). It is a mid-season flowering type with long flowering duration (100 days) and medium flowering intensity (66.8%). The nuts are medium to bold (8.3 g), apple big (130 g) with an average yield of 9.25 kg per tree in the initial six annual harvests and shelling percentage of 30.8 (Swamy *et al.*, 1988).

References

Bhaskara Rao EVV, KRM Swamy and MG Bhat (1998) Stauts of cashew breeding and future priorities. *J. Plantation Crops.* **26:** 103-113.

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentate* L.) Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54p.

NRC-111 (MARDOL-4) *(INGR No. 03081; IC 296555)*

KRM Swamy, MG Bhat and EVV Bhaskara Rao
National Research Centre for Cashew, Puttur-574 202 Karnataka

NRC-111 (Mardol-4) is a bold nuts cashew (*Anacardium occidentale* L.) accession collected from Mardol, Goa. Trees of this accession are tall with an average height of 5.2 m in 10th year of planting with canopy of 6.0 m^2, extensive branching and fairly small to medium size leaves (56.5 cm^2). It is a mid-season type with high flowering intensity (83.3%) and fairly good sex ratio (0.10). Both the nut (12.6 g) and apple (106.6 g) are big in size and the trees had an average of 8.11 kg nuts yield per plant in initital six annual harvests. The nuts had good processing quality with a low shelling percentage of 24.1 (Swamy *et al.*, 1998).

References

Bhaskara Rao EVV, KRM Swamy and MG Bhat (1998) Status of cashew breeding and future priorities, *J. Plantation Crops.* **26:** 103-113.

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-116 (CNSL Free) *(INGR No. 03082; IC 296557)*

MM Khan, KRM Swamy, EVV Bhaskara Rao and MG Bhat
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC-116 is a cashew nut shell liquid (CNSL) free cashew (*Anacardium occidentale* L.) accession, assembled from primary collections of Agricultural Research Station, Ullal, Karnataka. CSNL present in the cashew shells is an important by-product available in cashew processing. However, the CNSL causes skin burning and drudgery to the working force. Thus, development of hybrids with CNSL-free is desirable features. NRC-116 is a medium statured tree with a height of 3.7 m and spread of 5.4 m^2 in the 10th year of planting and totally CNSL-free. Trees have extensive branching with medium sized leaves (76.3 cm^2). It is early season flowering with long flowering duration (112 days) and high flowering intensity (81.2%). It gave an average yield of 2.66 kg nuts per plant in initial six annual harvests with low shelling percentage of 25.7 (Swamy *et al.*, 1998).

References

Bhaskara Rao EVV, KRM Swamy and MG Bhat (1998) Status of cashew breeding and future priorities. *J. Plantation Crops.* **26**: 103-113.

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for cashew (ICAR), Puttur, Karnataka, 54 p.

Cashew Research Station (CRS), Baptala, Andhra Pradesh.

The trees of NRC-59 are tall (4.1m in height) with a spread of 4.9 m^2 in the 10th year of planting. Trees are extensively branched with small to medium leaves (66.8 cm^2). It is a mid-season flowering type with long flowering duration (100 days) and medium flowering intensity (66.8%). The nuts are medium to bold (8.3 g), apple big (130 g) with an average yield of 9.25 kg per tree in the initial six annual harvests and shelling percentage of 30.8 (Swamy *et al.*, 1988).

References

Bhaskara Rao EVV, KRM Swamy and MG Bhat (1998) Stauts of cashew breeding and future priorities. *J. Plantation Crops.* **26:** 103-113.

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentate* L.) Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54p.

NRC-111 (MARDOL-4) *(INGR No. 03081; IC 296555)*

KRM Swamy, MG Bhat and EVV Bhaskara Rao
National Research Centre for Cashew, Puttur-574 202 Karnataka

NRC-111 (Mardol-4) is a bold nuts cashew (*Anacardium occidentale* L.) accession collected from Mardol, Goa. Trees of this accession are tall with an average height of 5.2 m in 10th year of planting with canopy of 6.0 m^2, extensive branching and fairly small to medium size leaves (56.5 cm^2). It is a mid-season type with high flowering intensity (83.3%) and fairly good sex ratio (0.10). Both the nut (12.6 g) and apple (106.6 g) are big in size and the trees had an average of 8.11 kg nuts yield per plant in initital six annual harvests. The nuts had good processing quality with a low shelling percentage of 24.1 (Swamy *et al.*, 1998).

References

Bhaskara Rao EVV, KRM Swamy and MG Bhat (1998) Status of cashew breeding and future priorities, *J. Plantation Crops.* **26:** 103-113.

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-116 (CNSL Free) *(INGR No. 03082; IC 296557)*

MM Khan, KRM Swamy, EVV Bhaskara Rao and MG Bhat
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC-116 is a cashew nut shell liquid (CNSL) free cashew (*Anacardium occidentale* L.) accession, assembled from primary collections of Agricultural Research Station, Ullal, Karnataka. CSNL present in the cashew shells is an important by-product available in cashew processing. However, the CNSL causes skin burning and drudgery to the working force. Thus, development of hybrids with CNSL-free is desirable features. NRC-116 is a medium statured tree with a height of 3.7 m and spread of 5.4 m^2 in the 10th year of planting and totally CNSL-free. Trees have extensive branching with medium sized leaves (76.3 cm^2). It is early season flowering with long flowering duration (112 days) and high flowering intensity (81.2%). It gave an average yield of 2.66 kg nuts per plant in initial six annual harvests with low shelling percentage of 25.7 (Swamy *et al.*, 1998).

References

Bhaskara Rao EVV, KRM Swamy and MG Bhat (1998) Status of cashew breeding and future priorities. *J. Plantation Crops.* **26**: 103-113.

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for cashew (ICAR), Puttur, Karnataka, 54 p.

Cashew Research Station (CRS), Baptala, Andhra Pradesh.

The trees of NRC-59 are tall (4.1m in height) with a spread of 4.9 m^2 in the 10th year of planting. Trees are extensively branched with small to medium leaves (66.8 cm^2). It is a mid-season flowering type with long flowering duration (100 days) and medium flowering intensity (66.8%). The nuts are medium to bold (8.3 g), apple big (130 g) with an average yield of 9.25 kg per tree in the initial six annual harvests and shelling percentage of 30.8 (Swamy *et al.*, 1988).

References

Bhaskara Rao EVV, KRM Swamy and MG Bhat (1998) Stauts of cashew breeding and future priorities. *J. Plantation Crops.* **26:** 103-113.

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentate* L.) Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54p.

NRC-111 (MARDOL-4) *(INGR No. 03081; IC 296555)*

KRM Swamy, MG Bhat and EVV Bhaskara Rao
National Research Centre for Cashew, Puttur-574 202 Karnataka

NRC-111 (Mardol-4) is a bold nuts cashew (*Anacardium occidentale* L.) accession collected from Mardol, Goa. Trees of this accession are tall with an average height of 5.2 m in 10th year of planting with canopy of 6.0 m^2, extensive branching and fairly small to medium size leaves (56.5 cm^2). It is a mid-season type with high flowering intensity (83.3%) and fairly good sex ratio (0.10). Both the nut (12.6 g) and apple (106.6 g) are big in size and the trees had an average of 8.11 kg nuts yield per plant in initital six annual harvests. The nuts had good processing quality with a low shelling percentage of 24.1 (Swamy *et al.*, 1998).

References

Bhaskara Rao EVV, KRM Swamy and MG Bhat (1998) Status of cashew breeding and future priorities, *J. Plantation Crops.* **26:** 103-113.

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-116 (CNSL Free) *(INGR No. 03082; IC 296557)*

MM Khan, KRM Swamy, EVV Bhaskara Rao and MG Bhat
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC-116 is a cashew nut shell liquid (CNSL) free cashew (*Anacardium occidentale* L.) accession, assembled from primary collections of Agricultural Research Station, Ullal, Karnataka. CSNL present in the cashew shells is an important by-product available in cashew processing. However, the CNSL causes skin burning and drudgery to the working force. Thus, development of hybrids with CNSL-free is desirable features. NRC-116 is a medium statured tree with a height of 3.7 m and spread of 5.4 m^2 in the 10th year of planting and totally CNSL-free. Trees have extensive branching with medium sized leaves (76.3 cm^2). It is early season flowering with long flowering duration (112 days) and high flowering intensity (81.2%). It gave an average yield of 2.66 kg nuts per plant in initial six annual harvests with low shelling percentage of 25.7 (Swamy *et al.*, 1998).

References

Bhaskara Rao EVV, KRM Swamy and MG Bhat (1998) Status of cashew breeding and future priorities. *J. Plantation Crops.* **26**: 103-113.

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-120 (Nairobi) *(INGR No. 03083, IC 296559)*

MM Khan, KRM Swamy, EVV Bhaskara Rao and MG Bhat
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC-120 is a bold nut and big apple cashew *(Anacardium occidentale)* accession, assembled from the primary collections of Nairobi maintained at Agricultural Research Station, Ullal, Karnataka. The trees of NRC-120 are slow growers with a mean plant height of 2.6 m and a canopy spread of 4.6 m^2 in the 10^{th} year of planting. Trees have extensive branching with small leaves (62.6 cm^2) and have early flowering (November-December) with long flowering duration (112 days) and high flowering intensity (86.3%). The nuts (8.8 g) and apple (150 g) are big in size. The trees gave an average yield of 5.78 kg nuts per tree in the initial six harvests with a low shelling percentage of 21.6 percent (Swamy *et al.*, 1998).

References

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors or cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-121(Purple Genotype) *(INGR No. 03084, IC 296561)*

MM Khan, KRM Swamy, EVV Bhaskara Rao and MG Bhat
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC 121 is cashew (*Anacardium occidentale* L.) accession with rare purple coloured leaves and stem. The accession was assembled from the primary collection of the Agricultural Research Station, Ullal, Karnataka. It has purple coloured stem and leaves and slow growth (2.7 m height and 2.5 m^2 spread in ten years). It has small sized leaves (51.7 cm^2) and extensive branching behaviour. It flowers in mid-season (January-February) with high flowering intensity (73%) and are of medium duration of 89 days. Both the nuts and apple are small in size with purple colour. The trees gave an average yield of 2.47 kg nuts per tree in the initial six harvests with shelling percentage of 28.9 (Swamy *et al.*, 1998).

Reference

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-140 (VTH-155 L) *(INGR No. 03085, IC 296564)*

MM Murthy, PM Kumaran, KRM Swamy, MG Bhat and EVV Bhaskara Rao
National Research Centre for Cashew, Puttur-574202, Karnataka

NRC-140 (VTH-155L) is a medium tall early season, long flowering duration genotype of cashew (*Anacardium occidentale* L.) assembled from Cashew Research Station, Bapatal, Andhra Pradesh. The treess of this accession are semi-tall type with a height of 3.1 m^2 and spread of 4.4 m^2 in the initial ten years of growth. Trees have extensive branching with medium to big leaves (109.4 cm^2). It is early flowering and have medium to long duration (90-120 days) of flowering with an intensity of 90 percent. The trees produce medium nuts (8.3 g) and big apple (142.8 g) and are high yielding with an average of 12.4 kg nuts per plant in initial six annual harvests and medium shelling percentage of 28.9 (Swamy *et al.*, 1998). This dwarf and compact types is suitable for high-density planting and development of hybrids with slow growth and compactness.

Reference

Swamy KRM, EVV Bhaskara Rao MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.) Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-120 (Nairobi) *(INGR No. 03083, IC 296559)*

MM Khan, KRM Swamy, EVV Bhaskara Rao and MG Bhat
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC-120 is a bold nut and big apple cashew *(Anacardium occidentale)* accession, assembled from the primary collections of Nairobi maintained at Agricultural Research Station, Ullal, Karnataka. The trees of NRC-120 are slow growers with a mean plant height of 2.6 m and a canopy spread of 4.6 m^2 in the 10^{th} year of planting. Trees have extensive branching with small leaves (62.6 cm^2) and have early flowering (November-December) with long flowering duration (112 days) and high flowering intensity (86.3%). The nuts (8.8 g) and apple (150 g) are big in size. The trees gave an average yield of 5.78 kg nuts per tree in the initial six harvests with a low shelling percentage of 21.6 percent (Swamy *et al.*, 1998).

References

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors or cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-121(Purple Genotype) *(INGR No. 03084, IC 296561)*

MM Khan, KRM Swamy, EVV Bhaskara Rao and MG Bhat
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC 121 is cashew (*Anacardium occidentale* L.) accession with rare purple coloured leaves and stem. The accession was assembled from the primary collection of the Agricultural Research Station, Ullal, Karnataka. It has purple coloured stem and leaves and slow growth (2.7 m height and 2.5 m^2 spread in ten years). It has small sized leaves (51.7 cm^2) and extensive branching behaviour. It flowers in mid-season (January-February) with high flowering intensity (73%) and are of medium duration of 89 days. Both the nuts and apple are small in size with purple colour. The trees gave an average yield of 2.47 kg nuts per tree in the initial six harvests with shelling percentage of 28.9 (Swamy *et al.*, 1998).

Reference

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-140 (VTH-155 L) *(INGR No. 03085, IC 296564)*

MM Murthy, PM Kumaran, KRM Swamy, MG Bhat and EVV Bhaskara Rao
National Research Centre for Cashew, Puttur-574202, Karnataka

NRC-140 (VTH-155L) is a medium tall early season, long flowering duration genotype of cashew (*Anacardium occidentale* L.) assembled from Cashew Research Station, Bapatal, Andhra Pradesh. The treess of this accession are semi-tall type with a height of 3.1 m^2 and spread of 4.4 m^2 in the initial ten years of growth. Trees have extensive branching with medium to big leaves (109.4 cm^2). It is early flowering and have medium to long duration (90-120 days) of flowering with an intensity of 90 percent. The trees produce medium nuts (8.3 g) and big apple (142.8 g) and are high yielding with an average of 12.4 kg nuts per plant in initial six annual harvests and medium shelling percentage of 28.9 (Swamy *et al.*, 1998). This dwarf and compact types is suitable for high-density planting and development of hybrids with slow growth and compactness.

Reference

Swamy KRM, EVV Bhaskara Rao MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.) Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-120 (Nairobi) *(INGR No. 03083, IC 296559)*

MM Khan, KRM Swamy, EVV Bhaskara Rao and MG Bhat
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC-120 is a bold nut and big apple cashew *(Anacardium occidentale)* accession, assembled from the primary collections of Nairobi maintained at Agricultural Research Station, Ullal, Karnataka. The trees of NRC-120 are slow growers with a mean plant height of 2.6 m and a canopy spread of 4.6 m^2 in the 10^{th} year of planting. Trees have extensive branching with small leaves (62.6 cm^2) and have early flowering (November-December) with long flowering duration (112 days) and high flowering intensity (86.3%). The nuts (8.8 g) and apple (150 g) are big in size. The trees gave an average yield of 5.78 kg nuts per tree in the initial six harvests with a low shelling percentage of 21.6 percent (Swamy *et al.*, 1998).

References

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors or cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-121(Purple Genotype) *(INGR No. 03084, IC 296561)*

MM Khan, KRM Swamy, EVV Bhaskara Rao and MG Bhat
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC 121 is cashew (*Anacardium occidentale* L.) accession with rare purple coloured leaves and stem. The accession was assembled from the primary collection of the Agricultural Research Station, Ullal, Karnataka. It has purple coloured stem and leaves and slow growth (2.7 m height and 2.5 m^2 spread in ten years). It has small sized leaves (51.7 cm^2) and extensive branching behaviour. It flowers in mid-season (January-February) with high flowering intensity (73%) and are of medium duration of 89 days. Both the nuts and apple are small in size with purple colour. The trees gave an average yield of 2.47 kg nuts per tree in the initial six harvests with shelling percentage of 28.9 (Swamy *et al.*, 1998).

Reference

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-140 (VTH-155 L) *(INGR No. 03085, IC 296564)*

MM Murthy, PM Kumaran, KRM Swamy, MG Bhat and EVV Bhaskara Rao
National Research Centre for Cashew, Puttur-574202, Karnataka

NRC-140 (VTH-155L) is a medium tall early season, long flowering duration genotype of cashew (*Anacardium occidentale* L.) assembled from Cashew Research Station, Bapatal, Andhra Pradesh. The treess of this accession are semi-tall type with a height of 3.1 m^2 and spread of 4.4 m^2 in the initial ten years of growth. Trees have extensive branching with medium to big leaves (109.4 cm^2). It is early flowering and have medium to long duration (90-120 days) of flowering with an intensity of 90 percent. The trees produce medium nuts (8.3 g) and big apple (142.8 g) and are high yielding with an average of 12.4 kg nuts per plant in initial six annual harvests and medium shelling percentage of 28.9 (Swamy *et al.*, 1998). This dwarf and compact types is suitable for high-density planting and development of hybrids with slow growth and compactness.

Reference

Swamy KRM, EVV Bhaskara Rao MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.) Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-142 (VTH 578/1) *(INGR No. 03086; IC 296565)*

KN Murthy, PM Kumaran, KRM Swamy, MG Bhat and EVV Bhaskara Rao
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC 142 (VTH 578/1) is a wild relative of cashew belonging to species *Anacardium microcarpum* L. assembled as seed from Brazil. The trees are tall and huge in size, 4.6 m high and 5.4 m^2 spread in the tenth year of planting. Trees have extensive branching with big leaves (137.4 cm^2). Usually trees flowers late in season (March-April) with high intensity of flowering (81.8%) and low sex ratio (0.05%). It flowers for medium duration, upto 72 days. It is a good yielder, with an average of 8.31 kg nuts per tree (a cumulative yield of initial six harvests) with medium shelling percentage of 28.5 (Swamy *et al.*, 1998).

Reference

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-152 (VTH 713/4) *(INGR No. 03087; IC 296567)*

KN Murthy, PM Kumaran, KRM Swamy, MG Bhat and EVV Bhaskara Rao
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC 152 (VTH 713/4) is a wild relative of cashew belonging to species *Anacardium orthonianum* L. It is slow growing with thick bark and profuse flowering habit. The accession was assembled as seed from Brazil. Trees are slow growing with a medium height of 3.6 m and very low spreading habit (3.3 m^2) in the 10^{th} year of planting. It has extensive branching with big leaves (100.3 cm^2). It is late flowering type with low flowering intensity (14.3%) and continues to flower for about 80 days. Sex ratio is very low (0.06%) with very poor fruit set. Both the nut (2.0 g) and apple (60 g) are small. It yields with an average of 0.80 kg nuts per plant (a cumulative yield of initital six annual harvests) and with a low shelling percentage of 22 (Swamy *et al.*, 1998).

Reference

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.) Germplasm Accessions-II. National Research Centre for Cashew, (ICAR), Puttur, Karnataka 54 p.

NRC-201 *(INGR No. 03088; IC 296571)*

PC Lenka, KRM Swamy, EVV Bhaskara Rao and MG Bhat
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC 201 is a semi-tall, upright branching and compact canopy cashew (*Anacardium occidentale* L.) accession collected from Cashew Reseach Station (OUAT), Bhubaneshwar, Orissa. Such dwarf and compact types are preferred for cultivation because of easy management. The trees are slow growing with a height of 2.9 m and a spread of 4.2 m^2 in the 10^{th} year of planting. They have extensive branching with medium leaves (82.9 cm^2). It flowers early (November-December) with medium flowering intensity (68.6%) and for duration of upto 84 days. It has medium size nuts (8.3 g) and apple (60.0 g). Plants are low yielding with an average yield of 3.22 kg nut per plant (a cumulative yield of 6 initial harvests), but high shelling percentage of 30.2 (Swamy *et al.*, 1998).

Reference

Swamy KRM, EVV Bhaskara Rao MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-142 (VTH 578/1) *(INGR No. 03086; IC 296565)*

KN Murthy, PM Kumaran, KRM Swamy, MG Bhat and EVV Bhaskara Rao
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC 142 (VTH 578/1) is a wild relative of cashew belonging to species *Anacardium microcarpum* L. assembled as seed from Brazil. The trees are tall and huge in size, 4.6 m high and 5.4 m^2 spread in the tenth year of planting. Trees have extensive branching with big leaves (137.4 cm^2). Usually trees flowers late in season (March-April) with high intensity of flowering (81.8%) and low sex ratio (0.05%). It flowers for medium duration, upto 72 days. It is a good yielder, with an average of 8.31 kg nuts per tree (a cumulative yield of initial six harvests) with medium shelling percentage of 28.5 (Swamy *et al.*, 1998).

Reference

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-152 (VTH 713/4) *(INGR No. 03087; IC 296567)*

KN Murthy, PM Kumaran, KRM Swamy, MG Bhat and EVV Bhaskara Rao
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC 152 (VTH 713/4) is a wild relative of cashew belonging to species *Anacardium orthonianum* L. It is slow growing with thick bark and profuse flowering habit. The accession was assembled as seed from Brazil. Trees are slow growing with a medium height of 3.6 m and very low spreading habit (3.3 m^2) in the 10^{th} year of planting. It has extensive branching with big leaves (100.3 cm^2). It is late flowering type with low flowering intensity (14.3%) and continues to flower for about 80 days. Sex ratio is very low (0.06%) with very poor fruit set. Both the nut (2.0 g) and apple (60 g) are small. It yields with an average of 0.80 kg nuts per plant (a cumulative yield of initital six annual harvests) and with a low shelling percentage of 22 (Swamy *et al.*, 1998).

Reference

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.) Germplasm Accessions-II. National Research Centre for Cashew, (ICAR), Puttur, Karnataka 54 p.

NRC-201 *(INGR No. 03088; IC 296571)*

PC Lenka, KRM Swamy, EVV Bhaskara Rao and MG Bhat
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC 201 is a semi-tall, upright branching and compact canopy cashew (*Anacardium occidentale* L.) accession collected from Cashew Reseach Station (OUAT), Bhubaneshwar, Orissa. Such dwarf and compact types are preferred for cultivation because of easy management. The trees are slow growing with a height of 2.9 m and a spread of 4.2 m^2 in the 10^{th} year of planting. They have extensive branching with medium leaves (82.9 cm^2). It flowers early (November-December) with medium flowering intensity (68.6%) and for duration of upto 84 days. It has medium size nuts (8.3 g) and apple (60.0 g). Plants are low yielding with an average yield of 3.22 kg nut per plant (a cumulative yield of 6 initial harvests), but high shelling percentage of 30.2 (Swamy *et al.*, 1998).

Reference

Swamy KRM, EVV Bhaskara Rao MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-142 (VTH 578/1) *(INGR No. 03086; IC 296565)*

KN Murthy, PM Kumaran, KRM Swamy, MG Bhat and EVV Bhaskara Rao
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC 142 (VTH 578/1) is a wild relative of cashew belonging to species *Anacardium microcarpum* L. assembled as seed from Brazil. The trees are tall and huge in size, 4.6 m high and 5.4 m^2 spread in the tenth year of planting. Trees have extensive branching with big leaves (137.4 cm^2). Usually trees flowers late in season (March-April) with high intensity of flowering (81.8%) and low sex ratio (0.05%). It flowers for medium duration, upto 72 days. It is a good yielder, with an average of 8.31 kg nuts per tree (a cumulative yield of initial six harvests) with medium shelling percentage of 28.5 (Swamy *et al.*, 1998).

Reference

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

NRC-152 (VTH 713/4) *(INGR No. 03087; IC 296567)*

KN Murthy, PM Kumaran, KRM Swamy, MG Bhat and EVV Bhaskara Rao
National Research Centre for Cashew, Puttur-574 202, Karnataka

NRC 152 (VTH 713/4) is a wild relative of cashew belonging to species *Anacardium orthonianum* L. It is slow growing with thick bark and profuse flowering habit. The accession was assembled as seed from Brazil. Trees are slow growing with a medium height of 3.6 m and very low spreading habit (3.3 m^2) in the 10^{th} year of planting. It has extensive branching with big leaves (100.3 cm^2). It is late flowering type with low flowering intensity (14.3%) and continues to flower for about 80 days. Sex ratio is very low (0.06%) with very poor fruit set. Both the nut (2.0 g) and apple (60 g) are small. It yields with an average of 0.80 kg nuts per plant (a cumulative yield of initital six annual harvests) and with a low shelling percentage of 22 (Swamy *et al.*, 1998).

Reference

Swamy KRM, EVV Bhaskara Rao and MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.) Germplasm Accessions-II. National Research Centre for Cashew, (ICAR), Puttur, Karnataka 54 p.

NRC-201 *(INGR No. 03088; IC 296571)*

PC Lenka, KRM Swamy, EVV Bhaskara Rao and MG Bhat
National Research Centre for Cashew, Puttur-574 202, Karnataka

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Reference

Swamy KRM, EVV Bhaskara Rao MG Bhat (1998) Catalogue of minimum descriptors of cashew (*Anacardium occidentale* L.). Germplasm Accessions-II. National Research Centre for Cashew (ICAR), Puttur, Karnataka, 54 p.

High Yielding and High Curcumin Content Turmeric (*Curcuma longa* L.), Coll No. 657 *(INGR No. 03089; IC 296550)*

B Sasikumar, Johnson K Geroge and KV Saji
Indian Institute of Species Research, Calicut-673 012, Kerala

Turmeric (*Curcuma longa* L.), indigenous to India is an important spice and medicinal plant. Coll No. 657 with good yield (14.9 kg/3m^2) and high curcumin content (7.5%) was identified at the IISR from 899 accessions. This accession is a clonal selection from popular turmeric cultivar 'Alleppey'. The plant height is 52 cm with a stem girth 12 cm. The main shoot bears nine leaves with an average of three tillers and, seven leaves per tiller. Leaves are 56 cm long and 15.3 cm wide. The yield per three square meter beds is 14.9 kg of fresh weight with 18 percent dry recovery and 7.5 percent curcumin content. Table 1 gives the yield and quality features of Coll No. 657. For cultivation, a seed rate of 2500 kg rhizome/ha with spacing of 25.0 x 30.0 cm in beds or 45-60 x 25 cm in ridges and furrows is recommended.

Table 1. Yield and quality features of Coll No. 657

Accessions/ Check	Yield/3m^2 (Calicut)				Dry recovery	Curcumin content (%)	Curcumin (kg/ha)
	2001-02	2002-03	2002-03	Mean			
Acc. 657	**17.3**	**26.5**	**20.18**	**21.32**	**19.45**	**7.5**	**455.3**
Prabha*	15.0	25.4	16.21	18.84	20.0	6.5	419.1
Prathiba*	15.0	24.1	16.67	18.59	18.7	6.5	349.1

*Checks

Betelvine (*Pipe betle)* Germplasm, SPb-10 *(INGR No. 03090; IC 296595)*

R Arulmozhiyanan, R Chitra, K Prabakar and S Md Jalaluddin
Sugaracane Research Station, Sirugamani, Tamil Nadu Agricultural University, Trichy-639 115, Tamil Nadu

SPb-10 (SGM-1) is a high yielding bushy female betel vine with light green, ovate and pungent leaves. This is a pureline selection from Palghat, Kerala. The leaf size, petiole length, venation number and internodal length of SPb-10 are 78.1 cm^2, 6.2 cm, 7.00 and 5.6 cm respectively. It produces about 15 branches per vine per year. The selection SPb-10 has given maximum average leaf yield of 105.56 lakhs per hectare as compared to 88.86 lakhs in Karpuri, 80 lakhs in Vellai Kodi and 70.42 lakhs, used as checks in pachaikodi. In the multi-location trails, the leaf yoeld in SPb-10 was about 113.51 lakhs per hactare. It has least elongation of vine (14.5 cm/month) as compared to the traditional varieties (15.2 to 18.5 cm/month). It produced 25 to 32 branches per vine as compared to 7 to 13 that of local checks at Sugarcane Research Station. Also in multi-location trials it produced 27-37 branches as compared to 9-17 in other enteries. Hundred-leaf weight is 240 g. It is moderately resistant to root knot nematode (gall index of 2.0), scales ant mites, (index of 1.5) and to *Phytopthora* wilt under field conditions.

High Yielding, Disease Tolerant Black Pepper *(Piper nigrum* L) Coll. 1041 *(INGR No. 03091; IC 316598)*

B Sasikumar; KV Saji, Johnson K George, PN Ravindran and VA Parthasarthy
Indian Institute of Species Research, Calicut-673 012, Kerala

Coll. 1041 black pepper is a high yielding and *Phytophthora* foot rot tolerant accession developed through clonal selection from the popular black pepper cultivar 'Thevanmndi' of Idukki district, Kerala. The vine of Coll. 1041 has dimorphic branching with light purple shoot tip colour, non-pubiscent stem, ovate-elliptic leaves, glabrous-coriacaous texture, pendent spike orientation with filiform shape green in colour, non-fragrant and 8.2 cm long. It produces around 47 round fruits per spike with 100-fruit weight of 15.5 g. Yield and quality attributes

High Yielding and High Curcumin Content Turmeric (*Curcuma longa* L.), Coll No. 657 *(INGR No. 03089; IC 296550)*

B Sasikumar, Johnson K Geroge and KV Saji
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R Arulmozhiyanan, R Chitra, K Prabakar and S Md Jalaluddin
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High Yielding, Disease Tolerant Black Pepper *(Piper nigrum* L) Coll. 1041 *(INGR No. 03091; IC 316598)*

B Sasikumar; KV Saji, Johnson K George, PN Ravindran and VA Parthasarthy
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High Yielding and High Curcumin Content Turmeric (*Curcuma longa* L.), Coll No. 657 *(INGR No. 03089; IC 296550)*

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High Yielding, Disease Tolerant Black Pepper *(Piper nigrum* L) Coll. 1041 *(INGR No. 03091; IC 316598)*

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of Coll. 1041 compared to check is presented in Tables 1 and 2 respectively. Also it is tolerant to root rot disease with an index 2 against 4 of Karimunda (2 = rotting of 50% or less root).

Rooted cutting are used as the planting material with a spacing of 3 x 3 m^2 on live standards such as *Erythrina spp. or Garuga pinnata* or *Grevilia robusta.*

Table 1. Yield of Coll. 1041 as compared to checks at Valparai (Tamil Nadu)

Line/ Control*	Average yield (fresh/vine (kg)							Mean yield/vine (kg)
	95-96	96-97	97-98	98-99	99-00	00-01	01-02	
Coll. 1041	**2.29**	**4.10**	**4.20**	**4.71**	**4.77**	**8.45**	**7.70**	**5.17**
Panniyur-1*	3.60	1.90	1.84	2.76	1.15	6.60	4.94	3.23
KS-14*	0.40	0.34	0.32	0.32	0.63	1.28	0.80	0.58
KS-27*	0.51	0.16	0.24	0.93	1.52	2.8	0.90	1.08

Table 2. Quality attributes of Coll. 1041 and controls at Valparai and Peruvannamuzhi

Line/ Control*	Valparai					Peruvannamuzhi				
	Dry recov. (%)	Bulk density (g)	Piperine (%)	Oleo-resin (%)	Essen tialoil (%)	Dry reco. (%)	Bulk density (%)	Piper-ine (%)	Oleo-resin (%)	Essen tial oil (%)
Coll. 1041	**35.0**	**582**	**1.4**	**8.5**	**3.2**	**30.5**	**569**	**1.9**	**7.8**	**3.0**
Panniyu-1*	30.0	512	3.0	9.4	2.0	-	-	-	-	-
KS-27*	-	-	-	-	-	34.0	565.2	3.0	10.6	3.6

Highly Pungent Chilli (*Capsicum grossum* L.) DRLT-1107 (Naga Jalokia) (INGR No. 03092; IC 399066)

Subash Chandra Das
Defence Research Laboratory, Tezpur-784101, Assam

DRLT-1107 (Naga Jalokia) is a highly pungent chilli germplasm it is an endemic herbaceous annual with plant height of 50-90 cm. 1.5-3.0 cm stem diameter; leaves are yellow and flat, alternate, petiolate, elliptical, wavy, dark green, 5-16 cm long, and 3-6 cm wide. Flowers are complete, actinomorphic, pedicellate, pentamerous, greenish white 0.5-1.0 cm. Fruits are pendulous, wrinkled, yellowish green at young stage and deep red at maturity and 3-7 cm long. The genotype contains maximum capsaicin and dihydrocapsaicin contributing to a pungency of 855,000 SHU (Scoville heat unit) in comparision to Red Savina (577,000 SHU) and famous Thai chillies (100,000 SHU) which is highest till date (Das, 2000). Also, it is disease resistant and tolerance to insect, pest and nematode of chilli.

Reference

Das Subash Chandra (2000), The hottest chilli variety in India. *Curr Sci* **79:** 287-288.

Bold Seeded with High Azadirchtin–A Selection of Neem, DOR Neem 2 *(INGR No. 03093; IC 395308)*

N Mukta
Directorate of Oilseeds Research, Rajendra Nagar, Hyderabad-500 030, Andhra Pradesh

DOR NEEM 2 is a bold seeded selection of neem with high kernel yield and high Azadirachtin-A content, identified from collection of an approximately 20 year old tree growing at Narkhoda village in Rangareddy district, Andhra Pradesh. The region receives an annual rainfall of 700 mm and maximum temperature upto 43°C during the months of April-May. The tree attained a girth at breast height of 177 cm in the year 2000 and was selected, based on the size of the fruit and seed, which were analysed for oil and Azadirachtin-A content

of Coll. 1041 compared to check is presented in Tables 1 and 2 respectively. Also it is tolerant to root rot disease with an index 2 against 4 of Karimunda (2 = rotting of 50% or less root).

Rooted cutting are used as the planting material with a spacing of 3 x 3 m^2 on live standards such as *Erythrina spp. or Garuga pinnata* or *Grevilia robusta.*

Table 1. Yield of Coll. 1041 as compared to checks at Valparai (Tamil Nadu)

Line/ Control*	Average yield (fresh/vine (kg)							Mean yield/vine (kg)
	95-96	96-97	97-98	98-99	99-00	00-01	01-02	
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KS-27*	0.51	0.16	0.24	0.93	1.52	2.8	0.90	1.08

Table 2. Quality attributes of Coll. 1041 and controls at Valparai and Peruvannamuzhi

Line/ Control*	Valparai					Peruvannamuzhi				
	Dry recov. (%)	Bulk density (g)	Piperine (%)	Oleo-resin (%)	Essen tialoil (%)	Dry reco. (%)	Bulk density (%)	Piper-ine (%)	Oleo-resin (%)	Essen tial oil (%)
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Panniyu-1*	30.0	512	3.0	9.4	2.0	-	-	-	-	-
KS-27*	-	-	-	-	-	34.0	565.2	3.0	10.6	3.6

Highly Pungent Chilli (*Capsicum grossum* L.) DRLT-1107 (Naga Jalokia) (INGR No. 03092; IC 399066)

Subash Chandra Das
Defence Research Laboratory, Tezpur-784101, Assam

DRLT-1107 (Naga Jalokia) is a highly pungent chilli germplasm it is an endemic herbaceous annual with plant height of 50-90 cm. 1.5-3.0 cm stem diameter; leaves are yellow and flat, alternate, petiolate, elliptical, wavy, dark green, 5-16 cm long, and 3-6 cm wide. Flowers are complete, actinomorphic, pedicellate, pentamerous, greenish white 0.5-1.0 cm. Fruits are pendulous, wrinkled, yellowish green at young stage and deep red at maturity and 3-7 cm long. The genotype contains maximum capsaicin and dihydrocapsaicin contributing to a pungency of 855,000 SHU (Scoville heat unit) in comparision to Red Savina (577,000 SHU) and famous Thai chillies (100,000 SHU) which is highest till date (Das, 2000). Also, it is disease resistant and tolerance to insect, pest and nematode of chilli.

Reference

Das Subash Chandra (2000), The hottest chilli variety in India. *Curr Sci* **79:** 287-288.

Bold Seeded with High Azadirchtin–A Selection of Neem, DOR Neem 2 *(INGR No. 03093; IC 395308)*

N Mukta
Directorate of Oilseeds Research, Rajendra Nagar, Hyderabad-500 030, Andhra Pradesh

DOR NEEM 2 is a bold seeded selection of neem with high kernel yield and high Azadirachtin-A content, identified from collection of an approximately 20 year old tree growing at Narkhoda village in Rangareddy district, Andhra Pradesh. The region receives an annual rainfall of 700 mm and maximum temperature upto 43°C during the months of April-May. The tree attained a girth at breast height of 177 cm in the year 2000 and was selected, based on the size of the fruit and seed, which were analysed for oil and Azadirachtin-A content

of Coll. 1041 compared to check is presented in Tables 1 and 2 respectively. Also it is tolerant to root rot disease with an index 2 against 4 of Karimunda (2 = rotting of 50% or less root).

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	95-96	96-97	97-98	98-99	99-00	00-01	01-02	
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Table 2. Quality attributes of Coll. 1041 and controls at Valparai and Peruvannamuzhi

Line/ Control*	Valparai					Peruvannamuzhi				
	Dry recov. (%)	Bulk density (g)	Piperine (%)	Oleo-resin (%)	Essen tialoil (%)	Dry reco. (%)	Bulk density (%)	Piper-ine (%)	Oleo-resin (%)	Essen tial oil (%)
Coll. 1041	**35.0**	**582**	**1.4**	**8.5**	**3.2**	**30.5**	**569**	**1.9**	**7.8**	**3.0**
Panniyu-1*	30.0	512	3.0	9.4	2.0	-	-	-	-	-
KS-27*	-	-	-	-	-	34.0	565.2	3.0	10.6	3.6

Highly Pungent Chilli (*Capsicum grossum* L.) DRLT-1107 (Naga Jalokia) (INGR No. 03092; IC 399066)

Subash Chandra Das
Defence Research Laboratory, Tezpur-784101, Assam

DRLT-1107 (Naga Jalokia) is a highly pungent chilli germplasm it is an endemic herbaceous annual with plant height of 50-90 cm. 1.5-3.0 cm stem diameter; leaves are yellow and flat, alternate, petiolate, elliptical, wavy, dark green, 5-16 cm long, and 3-6 cm wide. Flowers are complete, actinomorphic, pedicellate, pentamerous, greenish white 0.5-1.0 cm. Fruits are pendulous, wrinkled, yellowish green at young stage and deep red at maturity and 3-7 cm long. The genotype contains maximum capsaicin and dihydrocapsaicin contributing to a pungency of 855,000 SHU (Scoville heat unit) in comparision to Red Savina (577,000 SHU) and famous Thai chillies (100,000 SHU) which is highest till date (Das, 2000). Also, it is disease resistant and tolerance to insect, pest and nematode of chilli.

Reference

Das Subash Chandra (2000), The hottest chilli variety in India. *Curr Sci* **79:** 287-288.

Bold Seeded with High Azadirchtin–A Selection of Neem, DOR Neem 2 *(INGR No. 03093; IC 395308)*

N Mukta
Directorate of Oilseeds Research, Rajendra Nagar, Hyderabad-500 030, Andhra Pradesh

DOR NEEM 2 is a bold seeded selection of neem with high kernel yield and high Azadirachtin-A content, identified from collection of an approximately 20 year old tree growing at Narkhoda village in Rangareddy district, Andhra Pradesh. The region receives an annual rainfall of 700 mm and maximum temperature upto 43°C during the months of April-May. The tree attained a girth at breast height of 177 cm in the year 2000 and was selected, based on the size of the fruit and seed, which were analysed for oil and Azadirachtin-A content

were 39.2 per cent and 0.5 per cent respectively. Though Azadirachtin-A content upto 0.959 per cent has been reported in a study conducted by Venkateswarlu *et al.*, (1996) the maximum 100-seed weight reported in the collection is 22.9 g, which is lesser than DOR Neem 2 (30.0 g).

Reference

Venkateshwarlu B, GR Korwar, K Mukhopadhyaya, and Jayjayanthi Mukhopadhyay (1996) scope and viability of neem plantations for producing quality seeds for biosesticide industry. In: Proceedings & Extended Summaries of International Conference on Neem-Setting Goals for a global vision, 20-22 December. Neem Foundation, Mumbai, pp 72-78.

A Novel Orchid Hybrid, Dendrobium 'A Abraham' *(INGR No. 03094; IC 401584)*

PG Latha, N Mohanan and S Seeni

Tropical Botanical Garden and Research Institute (TBGRI), Palode Thiruvananthapuram-695 562, Kerala

Dendrobium 'A Abraham' is a novel flowering orchid hybrid developed in 1996 by hybridization between a creamy white flowered *Dendrobium* hybrid called *D.* Ng Eng Cheow as the male parent and deep purple flowered *Dendrobium* hybrid called *D.* Tay Swee Keng as the female parent. *Dendrobium* 'A Abraham' grows erect and is stouter than both parents. The canes are 60-75 cm high, 1-2 cm diameter with 4-7 cm long internodes, greenish with parallel purple anthocyanin-rich stripes, on the sheath. Leaves 2-6 in number are elliptic lanceolate, actue towards the tip of the mature canes. Inflorescence is 30-70 cm long with green peduncles. Flowers are 5-7 cm across, lightly purple, white between the veins of sepals and petals; pedicles greenish-white; sepals 2.5-3 x 1-1.5 cm, oblong, acute, lighter than petals; petals 3.0-3.5 x 1.5-2 cm ovate-rhomboid, slightly emarginated at tip, narrow at base; lip dark purple with darker purple shade at the throat; mid-lobe of the lip not lobed, acute with a thickened tomentose cushion at the base; column purple. It is named after the late Professor. A. Abraham, the Founder-Director of TBGRI. It is fast growing and multiplies by the frequent production of robust 'keikis' from the base of the stock. The flowers of this hybrid exhibit the mixed characters of both the parents. (Seeni and Latha, 1990) but overall morphologically close to that of *D.* Ng Eng Cheow, having petals and lips are larger in size. Most of the first flowered plants are floriferous, as evidenced from 15-20 well spread flowers seen on a spike, produced from the axils of upper leaves and more than 5 spikes, produced from a cane. The young robust rooted offshoots (keikis) developing from the base of the stock can be grown in 10 inch perforated orchid pots, placed on concrete benches.

References

Abraham A and P Vatsala (1981) *Introduction to Orchids.* Tropical Botanic Garden and Research Institute, Trivandrum, 108 p.

Seeni S and PG Latha (1990). Green pod culture and post-transplanation growth of a hybrid *Dendrobium.* In: "New Avenues in Crop Breeding". Proceedings of the National Seminar on Plant Genetics and Biotchnology, CMS College, Kottayam, pp 50-53.

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