INDIAN JOURNAL OF
ARID HORTICULTURE
2012, Vol. 7 (1-2) : 1-11

Conservation and management of plant genetic resources of arid fruits : A review

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Received: November, 2012, Accepted: April, 2013

Abstract

Arid climate is characterized by harsh environmental conditions such as low rainfall, high evapo-transpiration and high temperature. The arid zone soils are very poor in fertility, organic matter and water holding capacity. The soils of the north-western arid region described as 'desert soils' and order of Aridisols are light in texture. The ground water resource is not only limited but is also of saline quality. The average annual rainfall is very low and varies from 100 mm in north- western sector of Jaisalmer to 450 mm in the eastern boundary or arid zone of Rajasthan. The rich genetic diversity is available in arid fruit crops such as ber (*Ziziphus mauritiana);* boradi (*Ziziphus rotundifolia*), Lasoda (*Cordi*a *myxa*), Ker (*Capparis decidua*), Phalsa (*Grewia subinaequalis*), Pomegranate (*Punica granatum*), Date palm (*Phoenix dactylifera*),Bael (*Aegle marmelos*), Pilu (*Salvadora spp.),* Karonda (*Carissa carandus*), Fig (*Ficus carica*), Wood apple (*Feronia limonia*), Mulberry (*Morus* spp.), Manila tamarind (*Pithocelobium dulce*), etc. and it should be conserved for crop improvement programme. Due to hardy plant types, these fruit plants can thrive well under drought situations, which is common feature in arid region. The fruit crops which have the potential for commercial exploitation are yet to be exploited to their potential for providing food and livelihood security in semi arid and arid parts of the country. These fruit plant species produce edible nutritious fruits and other products of economic importance. In this paper, the genetic variability, conservation and utilization in arid fruits have been discussed for genetic improvement and sustainable production in arid region.

Kew words: *Arid fruits, germplasm conservation, genetic diversity, arid region,*

Introduction

A wide range of genetic variability is available in arid fruit crops which are mainly grown in arid and semi arid parts of the country. However, this vast genetic pool has so far largely remained underutilized. Conservation of plant genetic resources is essential for future crop improvement programmes (More and Singh, 2008). This genetic variability can be effectively utilized for the development of desired varieties in fruit crops as limited work has been done on arid fruit crops, which are perennial in nature. The common objectives in crop improvement of arid zone fruits till now have been to improve the quality attributes and appearance of fruits in addition to fruit yield. These goals were achieved mostly by exploiting the naturally occurring intra-species variability in fruit species. Most of the varieties grown, presently, are seedlings or clonal selections. The other important objectives in breeding of arid fruit crops includes the development of varieties / rootstocks, which perform well even under extremes of temperature regimes and can withstand water stress or have low water requirement, besides tolerance for other abiotic and biotic stresses. Frost is common features in hot arid region. To date, there are no varieties in arid zone fruits against frost/low temperature tolerance. Traits like dwarf canopy in order to increase orchard plant density, selecting self-fertile genotypes to maintain a higher consistent yield over time and selecting genotypes with higher nutritional value of the fruits also need to be taken into account in breeding depending on the fruit crop, which is to be dealt with. India is home of variety of minor fruit commonly found in semi arid and arid regions which includes ber, aonla, fig,lasoda ,karonda phalsa, ker and Khejri (Dhillon and Saxena,2005).

Improvement of fruit crops is difficult owing to long gestation period, high heterozygosity, scanty information on inheritance pattern, often cross pollination, excessive fruit drop, polyploidy and less number of seeds per fruit restricting the availability of hybrid seedlings for evaluation. These characteristics make breeding techniques difficult, expensive and time consuming. Even though, planned hybridization and clonal selection have been attempted in a number of fruit crops and these efforts have resulted in the development of promising varieties in grape, guava, sapota etc. This explains why some fruit crops have been improved almost exclusively with clonal selection, using variability from spontaneous mutations or selecting plants derived from natural hybridization. There is vast potential in crop improvement in underexploited fruit crops of arid region. Recently molecular and biotechnological approaches such as somaclonal variation, gene transformation or protoplast technology provide the scope for making significant changes to varieties, but less progress has been made in the

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arid zone fruit crops (Singh *et. al.,* 2012).However, systematic and dedicated efforts are still required for the development of ideal varieties through modern tools in arid fruit crops (Shukla *et. al.,* 2011).

In this review paper, genetic variability, varietal status, breeding approaches and progress made will be dealt, while taking into account work done at different places in our country on arid fruit crops such as ber, pomegranate, bael, aonla, custard apple, date palm, phalsa, lasoda, wood apple, tamarind and fig.

Table 1. Status of Germplasm of Arid fruits at National Active Germplasm Site (NAGS).

CIAH, Bikaner			**CHES, Godhra**		
Name	**Scientific name**	**No.**	**Name**	**Scientific name**	No.
Ber	*Ziziphus mauritiana*	318	Ber	*Ziziphus mauritiana*	55
Bordi	*Z. rotundifolia*	22	Custard apple	Annona squamosa	09
Pomegranate	*Punica granatum*	150	Pomegranate	*Punica granatum*	45
Aonla	*Emblica officinalis*	10	Aonla	*Emblica officinalis*	14
Date palm	*Phoenix dactylifera*	60	Sapota	*Achras zapota*	07
Bael	*Aegle marmelos*	17	Bael	*Aegle marmelos*	40
Jamun	*Syzigium cuminii*	02	Jamun	*Syzigium cuminii*	50
Cactus pear	*Opuntia ficus indica*	20	Tamarind	*Tamarindicus indica*	25
Phalsa	*Grewia subinaequalis*	06	Phalsa	*Grewia subinaequalis*	02
Fig	*Ficus carica*	03	Fig	*Ficus indica*	05
Mulberry	*Morus spp.*	15	Mango	*Mangifera indica*	52
Marula nut	*Sclerocarya birrea*	01	Wood apple	*Feronia limonia*	10
Sweet orange	*Citrus sinensis*	03	Karonda	*Carissa carandus*	40
Karonda	*Carissa carandus*	08	Mahua	*Madhuca latifolia*	50
Lasora	*Cordia myxa*	65	Chironji	*Buchanania lanzen*	30
Pilu	*Salvadora spp.*	02	Khirni	*Manilkara hexandra*	30
Ker	*Capparis decidua*	06			
Manila tamarind	*Pithocelobium dulce*)	03			

Conservation and Management of Genetic Resources of arid fruits:

There are two principal methods of germplasm conservation, which are referred as '*in situ*' and '*ex situ*' conservation approach. *In situ* refers to maintaining plants in their original habitat for instance at farmers' fields (also known as on-farm conservation), while *ex situ* conservation imply maintaining plants outside their original habitats under facilities like genebanks, field gene banks/ NAGS or botanical gardens. Experience shows that diversity is only secure when diverse conservation strategies are employed. *Ex situ* and *in situ* approaches are not mutually exclusive; no single method of conservation is optimal for all situations, and no single method can succeed alone. Different conservation systems can complement each other and provide insurance against the shortcomings of any one method. Germplasm of arid fruits have been collected and conserved in field gene banks at AICRP on AZF centres located in different parts of country (Dhandar and Singh, 2004). However, in this paper, emphasis has been made primarily on *ex situ* approaches as documentation is available on the status of *in situ* germplasm conservation in arid fruit crops.

Ber (*Ziziphus mauritiana Lamk.*)

The genetic diversity exits in ber growing areas of the country and it should be exploited for different traits. Maximum variability in ber is available in dry parts of country as well as desert. Several ber germplasm including species, cultivars and other types have also been collected at different Research stations in the country and are being maintained in the field gene banks. Among various field gene bank centres, CIAH, Bikaner; NBPGR, Jodhpur; MPKV, Rahuri; CCS HAU, Hisar; CAZRI, Jodhpur, Regional Station, PAU, Bahadurgarh, SDAU, S.K. Nagar are important centres . At CIAH, Bikaner highest collections (318) have been made in the National Field Repository. A large number of cultivars (> 150) are in cultivation in India. In India, a number of varieties have been developed and released through selection methods**.** Most of the common cultivars are the result of selection made by local people in different regions of the country. The promising cultivar under commercial cultivations are Gola, Seb, Banarsi Karaka, Banarsi Pebandi, Kaithali, ZG-1, Sanaur-1, 2, 3, 4, Katha, Umran, Mundia, Chonchal, Illaichi, Rashmi, etc. (Shukla *et al*, 2011). B.S.75-1 variety of ber has been developed from CCS HAU, RRS, Bawal

which is resistant against fruit fly and powdery mildew. Hybridization work is going on in ber at HAU, RRS, Bawal and highest fruit yield was obtained in Hybrid-1 (64.7 kg/tree) and incidence of powdery mildew was negligible followed by Hybrid-10 (63.7 kg per tree) (Anon., 2011).

Narendra Ber Selection-1 has been released from NDUA&T, Faizabad and it is performing well under climatic conditions in Eastern UP (Anon, 2011). The new promising ber varieties such as Thar Sevika and Thar Bhubharaj developed by CIAH, Bikaner for cultivation in arid conditions has been released (Shukla *et al.*, 2004).

Thar Sevika (CIAH Hybrid -1): It has been developed by the hybridization from a cross Seb x Katha. Thar Sevika is an early maturing variety. The fruits are juicy, sweet with a TSS content of 22-24%. Fruits after consumption do not cause throat soaring, which is common in other cultivars. Average fruit yield of five year old tree is 30-32 kg/tree. The hybrid is also suitable for staggered picking which can be done up to third week of January.

Thar Bhubharaj: A selection from local material of Bhusavar area of Bharatpur district of Rajasthan, CIAH-Selection-1 is an early maturing cultivar having an average yield potential of five year old tree is 30-35 kg/tree. It is free from fruit rot. The fruits are ready for harvesting during last week of December-first week of January. The fruits are very juicy, sweet with a TSS content of 22-23%.

Goma Kirti: It is a clonal selection from cultivar Umran and developed at CHES, Godhra, Gujarat. It is a clonal selection from cultivar Umran done at CHES, Godhra. It is high yielding, early maturing variety, which fetches good price in the market. Fruit yield potential at 5 year age is 35.60 kg per tree. Fruit size is 3.97 x 3.05 cm. TSS is 30.7° brix. It has superior keeping quality. It is resistant to various diseases and pests by virtue of its earliness (More *et al*, 2008).

Pomegranate (*Punica granatum*)

Pomegranate (*Punica granatum*) belongs to family Punicacae with 2n = 16 chromosomes. The fruit has wide consumer's preference for its attractiveness, juicy, sweet:-acidic ratio and refreshing arils. There is also a growing demand for good quality fruits both for fresh use and processing into juice, syrup and wine. Pomegranate production has attracted several growers in India, but the genetic improvement of this fruit crop has not received much attention.

There are several varieties of pomegranate both adapted to tropical and sub-temperate climate. Some are evergreen while others are deciduous. In India, until recently Ganesh pomegranate variety was by far the most popular one. Improvement in pomegranate has been made through selection and a number of selections have been developed (Choudhari and Shirsath, 1976). This is a seedling selection from a hard seeded 'Alandi'. It produces large size (400-450 g), fruits with sweet (16-17^{0}Brix) arils containing soft seeds. But the arils are pink or light pink in colour. Phule Arakta and Bhagawa variety has been released from MPKV, Rahuri, Maharashtra during 2001. These varieties are suitable for export purpose. Three varieties viz., 'Ruby', 'Phule Arakta', 'Mridula' with red aril colour were developed using 'Ganesh' as base. Phule Arakta is a segreegant of Ganesh x Gul-e-Shah Red having deep blood red soft sweet arils of average fruit weight 250-350g. Bhagava is also segregate of Ganesh x Gule-e-Shah Red having attractive cherry colour soft, sweet arils and with better keeping quality of fruits. The average fruit weight is of 350 to 400g. All these varieties derive genes for red aril colour from Russian temperate varieties. 'Ruby' is a multiple hybrid resembling more of 'Ganesh', but for the red aril colour, while 'Arakta' is A F_2 selection for dark red arils. Among the 16 Bhagava types collected Sel. No.-4 registered lowest maturity period (177days) higher numbers of fruit per plant (52), maximum juice percentage (56.6%) and maximum fruit weight (298.7g).

Recently, another variety under various names-'Bhagava', 'Ashtagndha', 'Mastani', 'Keshar' Sinduri has gained popularity among the growers for its external and internal attractive colour with good shelf life because of thick skin, although it has slightly hard seeds and slow to mature within about 5-6 months (Anon, 2008). There are several other seedling selections which are grown on a limited scale across the country like 'Yercaud', Co-1 (Tamil Nadu), 'Dholka' (Gujarat), 'Jalore Seedless', 'Jodhpur Red' (Rajasthan), Muscat (Maharashtra) and 'Panji' (Goa). In Himachal Pradesh, a sour pomegranate-'Daru', comes abundantly in wild. A rich genetic diversity has been observed in foot hills in Himachal Pradesh (Singh and Singh, 2006). The sour type pomegranate is utilized for anardana purpose. It has potential to exploit for further improvement. Remarkable variability was observed among clones for fruit length, weight, number of arils per fruits and dry weight. This is used mostly in the preparation of *anardana*, an acidulant product used in the culinary preparation. 'Amlidana' is a F_1 hybrid variety suitable for *anardana* production was developed at IIHR, Bangalore. Amlidana is an F_1 hybrid (Ganesh x Nana). It grows well under tropical climate .with quality fruit attributes Amlidana is superior to sour variety Daru , whose trees come up naturally in temperate region of north India . Its fruits provide more acidic (16.18%) anardana and higher fruit yield/tree. In addition, short-statured trees are suitable for high-density planting, giving increase fruit yield/unit area (Jalikop *et. al*., 2002). Under evaluation of germplasm, Amlidana was found suitable for hot arid region for anardana purpose (Singh *et al*, 2011a). However, collections made from H.P. were also found promising for utilization.

Pomegranate is often-cross-pollinated crop and is genetically heterozygous, thus a large variation for several plant and fruit traits is generated in nature as well as upon crossing. Hence, breeding of new varieties may be achieved by seedling selection, hybridization followed by selection or through mutation. However, mutation breeding has some limitations, as it is only a 'hit and miss' method and needs raising of large population to get a

desirable mutant. Development of pomegranate varieties through hybridization mainly involves crossing of selected genotypes, raising of hybrid population, evaluation of hybrids for desirable traits and identification of superior types, which can either be released for general cultivation after elaborate testing could be used in subsequent breeding programme.

When the breeding objective is for disease resistance, like bacterial blight, the progeny should be screened both in the nursery and in field and the resistant types are selected which often require further improvement for fruit traits. Currently two sources of resistance for blight viz., *'Daru'*- a wild sour pomegranate, and *'Nana'* - an ornamental *bonsai* like type have been recognized. If such non-cultivated types are involved in the breeding work, in order to eliminate several undesirable traits, one has to go for repeated backcrosses by making selection in each generation. Once the superior selections are made, they have to be multiplied by air layering and tested against appropriate ruling varieties in a replicated trail before identifying for release. Multi-location evaluation is preferred. Screening of 52 hybrids is in progress. All genotypes were produced sweet arils and low acidic fruits.

Goma Khatta: This variety is developed at CHES, Godhra, Gujarat for Anardana purpose. The yield potential is 6.59 kg/plant and anardana yield is 1.18 kg/plant. Seeds hardiness is medium. Fruit having 46.7% of Juice and TSS is 14.5^{0}Brix. Acidity is 7.3% (More *et al*, 2008).

Pomegranate breeding is slightly easier as compared to breeding of several other fruits as it bears large flowers making hybridization convenient, and produces fruits having abundant seeds, which generally germinate well, and the crop has relatively shorter juvenile phase.

Bael (*Aegle marmelos* Correa.)

Bael plant is found growing naturally in Uttar Pradesh, Bihar, Jharkhand, Madhya Pradesh, Orissa, West Bengal and Chhattisgarh with large genetic variability, which should be exploited. In Uttar Pradesh, Deoria, Basti, Gorakhpur, Gonda, Faizabad, Sultanpur, Jaunpur, Pratapgarh, Mirzapur, Allahabad, Lucknow, Etawah, Agra, etc. are the districts where large number of promising genotypes are either growing naturally or planted near the houses. There is a fast genetic erosion in wild bael genotypes, therefore, its conservation has become necessary (Srivastava *et al*., 1998). Rai *et al.* (1991) reported vivid account of bael genetic diversity available in India. The variability in bael germplasm was observed in identified types at different locations (Rai *et al*., 1991). Apart from the tree morphological characters, wide variability exists in fruit size and shape, bearing habit, flesh colour, texture, fibre content, sugar content, mucilage content, etc in different parts of country(Singh *et al*,2009; Vishalnath *et al*,2003). In Jaunpur area of UP, very old naturally growing bael plants are available. Some types have more number of seeds, gum locules and thick pericarp (Misra *et al*., 2000). However, some selections have been made at NDUA&T, Faizabad and GBPUA&T , Pantnagar and CISH, Lucknow, which are gaining popularity for commercial cultivation. At Central Institute for Arid Horticulture, Bikaner also collection of bael germplasm has been done, which are under evaluation. Besides this, some germplasm were also collected from nursery/farmers' field and maintained in the field repository at CAZRI, Jodhpur; CISH, Lucknow, CCS HAU, RRS , Bawal; NDUAT, Faizabad, GBPUAT, Pant nagar and TNAU, Aruppokottai for conservation and evaluation. Lal (2002) evaluated 12 genotypes collected from Jaipur (Rajasthan) and found that 8 genotypes produce fruits of excellent quality under semi-arid conditions. In Chomu area of Jaipur, fruit sample from seedling plants were collected during 2009. Variation was observed in fruiting, size, quality of fruits and two genotypes were identified. Fruit cracking was also observed in bael trees grown in Sikar district.

It belongs to family Rutaceae having chromosomes number x=9 and 2n=36. There is a wide range of genetic diversity in existing population and ample scope for selection of promising genotypes. Low seeded, less mucilage and medium size fruit is needed with high nutritive and medicinal value. In view of limitations of conventional methods of breeding, biotechnological approaches should be tried for improvement in bael. Recently bael NB-16 and NB-17 from NDUA&T, Faizabad and CISH B-1 and CISH B-2 from CISH, Lucknow has been released for commercial production. Pant Aparna, Pant Sujata, Pant Urvashi and Pant Shivani have been developed from G.B. Pant University of Ag. & Tech. Pantnagar (Singh *et. al.,* 2011) and are suitable for commercial cultivation in different parts of country.

Goma Yashi: It is developed through selection and released from CHES, CIAH, Godhra Gujarat. It produces very good quality fruit with weight of 1.0 to 1.25 kg/ fruit. Fruit are ovate in shape, greenish yellow. Plants are of drooping type and suitable for high density planting. It is early maturing variety. Flesh colour is straw colour.

Fruit shell weight is 180. Number of locules is cross section/ fruit is 17. It is suitable for dry land condition and fruit cracking is also less. The fruit yield in a six years old plant is 40-50kg.

Aonla (*Emblica officinalis* Gartn.*)*

Aonla is medicinal fruit tree and generally growing in the forests and also cultivated in systemic manner. A number of aonla variety series like NA-6, NA-7,NA-9, NA-10 have been developed from NDUA&T, Faizabad;,Annad Aonla-1,Aonla-2, from AAU, Anand, and CISH, Lucknow. Laxmi-52 aonla is a selection and recently released from CISH, Lucknow. The genetic diversity of wild grown aonla is found in forests throughout the country which are still unexploited for their commercial utilization and conservation. It is a salinity and drought tolerant plant but susceptible to low temperature in arid region. Fruit is used for making several ayurvedic medicines and for making value added products such as squash, juice, candy, preserve, sweets, mouth freshener,etc.. Very little efforts have been made to collect vast variability for valuable traits like bearing potential,

nutritional and medicinal value, insects & disease resistance, frost tolerance, etc. Almost all varieties are developed through selection methods in Aonla (Mehta and Singh, 2003). Recently, a selection from plus tree, Goma Aishwariya an early, drought tolerant variety has been released from CHES, Godhra. The average yield potential is 102.9 kg/tree. It has low fibre content and is suitable for processing and export (More *et al*, 2008). Aonla BSR-1 small sized fruit, good bearer, reddish colour fruit, has been released from TNAU, Coimbatore. In aonla, the major problem is of frost/low temperature and there are no varieties available to tackle this problem especially in hot arid region. Development of suitable genotypes of frost resistant is required.

Annona fruits *(Annona chenimola*)

Annona is one of the 40 genera of Annonacae family. It has 120 species, 5 of them have pomological significance. Among the edible *Annonas*, cherimoya (*Annona cherimola*.), sugar apple (*A. squamosa*) and the hybrid between the two, atemoya, are most popular. The other less important edible *Annona* species are *A. reticulata* L. (Bullock's Heart), *A. diversifolia* (Ilama) and *A. muricata* (sour *spp*). The edible *Annonas* species differ for fruit traits and are amenable for genetic manipulation, as they cross with each other easily. Each species can benefit from the other edible *Annonas* for one or the other specific fruit and/or plant traits and hybridizing them should generate useful recombinants as illustrated by the popular *atemoya*.

Among the annonaceous fruits, sugar apple, locally called *sitaphal* or *sharifa* is by far the most relished and widely consumed fruit of India. Most of the *Annona* varieties in cultivation were often developed by clonal or seedling selection by mainly exploiting the intra species variability. Sugar apple plants come in wild abundantly in the vast arid tracts of the country. There are few varieties like Balanagar, Red Sitaphal, Local Sitaphal, British Guinea, Mammoth and Washington. Presence of several big seeds and poor shelf life are the major constraints limiting cultivation of *sitaphal* fruit on a commercial scale.

Inter-specific hybridization:

Evolving *Annona* hybrids is primarily same as described for pomegranate, only care necessary is that the hybrid seeds have to be stratified by keeping under running water for about 48 hours for better seed germination. *Annona* breeding was initiated at Indian Institute of Horticultural Research, Bangalore, several intra- and inter-specific hybrids were produced and evaluated, which resulted in isolation of variety 'Arka Sahan' from the cross atemoya (cv. Island Gem) x Sugar Apple (cv. Mammoth). This exemplifies the use of allied species in breeding of arid fruits, if the traits of interest are not detected in the same species. Hybridization work is also being done in Custard apple at MPKV, Rahuri and Hybrid No. -6, Hybrid No.-13 and Hybrid No.-22 have been found promising. Hybrid No.- 13 has bigger fruit size and less seed percentage (7.02%) and TSS 26% with higher yield (12.3kg/plant) than other hybrids.

Fruit set in *Annonas*

'Arka Sahan' has remarkable sweetness (>32^{o} B TSS; 22.8% total sugars), scanty small seeds (9/100 g fruit weight) and slow ripening (6-7 days). The pulp is snow-white (76%), mealy and juicy with a mild pleasant aroma. As in other *Annonas*, in this hybrid also few flowers of (about 1-2%) develop into fruits owing to male and female structures maturing at different time, besides limited insect and wind pollination. To supplement this, simple artificial hand pollination was worked out by testing different pollen source. Hence, even after a superior genotype is isolated, sometimes it may require further improvement in order to realize the full potentiality of the genotype.

APK (Ca)-1 is a custard apple variety developed through selection and released by RRS, T..N.A.U., Aruppukottai for rainfed conditions. It has good bearing habit. The average fruit weight is 182.2g, pulp weight 11.13g per fruit and TSS 27.9^{o} brix.

Date palm (*Phoenix dactylifera* L.)

A rich genetic diversity is available in costal belt of Kachchh region, Gujarat in India which should be exploited (Singh *et al*., 2009). In other parts of country, seedlings are growing in meagre population. At CIAH, Bikaner, 60 genotypes/ cultivars have been conserved in National field gene bank collected from different available sources as well as introduced from abroad. Further, SDAU, DRS, Mundra, (Gujarat); CAZRI, Jodhpur, SKRAU, Bikaner, PAU, RFRS, Abohar, (Punjab); Central State Farm, Jetsar, Sri Ganganagar, has also maintained and evaluated the date palm germplasm. There is no hybrid reported in date palm so far. Further, no breeding work has so far been taken up on date palm in India except evaluation of cultivars/genotypes against rain damage and selection of some promising female seedlings from the Kachchh region of Gujarat. Most of the cultivars of date palm have introduced from different countries from time to time e.g. Halawy, Barhee, Medjool, Khalas, Sayar, Zahidi (USA), Khadrawy (Iraq), Barshi , Khuneizi, Nagal, Khashab (Oman), Hatemi, Tayar, Ruziz (Saudi Arabia), Amri, Sakloti, Agloni, , Chipchap and Braim (Iraq) during 1998. Sewi and Amhat (Egypt) during the year 2009. Both cultivars have established well under field conditions.

All the commercial date cultivars have developed through selection of chance seedlings based on local needs. From the rich genetic diversity of nearly 1.66 million palms developed from seeds in the coastal belt of Kachchh region of Gujarat, 20 promising palms have been selected, most of which yield non-astringent fruits at doka stage (Muralidharan *et al.*, 2008). One of them bears coconut shape fruit. These selections flower twice in a year. An early ripening date seedling has been identified at Abohar.

At Abohar, Zahidi cultivar has been found to be resistant to rain damage; Barhee is more tolerant than Shamran. It was also found that Medjool is resistant to rain damage, as it missed rains during fruit ripening, which is a late maturing cultivar. A large number of varieties and some promising selections (Sel. - 9, Sel.-13, Yaqubi, Kotho, Trofo, Gulchati, Bhugoso, Madhepura, Khedoi-7, Sopari,

Saidy,) have been made in our country from natural populations existing in Kachchh region. Some selections have also been made by the farmers of the region (Muralidharan *et al.*,2008). Further, these yellow and red berry colour types are suitable for making different processed products (Singh *et al.,* 2011). An elite type of green colour, sweet berry at doka stage has been identified from seedlings population in Kachchh region of Gujarat.

Fig (*Ficus carica* L.)

The edible fig (*Ficus carica* L.) is well known since prehistoric times. Currently several tropical countries are growing fig as a commercial fruit crop and it has emerged as an important fruit in the world trade. Fresh fruits have a luscious taste and are highly nutritious but fruits are mostly sold in the dried form as figs are easily handled and keep well in dried state. Fig is grown in more than 3000 ha area in our country.

Poona Fig is the most popular cultivar in our country. The varieties Bangalore, Bellary, Coimbatore, Daulatabad, Dindigul, Ganjam, Hindupur, Lucknow and Saharanapur have clearly acquired the names from the locations in which they are grown. Since, these varieties resemble cv. Poona Fig in plant and fruit morphology, they are possibly clones or ecotypes of cv. Poona Fig and hardly warrant varietal status. Dinkar, an improvement over cv. Daulatabad for yield and quality is a recently identified variety, both of which resemble Poona Fig variety in fruit characteristics. The other varieties Black Ischia, Shahi, and Maisram are yet to achieve prominence. As many as 700 varieties of fig are known in the world and there is good scope to introduce, evaluate and popularise the exotic fig varieties in our country. Recently some promising types have identified.

In India hybridization programmes in fig have yet not been initiated. California is a major producer of fig in the world and strategic-breeding programmes are going on since several decades at University of California. In 1986, Indian Institute of Horticultural Research introduced 20 promising hybrids /varieties from California. When these varieties were raised from the rooted cuttings in the field they put-forth very little growth and produced very poor crop. However, the fruit quality was excellent. Therefore, Brown Turkey, a vigorous growing entry in the germplasm was identified for chip budding the exotic figs on it. The rootstock was successful in imparting vigour and precocity to otherwise slow growing varieties.

Three exotic varieties viz., Deanna, Conadria and Excel were found promising. All the exotic types are early, and like Indian edible figs, fruit develop syconia parthenocarpically *i.e.*, without the interference of fig wasp, which assists pollination in several edible and non-edible types. The eye or ostiole of fruits of cv. Poona Fig is loose which facilitates easy access to pulp for insects and fungi. Thus the ripe fruits spoil quickly and the fruits split open at the ostiole. However, the tight eye of Conadria and Excel protect the fruit from spoilage and splitting (Anon, 2011).

Deanna produces large sized fruits while fruit size of cvs. Conadria and Excel is comparable with Poona. Fruit shape is pyriform in all the varieties, except Excel, which has ovoid fruits. No clear difference is noticed between Poona Fig and exotic types for total soluble solids. Fruits of cvs. Deanna and Excel, which are suitable for drying, retain their colours even after processing. The new introductions hold great promise for expanding area under fig in India. They also offer a good opportunity to farmers for exploiting the marginal land in arid and semi-arid regions where this fruit can be grown successfully. Thus introduction of appropriate promising varieties, testing and popularization (if found suitable) can be easy, fast and straightforward approach in expanding area under cultivation of given arid fruit crops.

Lasoda (*Cordia myxa* Roxb.)

It is known as Indian cherry, lehsua or goonda. The other important species are *C. gharaf* ,(goondi), *C. rothii, C. macleodii, C. vestita* and *C. wallichii*. Out of these, goondi (*Cordia gharaf*) is a popularly grown species. Medium size tree having dense foliage with crooked trunk. Lasora leaves have sunken stomata and other characters of drought tolerance. Plants are deciduous in nature (Singh *et al.,* 1996).The vegetative growth is very fast in lasora plant. New flush comes in spring (March) when plant enters in flowering phase. Bunch of light yellow colour, hermaphrodite fragrant flowers born auxiliary on current season growth. Flowering in lasoda is reported to change from place to place during the period of March-April in arid region (Pundhir, 1987). The duration of flowering varied from 41 to 50 days and the peak flowering reached 16 days after the first flower initiation .The development of flower bud takes about 21-22 days. According to Pundhir (1987), fruit setting was about 33.0 % and application of GA at 100 ppm produced the highest fruit set (59.96 %). Flowers are pedicillate, complete, perfect and actinomorphic. Individual florets are nearly 5 mm in diameter. At places these are somewhat hairy and white. The calyx part of an independent flower is about 8 mm long and glabrous, but not pubescent. It splits irregularly at the opening of its bud into flower. The filaments are hairy. Bunch of light yellow coloured hermaphrodite fragrant flowers are borne axillary on current season's growth. Fruits are formed soon after flowering and ripen during MayJuly, while the immature green fruits are available during April-June. Fruit is drupe, 13 cm long, yellowish brown and pink at ripening. The pulp is sweet, viscid, and transparent surrounding the stone (Yadav and Goel, 2006). Immature green fruits are available in April-May while ripe fruits are available during June-July. Fruits are mucilaginous with a stone (Singh and Vishwanath, 1991).

Great variation exist in natural population with respect to morphological characters particularly plant height, spread, leaf size, fruit size; fruiting behaviour; quality parameters like fruit colour, pulp content, pickling quality, seed and pulp ratio etc. Even, there is a small fruited types of lasoda locally called as gundi of which fruit is very small size (about 1 cm), orange to light pink in colour at maturity but very much liked by the rural people of western Rajasthan and Gujarat.

The proper efforts have not been done to conserve

genetic diversity of lasoda trees. However, in the recent past some efforts have been made by NBPGR Regional Station, Jodhpur and Central Institute for Arid Horticulture, Bikaner to identify some big fruited types with high productivity. At CCS HAU., Hisar, different genotype was evaluated by Saini *et al.* (2002) and they have reported variability in plant height and spread. Kaushik and Dwivedi (2004) reported wide range of biodiversity in morphological and quality characters from 45 collection of *lasoda* from Haryana.

There is no named or improved cultivar in lasoda. In general, two types of plants viz., large fruited and small-fruited are found growing and are sold by nurserymen. Large fruited cultivars have an average fruit weight of 8.55 g, whereas small-fruited cultivars have fruit weight of 3.0 g. In case of large fruited cultivars, fruit have comparatively more pulp thickness and therefore are suitable for consumption. A large fruited types in Gujarat also recognized as 'Paras Gonda', is a general term for any fruit variety with big size fruits. Similarly in Rajasthan 'Puskar Local' is of big size with good fruit shape. At CIAH, Bikaner under *ex-situ* conservation, 65 types of lasoda have been collected and planted under field conditions to identify promising types. One promising type of lasoda has been identified**.** CIAH Selection 1 is performing well under irrigated hot arid ecosystem with respect to fruit size, pulp content and productivity. The average annual production of tender fruit is more than 100 kg tree (Vishalnath *et al.,* 2008). However, plants are susceptible to frost/very low temperature during winter season. It is most suitable tree for wind break and shelterbelt because its growth is very fast and dense foliage. No systematic work has been conducted on its water and nutrients requirement. Attack of diseases and insects is less on lasoda plants in arid region. The average yield of tender fruit is about 50 - 60 kg/ plant. The potential of lasoda tree in arid region should be exploited at commercial scale.

Phalsa *(Grewia subinaequalis*)

It is a minor fruit crop of Sub-tropical region. It is native to India. It is one of the most hardy fruit plant, drought resistant and thus requires little care with low inputs. It can be grown almost in all parts of north India except at higher elevations. It is mainly grown in the states of U.P., Bihar, Rajasthan, Haryana, Punjab, Gujarat, Maharashtra, Andhra Pradesh and Madhya Pradesh. Phalsa being very vigorous in growth can be an ideal plant for plugging gullies and ravines and for contours to protect bunds. The plants are multiplied through seeds and stem cuttings. Being a bush, it can be grown as filler plant in aonla, bael, ber orchards. It is mainly propagated through seeds and stem cuttings. The small fruits have to be picked from bush several times during the fruiting season and thus the cost of production is increased considerably. It is a small bush and bears many berries like fruits. Fruits ripen by the end of May and beginning of June. Fruits are perishable and keeping quality is very less. Its fruits are eaten as fresh .The fruits are highly perishable and are used in preparation of squash and juice. Ripe fruits are acidic in taste and rich source of vitamins A and C. Its medicinal properties are known since vedic times. Its fruits have cooling effect. Fruits are good source of carbohydrate, proteins, minerals and vitamins. Processed products like jam, squash and pickle can also be prepared from phalsa fruits. Bark of plants is used during preparation of jaggary for improvement of the quality. Pruned phalsa canes/shoots can be utilized for making baskets to transport fruit and vegetables to distant market.

There is no remarkable variability found in case of phalsa except erect and bushy type plant habit. It is mainly grown on boundary of farm and orchards. The genotypes large fruit size with less seeds and high pulp content should be identified and utilized. The fruit is highly perishable and used as fresh as well for processing purposes. There are no known varieties except local types. Its improvement requires varieties with long storability and keeping quality. It is mainly planted in orchards as filler crop and as hedge plants on the boundary. It can be planted at 2-3m distance. Fast growth of plants and regular pruning has good potential for its cultivation. It is pruned from 10cm above ground level every year. Fruit yield is low (2- 4 kg/bush) in comparison to other fruit crops depend on management practices.

Karonda (*Carissa carandus*)

It is one of the few fruits indigenous to India while 30 species of genus *Carissa* have been reported; many species are found growing wildly in India while other species came from Malaysia and South Africa. It is cultivated throughout India in tropical and sub-tropical areas. In India *Carissa* are found growing most widely in plains and hills and grow wild in Deccan Peninsula, Maharashtra along the west coast, parts of Gujarat, Punjab, foot hills of J & K, U.P., Uttarakhand and Arrawali hills, Mount Abu (Rajasthan). In karonda plants, thorns are found and is suitable fruits for dry land horticulture. Karonda is generally grown on the boundary of orchard, farm, fields as bio-fencing. There is no regular orchard. Karonda fruits are mainly used for pickle and jelly preparation.

Carissa species are mainly propagated by seeds but the seedlings are slow in growth, variable and are ordinarily not ready to plant until about 2 years old. The other drawback with seeds is that they are recalcitrant, which hampers the availability of planting material throughout the year. The other methods of propagation such as hard wood stem cuttings in open nursery, semi-hardwood stem cuttings under mist, softwood cuttings with the use of auxins under mist, air layering, stooling and grafting have been tried in the past but with variable success. The above methods are cumbersome, time consuming, labour expensive, weather dependent and produce limited number of plants per unit time to meet the growing demand for planting material of superior types. The soft wood cuttings planted under mist condition have found very success to raise plants under arid conditions. Rooting in soft wood thin cuttings was 100% under mist. As *Carissa* is planted at closer spacing and requires large number of plants per unit area, some alternative method is

required to produce large number of uniform plants. Hence in order to remove this major constraint in increasing area under *Carissa* cultivation and to protect the valuable germplasm from being eroded, micro-propagation can be tried.

On the basis of fruit colour, the cultivars of Karonda can be classified as : (i) Green fruited, (ii) Pink fruited, and (iii) White fruited. There is a quite resemblance in the shape and size of their fruits. However, there is a tremendous scope for improvement using selection force and vegetative method of propagation. Some promising clones have selected in Maharashtra. These are K_1, K_2, K_3 (Joshi *et al.*, 1986). At MPKV, Rahuri, promising clones as No. 3, 12, 13 and 16, have been identified (Karale *et al.*, 1989). At GBPUAT, Pantnagar, three clones have been selected and named as Pant Manohar, Pant Sudarshan and Pant Suvarna. These varieties are of big fruit size and high yield. It is generally planted on farm/ orchards boundary and it is very important plant for live fencing. It is evergreen shrub or small tree and attain height of 3 to 6 m when allow to grow. The species is thorny bush commonly found in degraded areas and ideal for use in hedges. A promising genotype of Karonda (CHES K-1) has identified at CHES, Godhra which is red colour fruit type and high yield potential.

Keeping in view, fast growing, drought tolerance and high yielding genotypes should be identified. It is susceptible to frost/low temperature; hence, frost tolerance types should be identified for hot arid regions.

Tamarind (*Tamarindus indica*)

Tamarind (*Tamarindus indica* L.) is an excellent tree for social forestry, agro-forestry, wasteland development and dry land horticulture. The tree assumes great significance due to its multifarious uses and capacity to withstand adverse agro-climatic conditions. The pulp of the mature, ripe fruit has considerable export value in many parts of the world.

There are several types of tamarind. They can be broadly grouped under three types based on fruit size and shape, colour of pulp, taste etc., as follows.

Tamarinds in the America are of the shorter type. Paulos (1975) recognized a tamarind type known as "Valakatchi" which bears long and rectangular pods as against some other types, which produce short and cylindrical pods. Karale (1998) reported that tamarind pods vary considerably in size and shape and variability in yield of pods and quality is found. Many are sickle shaped while some have straight long pods (16 to 22 cm) while others were with short pods. Seeds also exhibit a wide range of variation in shape size, colour and the ornamentation of the seed coat.

On the basis of pulp colour

There are two distinct phenotypes of tamarind based on mainly their pulp colour.

1. The yellow or brown pulp type turning dark brown on storage. It is harvested after full maturity.
2. The reddish pulp type is locally known as *"Raktichinch*". The term red type covers the various shades of pink pulped fruits. The red type is sweeter than brown (common) type because it has lower content of free acids and is generally harvested when fruits are immature and green. It is mostly prefered for making preserves. A high yielding Red type (*Yogeshwari variety*) has been released by Marathwada Agricultural University, Parbhani, Maharashtra.

On the basis of organoleptic taste

The cultivated types could be broadly classified into two groups namely sweet and sour types.

Sweet type: The ripe fruits of this type have sweeter pulp coupled with less acidity and fruits are mainly used for dessert purpose (Karale, 1998). Makham Waan, Secthong breed, Manila sweet are few cultivars found mostly in South East Asia (Thailand). A sweet type viz., No. 263 has been located by MAU, Parbhani.

Sour type: It is highly acidic in taste and pulp is commercially marketed. The tamarind variety `Pratisthan' released by Fruit Research Station, Aurangabad is a sour type and is reported to constitute of 61 per cent pulp, 12 per cent seed and 27 per cent shell. The sour type selections `Urigam' and `Cumbum' (good yielder) are popular in Tamil Nadu. A high yielding sour type PKM-1 (Periyakulam-1) has been released during 1992 from Horticulture Research Station, Periyakulam, Tamil Nadu . This cultivar is preferred for its early bearing habit and claimed to be suitable for high density orcharding (160 plants/acre against 40 plants/acre under conventional planting). Patil *et al*, (1997) reported high yielding elite types DT-1 (500 kg) and DT-28 (450 kg) from University of Agricultural Sciences, Dharwad.

Trees of outstanding merit are to be selected after a thorough survey in the tamarind growing regions. The selected trees should have higher yield potential, excellent fruit quality and better performance for precocious and regular bearing. The fruits should contain thicker pulp with less seeds, yellow or dark red pulp colour with extra white endocarp (locally known as *phool patti*) coupled with high acidity are desirable attributes of tamarind pulp (Karale *et al.*, 1997). The average composition of the pod is 55 per cent pulp, 34 per cent seed and 11 per cent shell and fibre. The selected types should be propagated vegetativly to maintain homogenity in the population and to reduce long juvenile phase and a mother orchard has to be established for preparing planting material.

Success of any breeding programme depends on the selection procedure adopted. The characters under selection should present in high heritability. Genetic analysis reveals wide range of variability among the economic traits. Heritability and genetic advance was higher for mean fruit weight, pulp content and pod girth.

Estimation of genetic divergence among 282 genotypes at 8 different agro-climatic locations revealed high variability for 18 characters. In all 8 principal components accounted for 80 per cent of the divergence. Pulp yield/tree was the most important character contributing to divergence followed by tartaric acid content. Pulp yield/tree ranged between 14.6 and 99.6

kg/tree while seed yield was 3 to 87.5 kg. The range of tartaric acid was 1 to 17.8 kg/ha.

A promising line have been identified and released at Institute level as Goma Prateek from CHES, Godhara, Gujarat. Fruit yield /plant is 58.5kg during 9th year of fruiting under rainfed conditions.

Karale (1998) carried out detailed study on 37 seedling originated genotypes and observed high heterozygosity and large variation with respect to pod shape, size, fruit quality and productivity. Many were sickle shaped while some had straight long pods (16 to 22 cm). The extra white endocarp membrane locally known as "*phool patti*" fetches more price and is an important quality character in tamarind trade. Further, he reported that there was not much difference in respect of TSS content of the pulp among the sweet, sour and red types. But the colour of pulp and seed varied among the types and within the types also. The pulp colour varied from reddish brown to different shades of black and sweet types recorded medium values for various physical characters. Based on positive attributes T-1, T-16, T-22, T-26, T-28, T-29 in sour (brown pulp) type, TR-1 in red pulp type and TS-1 and TS-2 in sweet pulp type were selected as elite types.

Wood apple *(Feronia limonia)*

Wood apple (*Feronia limonia* Linn. Swingle), syn. *Limonia acidissima L. Feronia elephantum* Correa, *Schinus limonia* L. belongs to family Rutaceae. Wood apple is also called kainth, monkey fruit, curd fruit and kathabel in India. The wood apple is native to India and common in the wild form in dry plains of India and Ceylon. It is also found growing throughout South East Asia, in Northern Malaya and on Penang Island. In India, the fruit was traditionally a “Poor man's food” until processing techniques were developed in the mid-1950's. It occurs, wild or cultivated, up to an elevation of 1500 ft, in Western Himalayas, but more common in the Deccan; Thane and Chandrapur districts of Maharashtra. It is also reported to occur in parts of Hazaribagh, Palamu and Chhota Nagpur in Jharkhand, in forest of Vidhyan hills of Uttar Pradesh and Chattishgarh. It is often cultivated on borders of fields and as a roadside tree near villages and sometimes planted as orchards. There are no regular plantations however; stray plants along the border of fields, roads, railway lines and banks of the river are the common places where the plants are found.

There are two types of wood apple, one with fruit larger and sweeter than the other and states that the ripe fruit pulp contains 2.3 per cent acid and 7.25 per cent sugars. Fruit is much used in India as a liver and cardiac tonic, and when unripe, as a means of halting diarrhea and dysentery and effective treatment for hiccough, sore throat and diseases of the gums. The pulp is poultice on to bites and stings of venomous insects as is the powdered rind. Juice of young leaves is mixed with milk and sugar candy and given as a remedy for biliousness and intestinal troubles of children. The powdered gum, mixed with honey, is given to overcome dysentery and diarrhea in children. Oil derived from the crushed leaves is applied on itch and the leaf decoction is given to children as an aid to digestion. Leaves, bark, roots and fruit pulp are used against snakebite. The leaves are aromatic, carminative and astringent.

Biotechnological approaches for improvement of arid fruit crops

Biotechnology is emerging as a powerful tool for crop improvement. Biotechnological approaches like gene transformation and somaclonal variation are attractive as they make possible a great range of improvements to varieties in a short period of time with little or no change in the genetic makeup of otherwise acceptable variety. Application of biotechnological tools in crop improvement programmes can be effective in three different complementary ways: speeding up the process of conventional breeding, creating genetic variability through tissue culture, and evolving novel genotypes through recombinant- DNA (r-DNA) technology (Chopra and Sharma, 1991). Somatic hybridization approach helps in generating cybrids by fusion of two sexually incompatible species. In developing new fruit varieties, biotechnology has two main applications: (1) transfer of desirable genes from quite distant living being, and (2) assist the conventional breeding programmes by reducing the time required for developing a variety and the number of progenies to be raised in the field. Genetic engineering enables to add any gene from any living organism including bacteria. Moreover, biotechnology makes it possible to transfer specific genes to a crop variety in one step, avoiding several back-crossing that is often followed, which is very difficult and time consuming and sometimes impractical because of perennial and heterozygous nature of many of the arid zone fruit crops. Anticipated changes in climate and its variability, particularly extreme temperature and changes in rainfall patters are expected to make crop improvement even more crucial for food production the biotechnological approaches such as molecular breeding and genetic engineering and their integration with conventional breeding to develop crops that are more tolerant of abiotic stresses (Varshney *et al*,2011). Biotechnology is a viable option for developing genotypes that can perform better under harsh environmental conditions. Biotechnology approaches have the potential to enhance crop production under different stress conditions.

The steps involved in transfer of foreign gene include: (1) selection and isolation of gene of interest from the appropriate living organism, and (2) gene transfer to target tissue capable of regeneration. Transformation could be achieved either by using Agrobacterium vector or electroporation microinjection. Although methods for DNA delivery into plant cells are well standardized, unpredictable transgenic expression and its subsequent stability in the new background limit the practical transformation of many plant species. Recombinant DNA gene transfer, embryo manipulation, plant regeneration, cell culture, monoclonal antibodies and bio processed engineering. These techniques can transform idea into practical application, viz. certain crops can be genetically altered to increase their tolerance to certain herbicides. Biotechnology offers new ideas and techniques applicable to agriculture and also develops a better understanding of

living system of our environment and over selves. It has a tremendous potential for improving crop production.

Conventional breeding has several limitations among others; it is time consuming, difficulty of raising large population and poor understanding genetics of several traits. Micro propagation technology ensure true to type, rapid and mass multiplication of plants that possesses special significance in vegetatively propagated plant species. Research in genomics allows high- resolution genetics analysis for physical mapping and positional gene cloning of useful genes for crop improvement. Molecular (DNA) markers help in precise characterization of germplasm, construction of saturated linked maps and DNA fingerprinting of crop varieties. Molecular markers are now increasingly being used for marker- assisted gene pyramiding and alien gene introgression. Current research, involving large scale DNA sequencing, microarrays and robotics, is heading towards gene revolution and nanobiotechnology (Mendeley, 2010). Hence, genome mapping, aimed at molecular markers tightly linked to the traits under selection, is particularly important in fruit tree species in permitting early selection of the most interesting genotypes. Molecular markers based on PCR technology, such as RAPDs, AFLPs and SSRs have been found more efficient than markers such as RFLPs and isozymes in characterizing genotypes. Sivalingam et al, (2012) characterized twenty two germplasm accessions of Cordia myxa collected from Rajasthan through morphological and RAPD markers. In their study, out of 50 random decamer primers used for random amplification (RAPD), 25 were polymorphic. Average polymorphism resolved by these markers among these accessions was 69.8% with an average polymorphic information content of 0.43. Genetic diversity revealed by Jaccard's co-efficient was between 0.44 and 0.94, and three major clusters were identified among these accessions by phylogenetic analysis using NTSYSpc-2.02e software. RAPD markers associated with leaf size and pulp:stone ratio were also identified. This study shows the existence of high genetic diversity among these accessions.

Moisture stress and high temperature tolerance are the traits that are to be addressed often in arid fruit crop breeding. In response to moisture stress heat shock proteins have been identified in some plants. Modification of heat shock proteins in the cell via genetic engineering has been done in herbaceous plants indicating a possible use of this strategy for increasing thermal tolerance in arid fruits (by use of appropriate promoters). Many of the horticulturally valuable varieties or rootstocks often show very poor rooting ability. Rooting can be improved by inoculating Agrobacterium rhizogenes by wounding the basal part of in vitro micro cuttings.

The concentrated efforts and standardization of several techniques like induction of somoclonal variation and in vitro selection, somatic embryogenesis, in-vitro regeneration, protoplast culture, genetic transformation in arid fruit crops is necessary if we have to see biotechnological tools benefiting this group of fruits production.

In conclusion, it could be mentioned that despite several limitations and problems associated with breeding of arid fruit crops by conventional methods, novel biotechnological approaches will not replace the former approach, but it will effectively compliment the traditional breeding methods. Conservation of genetic resources of arid fruits are very essential for future crop improvement programme.

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INDIAN JOURNAL OF
ARID HORTICULTURE
2012, Vol. 7 (1-2) : 12-15

Genetic variability and heritability for quantitative characters in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) for rainfed system

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Received November, 2012; Accepted March, 2013

Abstract

The study was carried out on twenty genotypes of bottle gourd collected from diversified areas of the country assessed under rainfed condition for genetic variability, heritability and genetic advance in respect of 16 quantitative characters. The genotype LS-6 recorded the highest fruit yield per plant, highest no of fruits per plant lowest sex ratio and highest fruit set percent, followed by LS-20. The phenotypic and genotypic coefficient of variation for different characters ranged from 6.270-34.045 and 3.749-30.732 respectively. The highest PCV and GCV were observed for fruit yield per plant, fruit length, no. of fruits per plant and sex ratio indicating the extent of variability based in these characters. High heritabilty coupled with higher genetic gain was observed for no. of seed per fruit, fruit length, no. of fruits per plant and yield per plant indicating the additive gene action. Days to first fruit harvest showed moderate to low heritability with low genetic gain expressed non -additive gene action governing these characters.

Keyword: *Heritability, bottle gourd, PCV, GCV*

Introduction

Bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) is an important vegetable crop among cucurbitaceous vegetable grown in the country . It is grown in an area of 1.17 lakh ha with a production of 14,28,296 M.T. and productivity of 12.21 t/ha. (Sidhu, 2002). Although the crop is cultivated widely in large part of the country, the productivity varies from season to season and region to region ie. hot arid (Samadia, 2002) to coastal region (Karuppaiah *et al.*, 2002) in cucurbit crops, especially the areas like zero irrigation ie rain fed ecosystem where the crop faces water stress during flowering and late fruit development stages due to inadequate soil moisture leads to higher loss in marketable fruits. Thus there is a need to identify stable varieties for a particular region and location. Rios Labrada *et al.* (1998) studied the role of pumpkin land races for tolerance to marginal condition characterized by drought, high temperature and biotic stress interactions. Such information's are lacking in bottle gourd. Hence, screening of germplasm is essential to select best genotypes for commercial exploitation for zero irrigation areas. As the success of any breeding programme is to pickup desirable genotypes based in the wide genetic base and the larger genetic variability resulting from it, the present study was undertaken to study the extend of variability and heritability with respect to yield and yield components to identify best genotypes adapted to zero irrigation areas.

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Materials and Methods

The present study was conducted at Central Horticultural Experiment Station, Vejalpur, Gujarat comprising twenty diversified genotypes collected from different parts of the country. The genotypes were assessed in the field experiment under randomized block design replicated thrice. Six plants were maintained in each replication spaced at 3.0 x 1.5m between rows and plants, respectively. Cultural practices including need based plant protective measures were followed. The data was recorded from five randomly selected plants from each genotypes in each replication for main vine length (m), no. of primary branches, internode length (cm), days to first female flower anthesis (days) , node of first female flowers appears, sex ratio, days to first fruit harvest (days), Fruit set (%), no. of fruits per plant, yield per plant (kg), fruit weight (kg), fruit length (cm), fruit girth (cm), fruit flesh thickness (cm), 100 seed weight (g), no. of seed per fruit. The mean data were subjected for statistical analysis as per method of analysis of variance (Panse and Sukhatme, 1961), estimation of variance components and coefficient of variation (Johnson *et al.*, 1955) and heritability in broad sense and genetic advance as percent mean (Robinson *et al.*, 1949)

Results and Discussion

The extent of variability present in germplasm was estimated in terms of range, mean, standard error, phenotypic and genotypic coefficient of variation. The analysis of variance (Table 1) showed significant mean sum of square estimates for all the characters under study indicating great wealth of variability among the genotypes

selected for all the economic traits. The genotype LS-8 recorded the highest mean value for main vine length (12.15m). The lowest time taken for first female flower anthesis was observed in the genotype LS-14. The genotype LS-6 expressed the lowest sex ratio, highest fruit set, highest no of fruits, higher no of primary branches per plant and higher fruit yield per plant (Table 2). The lowest time taken for first harvest and higher crude protein content were observed in LS-19.

Estimation of quantitative variation like mean, range and standard error etc doesn't indicate the relative amount of variability, the coefficient of variation appears to be a better index when the characters with different units of measurements are to be compared. In the present study, considerable differences between Phenotypic (PCV) and genotypic (GCV) coefficient of variation were observed for the character studied. All character showed higher the PCV than the corresponding GCV due to interaction of the genotypes with the environments and by environmental factors influencing the expression of theses characters. The highest phenotypic coefficient of variation was observed for no. of seeds per fruit (37.329), yield per plant

Table 1. Abstract of analysis of variance for different characters of Bottle gourd genotypes under rainfed condition

Sl. No	Characters	Mean sum of Square values			F values
		Replication (d.f. =2)	Genotypes (d.f. =19)	Error (d.f. =38)	Genotypes
1	Main vine length (m)	2.028	14.97**	1.257	11.901
2	No of primary branches	4.693	4.989**	0.295	16.901
3	Internodal length (cm)	2.47	5.885**	0.51	11.486
4	Days to first female flower anthesis (days)	7.194	54.640**	7.798	7.006
5	Node of first female flower appears	0.087	31.662**	3.575	8.854
6	Sex ratio	1.015	16.825**	1.421	11.837
7	Days to first fruit harvest (Days)	97.539	33.329**	12.483	2.669
8	Fruit set percent (%)	192.63	196.58**	32.15	6.114
9	No of fruits per plant	0.544	15.133**	0.449	33.672
10	Yield per plant (kg)	1.403	17.529**	1.233	14.215
11	Fruit weight (kg)	0.220	0.139**	0.045	3.031
12	Fruit length (cm)	62.208	540.80**	20.23	26.723
13	Fruit girth(cm)	44.27	72.39**	4.697	15.410
14	100 seed weight (g)	6.104	10.975**	1.064	10.305
15	No of seeds per fruit	429.755	44335.5**	549.16	80.732
16	Crude fiber content	7.976	7.338**	1.175	6.240

** Indicates the significant at 1%, * indicates the significant at 5%

Table 2. Range of variability for different morphological characters among Bottle gourd genotypes

Sl.No	Characters	Range	Mean±SE	Standard Deviation	Genotype
1	Main vine length (m)	4.38-12.15	9.316± 0.915	1.121	LS-17-LS-8
2	No of primary branches	4.738-9.446	6.772 ±0.443	0.543	LS-13-LS-6
3	Internodal length (cm)	12.00-16.77	14.687± 0.584	0.715	LS-4-LS-16
4	Days to first female flower anthesis	42.87-56.24	47.231± 2.280	2.792	LS-14-LS-3
5	Node of first female flower appears	10.86-22.04	15.365± 1.543	1.890	LS-12-LS-10
6	Sex ratio	5.36-13.33	8.470± 0.973	1.192	LS-6-LS-5
7	Days to first fruit harvest	61.55-74.94	70.305± 2.884	3.533	LS-5-LS-19
8	Fruit set (%)	15.65-52.58	34.361 ±4.629	5.670	LS-5-LS-6
9	No of fruits per plant	4.13-12.75	7.554 ±1.662	2.036	LS-19-LS-6
10	Yield per plant (kg)	5.00 -13.35	7.583 ±0.906	1.110	LS-1-LS-6
11	Fruit weight (kg)	0.94 -1.88	1.319 ±0.175	0.214	LS-6-LS-8
12	Fruit length (cm)	24.13-67.05	42.428± 3.673	4.498	LS-3-LS-5
13	Fruit girth (cm)	23.26-39.26	30.659± 1.769	2.167	LS-2-LS-12
14	100 Seed weight (g)	11.71-18.74	15.018 ±0.842	1.031	LS-7-LS-3
15	No of seed per Fruit	192.67-616.62	329.66 ±19.133	23.434	LS-6-LS-15
16	Crude fiber content	10.90-16.94	13.028 ±0.885	1.084	LS-13-LS-19

(34.045), fruit length (32.807) and no. of fruits per plant (30.689). Moderate values of PCV was observed for fruit set percent (27.138), main vine length (25.916), node to first female flower appears (23.409), fruit weight (21.054) and no. of primary branches per plant (20.137). The PCV was ranged from 6.270 to 17.030 for the other remaining characters. Rajnarayanan *et al.* (1996) also observed lower values of PCV for days to first female flower anthesis in bottle gourd The genotypic coefficient of variation measures the extent of genetic variation among the genotypes within the particular characters. The highest genotypic coefficient of variation was observed for no. of seeds per fruit (36.646), yield per plant (30.732) and fruit length (31.046). Moderate values of GCV were observed for no. of fruits per plant (27.370), sex ratio (26.751), main vine length (22.949), fruit set percentage (21.545). The lower values of GCV was observed for days to first fruit harvest (3.749), days to first female flower anthesis (8.369), internode length (9.111). Rajnarayanan *et al.* (1996) also observed lower values of GCV for days to first female flower anthesis in bottle gourd. The magnitude of phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all the traits. It is further understood that suitable plant type could be selected where there is minimum difference between phenotypic and genotypic coefficient of variation indicates the least environmental influence. High degree of disparity between PCV and GCV was recorded for fruit weight, fruit set percent showing that these characters were being much susceptible to environmental fluctuation. These findings are in accordance with the findings of Mohanty and Mishra (1999) in pumpkin except for fruit set.

A character can be improved only if it is highly heritable. The magnitude of heritability indicates the effectiveness with which the selection of genotypes can be made a phenotypic performance (Johnson *et al.*, 1955). The success of selection depends on the breeding values of a genotype required from its phenotypic expression. The degree of correspondence between phenotypic and genotypic value and breeding value for a character is measured by heritability, which indicates the reliability of the former as a guide to the latter. In the present study, highest heritability was observed for no. of seeds per fruit (96.3) and no. of fruits per plant (91.5), fruit length (89.5), no. of primary branches per plant (84.1), fruit girth (82.7) and fruit yield per plant (81.4), main vine length, sex ratio, Internode length, 100 seed weight, node to first female flowers, days to first female flower anthesis, crude fiber content, fruit set percent. Joshi *et al.* (1981) and Rastogi and Arya Deep (1990) also observed high heritability for yield per plants, fruit weight and No of fruits per plant in cucumber. The Moderate heritability was observed for days to first fruit harvest and fruit weight in the study, indicated the considerable role of environment. High heritability indicated the large proportion of phenotypic variance was attributable to genotypic variance and the difference for these traits among genotypes was real and these characters are governed by additive gene action. Therefore, such high heritability estimation has been found to be helpful in making selection of superior genotypes on these traits on the basis of phenotypic expression. However, heritability estimates along with genetic advance is more useful than heritability values alone for selecting best individual.

The genetic gain reveals the genetic potential of the characters under selection and effectiveness of the selection. It also emphasizes the quantum of gain obtained under particular selection pressure. If the heritability were mainly due to additive effects, it would be associated with high genetic gain and if it is due to non additive (dominance and epitasis), the genetic gain would be low (Panse, 1957). In the present study, expected genetic gain ranged from 4.618 (days to first fruit harvest) to 74.110 (no. of seeds per fruit) (Table 3). High estimate of genetic gain were observed in the order for no. of seeds per fruit, fruit length,

Table 3. Genotypic and phenotypic variance, Genotypic and phenotypic coefficient variation, Heritability,Genetic advance and Genetic gain of Bottle gourd genotypes

Sl. No	Characters	(GV)	(PV)	Coefficient of variation		(H)	(GA)	Genetic gain
				(GCV)	(PCV)			
1	Main vine length (m)	4.571	5.829	22.949	25.916	78.4	3.900	41.865
2	No. of primary branches	1.564	1.860	18.470	20.137	84.1	2.363	34.890
3	Internodal length (cm)	1.790	2.303	9.111	10.332	77.7	2.430	16.550
4	Days to first female flower anthesis	15.614	23.412	8.369	10.244	66.6	6.647	14.072
5	Node of first female flower appears	9.362	12.937	19.913	23.409	72.3	5.361	34.896
6	Sex ratio	5.134	6.556	26.751	30.228	78.3	4.131	48.770
7	Days to first fruit harvest	6.948	19.431	3.749	6.270	35.7	3.247	4.618
8	Fruit set (%)	54.811	86.961	21.545	27.138	63.0	12.108	35.237
9	No. of fruits per plant	4.894	5.344	27.370	30.689	91.5	4.361	57.903
10	Yield per plant(kg)	5.432	6.665	30.732	34.045	81.4	4.334	57.158
11	Fruit weight (g)	0.031	0.077	13.378	21.054	40.3	0.231	17.513
12	Fruit length (cm)	173.52	193.76	31.046	32.807	89.5	25.67	60.524
13	Fruit girth (cm)	22.564	27.262	15.493	17.030	82.7	8.90	29.037
14	100 Seed weight (g)	3.303	4.368	12.102	13.916	75.6	3.255	21.679
15	No of seed per Fruit	14595.4	15144.6	36.646	37.329	96.3	244.31	74.110
16	Crude fibre content	2.054	3.230	11.001	13.795	63.5	2.354	18.072

(GV- genotypic variance, PV Phenotypic variance, PCV- Phenotypic coefficient of Variation, GCV-Genotypic coefficient of variation, GA- Genetic Advance)

no. of fruits per plant, yield per plant, sex ratio, fruit set percent, main vine length, node of first female flower appears and no. of primary branches per plant, fruit girth and 100 seed weight indicates the higher response to these characters to selection. Moderate genetic gain was observed for crude fiber content, fruit weight, internode length, days to first female flower anthesis. The low magnitude of genetic gain was observed for days to first fruit harvest. Raj narayanan *et al.* (1996) also reported low genetic gain for Days to first fruit harvest in bottle gourd.

The characters showing high heritability coupled with high genetic gain possess high selective value and offer ample scope for efficient selection. Rajnarayanan *et al.* (1996) also reported high value of GCV and heritability estimates along with greater genetic gain suggesting of additive gene effect governing the inheritance of such traits. In the present study, high value of GCV, highest heritability coupled with higher genetic gain was observed for no of seeds per fruit, fruit length, fruit yield per plant, sex ratio, main vine length, node of first female flower appears and fruit set percent indicated these character governed by additive gene action. Singh and Rajesh Kumar (2002) also observed high heritability for fruit yield, vine length fruit diameter, fruit length and no. of primary branches per plant indicating the predominance of additive gene action involved in these characters in bottle gourd and contradicting for fruit weight. Raj Narayanan *et al.* (1996) also reported low GCV and lower value of genetic gain for days to fruit harvest and fruit weight in Bottle gourd. The Fruit yield per plant can be raised by 4.334 kg with a selection pressure of 5% intensity and this improvement would 57.158% of mean yield per plant. This is in conformity with the findings Mohanty and Mishra (1999) in pumpkin. Karuppaiah *et al.* (2002) also reported high heritability coupled with higher genetic gain for no. of female flowers per plant, yield per plant, no. of fruits per plant and flesh thickness in ridge gourd. Krishna Prasad *et al.* (2002) also observed additive gene effect for no. of fruits per plant and yield per plot in Watermelon.

Days to first fruit harvest showed low genotypic coefficient of variation and moderate heritability coupled with low genetic gain indicated the non-additive gene action. Dahiya *et al* (2001) also reported moderate to high heritability with low genetic gain for days to first picking, days to 50% female flowering and fruit weight in bottle gourd. Raj Narayanan *et al.* (1996) also reported low GCV and low heritability coupled with low genetic gain for days to fruit harvest and fruit weight in bottle gourd. Karuppaiah *et al.* (2002) also reported non-additive gene action for days to first fruit harvest in ridge gourd. This implies that the selection over several successive generations following hybridization of desirable transgressive segregates. Node to first female flower appears and days to first fruit harvest showed low heritability with low genetic gain indicating marked influence of environment for expression of these characters and they need to be tested under diverse environment s for their effective selection.

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INDIAN JOURNAL OF
ARID HORTICULTURE
2012, Vol. 7 (1-2) : 16-21

Inspirational factors in adoption and production of *Kachri* (C*ucumis callosus)* on large scale in hot arid parts of western Rajasthan: An assessment

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Received: December, 2012; Accepted : February, 2013

Abstract

The study was conducted in Bikaner district of western Rajasthan and inspirational factors, which encourage the farmers to adopt and produce the *kachri* (C*ucumis callosus)* in hot arid eco-system, *were assessed.* The major inspirational factors which motivate the farmers for the adoption and production of *kachri* on large scale in hot arid eco-system were "substantial income from fresh fruits of *kachri*, substantial income from dried (dehydrated) *kachri*, low cost of cultivation, minimum loss due to the attack of insects and diseases, very low water requirement of the crop, high seed germination capacity of the crop, accessibility of drought hardy local varieties, the vegetables of mature *kachri* fruits is most favorite, *kachri* vegetable has a special test and flavour, its preserved items are most liked and acceptable in the society, high demand of *kachri* fruits in localities/ local markets/villages, high demand of value added products of *kachri* in the markets, very good storage life of the fruit. Among the major factors which restrain the adoption and production of *Kachri* at large scale in hot arid eco-system, were; scarcity of water, very low and erratic rainfall and occurrence of drought very frequently, lack of viable schemes and support system for *kachri* growers, no standardized technique is available for value addition of *kachri*, very deep and salty ground water, inadequate supply of electricity, poor marketing system and market intelligence, lack of knowledge and awareness among the farmers about improved technologies of *Kachri* cultivation.

Key words: *Kachri, inspiration factors, constraints in adoption*

Introduction

Kachri (C*ucumis callosus)* is one of the most important and drought hardy cucurbitaceous vegetable crop of hot arid region of western Rajasthan. It is grown at large scale in hot arid ecosystem of the region during both rainy as well as summer season. It is one of the most important and most favorite vegetable of hot arid region. It is one of the major component crop of mixed cropping system followed in hot arid ecosystem of western Rajasthan. Almost, all the farmers of western part of Rajasthan grow it on their fields as a sole crop or intercrop or mixed crop during *Kharif* and summer season of the year. It is one of the most ancient vegetable crop of the Indian desert and is being grown under extremely harsh climatic conditions at commercial scale. It can give good production even under very low rainfall / limited irrigation, poor soil and other hostile climatic conditions of western Rajasthan. The Central Institute for Arid Horticulture, Bikaner, Rajasthan is working from long back to develop improved technologies to encourage the production of k*achri* crop in harsh climatic conditions. Recently, the Institute has developed two improved varieties (AHK-119 and AHK-200) and other agro-techniques of production which become the boon for the farmers of the hot arid zones.

The farmers of Bikaner district of western Rajasthan adopt and produce k*achri* at large scale during k*harif* and summer season and earn a lot of money and other benefits from it. It is one of the major component crop of their cropping system, particularly of their mixed cropping system. However, the actual reasons which inspire the farmers to produce k*achri* at large scale in hot arid ecosystem of Bikaner district are not yet crystal-clear. Keeping these facts in mind, this study was conducted in Bikaner district of western Rajasthan with the following objectives:

1. To assess factors which inspire the farmers for adoption and production of k*achri* at large scale in hot arid eco-system.
2. To analyze the factors which restrain the adoption and production of *Kachri* at large scale in hot arid eco-system.

Materials and methods

The present study was conducted in Bikaner district of western Rajasthan. The district consist of eight revenue Tehsils. Out of these, two Tehsils namely, Bikaner and Lunkarnsar Tehsils were selected randomly for the study. With the help of secondary data available at each selected Tehsil's headquarter, a list of the total number of villages falling under these two Tehsils were prepared separately during the study. On the basis of population size, all villages of these Tehsils were categorised in three groups i.e. small, medium and big villages. Further, four villages were selected randomly from each above

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categories of villages. Thus, a total of 24 villages were selected from concerned two Tehsils for the study. All *kachri* growing farmers of these selected villages were listed one by one on the occasion study and divided in three groups i.e. small, medium and big farmers (*kachri* growers). Amongst the selected 24 villages, two small farmers, two medium small farmers and two big farmers were selected randomly from each group of above farmers. In this way, 6 respondents (*kachri* growers) were chosen from each category of so selected villages by using random method of sampling. Thus, a total of 144 respondents (*kachri* growers) were selected amongst the above groups of the farmers of 24 villages of the selected two Tehsils. Further, the selected *kachri* growers were personally contacted and interviewed one by one to assess factors which inspire them to adopt and grow *kachri* crop at large scale on their fields. Simultaneously, the factors which restrain adoption and production of *kachri* crop at large scale were also collected. To find out the rank order of different inspirational factors of the farmers, each factor was assigned with specific score as per response of individual farmer as was interviewed. The first factors of their inspiration was assigned with highest score and last one assigned with lowest score under different groups of the factors. For example, under group of 'economic inspirational factors' there were 8 inspirational factors in total. Therefore, the first ranked inspirational factor was assigned with score 8 (highest) and the inspirational factor which was ranked by farmer as 8th economic inspirational factor was assigned with score 1 (lowest). The final rankings of these factors were work out on the basis of total score obtained by each such factor. To measure the factors which restrain the adoption and production of *kachri* at large scale, a five-point continuum viz:, strongly disagree, disagree, undecided, agree, strongly agree, was developed and used. The score 1,2,3,4, and 5 was allotted in response of strongly disagree, disagree, undecided, agree, strongly agree, respectively. The all responses of the farmers during the survey were recorded on semi-structured interview schedule. The statistical tools like frequencies, scoring, ranking, percentage, etc. were used for analysis and drawing inferences of the study.

Results and Discussion

During the survey, there were observed several inspirational factors which encourage the farmers to grow *kachri* crop extensively. These inspirational factors were grouped as economic, production and technological, socio-religious inspirational factors and inspirational factors related to storage and marketing, agro-ecological aspects, etc. The major such motivational factors as reported by the farmers (*kachri* growers) during the survey are described here.

1. Economical inspirational factors

The data in Table 1, reveals that amongst the economical inspirational factors "substantial income from fresh fruits of *kachri*, substantial income from dried (dehydrated) *kachri, l*ow cultivation cost of cultivation, minimum loss due to the attack of insects and diseases" were the major economical inspirational factors behind the production of *kachri* at large and commercial level which were ranked as first, second, third and fourth important economical inspirational factors with score 822, 777, 765, and 711, respectively. The other economical inspirational factors which leads to large production of *kachri* crop in hot arid environment of Bikaner district were, low cost of picking and handling, enough income from seeds,

Table 1. Economical motivational factors

S.No	Inspirational factors	Score (PMS* =1152)	Rank
1	Substantial income from fresh fruits of *kachri*	822	1
2	Substantial income from dried (dehydrated) *kachri*	777	2
3	Low cost of cultivation	765	3
4	Low cost of picking and handling	612	5
5	Minimum loss due to the attack of insects and diseases	711	4
6	Enough income from seeds	555	6
7	Availability of plenty of land resource.	432	7
8	Availability of surplus family labour / manpower.	323	8

*PMS = Possible Maximum Scores

2. Production and technological inspirational factors

Table 2, reveals that the major production and technological inspirational factors which encourage/motivate the farmers for commercial production of *kachri* in hot arid ecosystem were, " very low water requirement of the crop, high seed germination capacity of the crop, accessibility of drought hardy local varieties, high productivity of the crop, minimal land preparation requirement, and comparatively short duration crops" which were ranked as first, second, third, fourth, fifth and sixth important production and technological inspirational factors which were scored as 1098, 1047, 1007, 964, 888 and 787, respectively. Singh and Singh (2005) reported that the farmers grow vegetables because the vegetables provide regular income to fulfil the needs of food and fodder, create regular employment for family labour and utilize agro- resources efficiently. Swarup *et al.* (1987) also reported that compelling reasons of growing horticultural crops by farmers other than nutritional advantages were favourable climatic features, higher income from per unit area from horticultural crops profitability and employment generation. The other production and technological

inspirational factors behind production of *kachri* on large and commercial scale *kachri* in hot arid ecosystem were 'easiness in sowing and harvesting of the crop, minimal requirement of intercultural operation and agro-chemicals and advancement in production technologies of the *kachri* crop. There is well known fact that the water scarcity and occurrence of frequent drought are the major problem of hot arid regions. In such conditions, the *kachri* crop can be grown with limited irrigation water/rainfall. Its seed germination capacity is very high and it is highly drought resistant crop, it requires minimum land preparation. It is very short duration crop and does not require any special management. Hence, the farmers of Western Rajasthan like Bikaner district produce *kachri* at commercial scale.

Table 2. Production and technological inspirational factors.

S. No.	Inspirational factors	Score (PMS* 1440)	Rank
1	High productivity of the crop	964	4
2	Easiness in sowing & harvesting	703	7
3	Minimal land preparation requirement	888	5
4	Minimal requirement of intercultural operation	606	8
5	Minimal agro-chemicals/pesticides requirement of the crop.	511	9
6	Accessibility of drought hardy local varieties	1007	3
7	Comparatively short duration crop	787	6
8	Very low water requirement of the crop.	1098	1
9	High seed germination capacity	1047	2
10	Advancement in productional technologies	333	10

*PMS = Possible Maximum Scores

3. Socio-psychological inspirational factors

There were several socio-psychological inspirational factors (Table-3) which inspired the farmers of arid regions to produce *kachri* on large scale in their fields. The major socio-psychological inspirational factors as reported by the farmers were, " the vegetables of mature *kachri* fruits is most favorite, *kachri* vegetable has a special test and flavour, its preserved items are most like and acceptable in the society, has high value of nutrition and digestion capacity, preparation of vegetable of *kachri* is very easy and economic, *kachri* fruits are used as in worshiping " which were ranked as 1st, 2nd, 3rd, 4th, 5th and 6th with scores1133, 1112, 1091, 889, 788 and 688, respectively. Maini (1997) also reported that the socio-economic reasons of growing common vegetables were to make value added products. They cited that people in dessert areas of Rajasthan grow vegetables (beans) and fruits like cluster bean, *kachri*, *ker*, *khejri*, *lasoda* etc. to make their value added products and as the main source of vegetables during chronic shortage of common vegetables. Thus, they were inspired to grow these vegetables to meet out their vegetable needs in adverse climatic conditions.

Moreover, a farmer who produces batter higher quantity of *kachri* fruits on his field was viewed as a person having high social status.

Table 3. Socio-psychological inspirational factors

S.No.	Inspirational factors	Score (PMS* =1296)	Rank
1	The vegetables of mature *kachri* fruits is most favorite vegetable of the region.	1133	1
2	*k achri* vegetable has a special test and flavour	1112	2
3	The preparation of vegetable of *kachri* is very easy and economic.	788	5
4	Has high value of nutrition and digestion capacity	889	4
5	Batter production of *kachri* fruit is viewed as high social status	323	8
6	Its preserved items are most like and acceptable in the society.	1091	3
7	Preparation of soft drinks from *kachri* juice	563	7
8	*kachri* fruits are used as in worshiping	688	6
9	*kachri* has esthetic value also.	319	9

*PMS = Possible Maximum Scores.

4. Inspirational factors related to storage and marketing aspects.

Table 4, reveals that the important inspirational factors related to storage and marketing aspects of k*achri* were," high demand of *kachri* fruits in localities/ local markets/villages, high demand of value added products of *kachri* in the markets, very good storage life of the k*achri* fruit, k*achri* fruits are within reach of purchasing capacity of common people, easy in packing, loading-transportation-unloading" which were ranked as 1st, 2nd, 3rd,

4th, and 5th with scores 711, 635, 567, 486 and 412, respectively. During the survey, it was also reported by the farmers that the *kachri* crop was grown not only due to its drought hardiness, high consumption, and high productivity but it can be stored and sold up to a desirable period at different consumption centers / local markets without degradation in its quality and weight. Every body like to eat *kachri* fruits and poorest amongst poor also want to purchase it. Moreover, the k*achri products* have high nutritional value and multipurpose use. Hence, its demand is very high in localities/local markets that is why farmers grow *kachri* crop at large scale to earn money. It has been revealed that horticultural crop production can be promoted/ increased by developing effective and cheap pest control measures, irrigation, storage facilities, efficient transportation facilities, processing, marketing system, etc.

Table 4. Inspirational factors related to storage and marketing aspects.

S. No	Inspirational factors	Score (PMS* = 864)	Rank
1	High demand of *Kachri* fruits in localities/ local markets/villages.	711	1
2	Easy in packing, loading-transportation-unloading	412	5
3	*Kachri* fruits are within reach of purchasing capacity of common people	486	4
4	Very good storage life of the *Kachri* fruit.	567	3
5	High demand of value added products of *Kachri* in the markets	635	2

*PMS = Possible Maximum Scores .

5. Agro-ecological inspirational factors

The farmers disclosed several agro- ecological inspirational factors behind production of *kachri* on commercial scale in Bikaner district (Table 6). They reported that the *kachri* crop has some special agro-ecological beneficial peculiarities which make suitable this crop to grow at large scale in hot arid conditions. The major agro - ecological inspirational factors which motivate the farmers to grow *kachri* crop extensively were " *kachri* is very important component of traditional mixed cropping system of arid regions., *kachri* is most suited crop in hot arid ecosystem, it has high growth capacity even during low rainfall/drought conditions, *kachri* crop helps in soil and moisture conservation and it has high water absorbing capacity ", which were ranked as 1st, 2nd, 3rd, 4th and 5th important agro - ecological inspirational factors with scores 883, 824, 766, 678, and 587, respectively.

The other agro - ecological inspirational factors encouraging the farmers to grow *kachri* crop at large scale on their fields were, "*kachri* crop adds organic matter into the soil and increases soil fertility, it generates suitable micro-climate in the crop field and help in productivity of other fellow crop or succeeding crops." Samadia (2006) also stated that arid region of Rajasthan were best suitable for production of some cucurbits like water melon, (*mateera*), musk melon, snap melon, *kachari*, round melon, etc. during both summer and kharif season of the year. He mentioned that the best quality of these cucurbits are produced in these regions due to high temperature, low humidity and plenty of sunshine at the time of fruit maturity and ripening. The mixed cropping system is prominent cropping system of arid regions in which cucurbits are considered as major components of the above cropping system.

Table 5. Agro - ecological inspirational factors

S. No.	Inspirational factors	Score (PMS* =1008)	Rank
1	*Kachri* is most suited crop of hot arid ecosystem	824	2
2	It has high growth capacity even during low rainfall/drought conditions	766	3
3	*Kachri* crop helps in soil and soil moisture conservation	678	4
4	*Kachri* is a very important component of traditional mixed cropping system of the arid regions	883	1
5	It adds organic matter into the soil and increases soil fertility	514	6
6	It generates suitable micro-climate in crop fields	398	7
7	It has high water absorbing capacity .	587	5

PMS = Possible Maximum scores.

7. The factors which restrain the adoption and production of k*achri* at large scale in hot arid eco-system.

It is a well-known fact that the *kachri* crop is a tremendous crop grown in hot arid ecosystem of western Rajasthan. It is grown at large scale in western Rajasthan. However, the farmers face various constraints in successful production of k*achri* at large and commercial scale. During the survey of present study, the farmers reported various factors (Table 6) which restrain the adoption and production of *kachri* at large scale on their fields. The major such restraining factors as reported by the farmers were; scarcity of water, very low and erratic rainfall and occurrence of drought very frequently, lack of viable

scheme and support system for *kachri* growers, no standardized technique is available for value addition *kachri*, very deep and salty ground water, inadequate supply of electricity, poor marketing system and market intelligence and lack of knowledge and awareness amongst the farmer about improved technologies of *kachri* cultivation," which were considered as 1st, 2nd, 3rd, 4th, 5th, 6th, 7th and 8th important factors which restrain the adoption and production of *Kachri crop* at large scale in hot arid ecosystem of Bikaner district. Singh *et.al* (2005) reported that there were several socio-economic, production and marketing constraints in vegetable production in Almora and Nainital districts of UttaraKhand . Singh (1997) also revealed that lack of adequate hybrid seed, lack of full package of practices, absence of practical training facilities and adequate incentives, lack of publicity and frontline demonstrations of the improved technologies etc. hindered the adoption of improved technologies /hybrid.

Table 6. Major factors which restrain the adoption and production of *kachri* at large scale

S.No.	Restraining factors	Score (PMS*=720)	Rank
1	Scarcity of water	699	1
2	Very deep and salty ground water	539	5
3	Very low and erratic rainfall and occurrence of drought very frequently	692	2
4	No standardized technique is available for value addition of k*achri* fruits.	565	4
5	Per hectare income/return from *kachri* crop is poor	321	11
6	Lack of improved production technologies	377	9
7	Poor extension system	344	10
8	Lack of viable schemes and support system for *kachri* growers	606	3
9	Poor transportation, communication and information network.	256	12
10	Inadequate supply of electricity	511	6
11	Lack of knowledge an d awareness amongst the farmers about improved technologies of *kachri* cultivation.	393	8
12	Poor marketing system and market intelligence	444	7

*PMS= Possible maximum score.

The other factors which restrain the adoption and production of *kachri crop* at large scale in arid ecosystem of Bikaner district of western Rajasthan were, lack of improved production technologies of *kachri* cultivation, poor extension system, per hectare income/return from *kachri* crop is poor, poor transportation-communication and information net work, etc. The farmers wanted to grow *kachri* crop at large scale not only during kharif season but in summer season also. However, the above factors create the problem in large production of *kachri* in hot arid regions of the western Rajasthan. Anon. (2002) also reported that low income, high cost of input, lack of farmers training, lack of location specific technologies, poor and erratic rainfall, water scarcity, occurrence of frequent drought, safety ground water etc. are the major constraints which hinder the horticultural development in arid region.

The present study revealed that there were several economical, production and technological, socio-psychological, storage and marketing, and agro-ecological inspirational factors which encourage the farmers for adoption and production of *kachri* crop at large scale in hot arid ecosystem of western Rajasthan. These factors should keep in mind while preparing any research and developmental programme for large scale production of *kachri* crop in such hot arid regions. However, the farmers also several factors which restrain the adoption and production of *kachri crop on* large scale in hot arid parts of western Rajasthan. Therefore, the suitable strategies and action plan should be prepared to combat these adverse so that farmers can able to produce *kachri* at large scale to sustain their livelihood in such harsh climatic conditions.

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INDIAN JOURNAL OF
ARID HORTICULTURE
2012, Vol.7 (1-2) : 22-25

Soil test based fertilizer recommendation under IPNS for vegetable guar in Torripsamments of Rajasthan

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Received: October,2012; Accepted: April, 2013

Abstract

Soil test crop response correlation studies were conducted with vegetable guar under integrated plant nutrition system (STCR-IPNS) in Torripsamments of Rajasthan during Kharif 2003. Fertilizer adjustment equations under IPNS were formulated for vegetable guar following Ramamoorthy's inductive-cum targeted yield model. The nutrient requirement for producing one quintal of veg. cluster bean was found to be 6.80, 1.17 and 4.62 kg of N,P_2O_5 and K_2O, respectively. The per cent nutrient utilization efficiencies from soil and fertilizer nutrients were found to be 72.72 and 59.62 for N, 33.93 and 17.73 for P_2O_5 and 45.34 and 50.10 for K_2O, respectively. Like wise the percent nutrient utilization efficiency from farmyard manure (FYM) was 200 for N, 32.66 for P_2O_5 and 137.92 for K_2O, respectively. In STCR-IPNS technology, the fertilizer doses are tailored to the requirements of specific yield targets of veg. cluster bean taking into account the contribution from soil, fertilizers and organics.

Key words: *Vegetables cluster bean, STCR-IPNS, fertilizer adjustment equations, Torripsammennts*

Introduction

Fertilizers with instant ability to refurbish depleted nutrients in necessary quantities and forms have come to be recognized as a key component of soil fertility management. The fertilizer prices have gone up and hence their use in required amounts depends much upon the purchasing ability of the farmers. Accordingly, economic rationality dictates a more compressive approach for fertilizer use, incorporating soils tests, magnitude of crop response to applied nutrients and economic evaluation of the results (Katyal, 2001). In these efforts, soil test based fertilizer recommendation plays a vital role in increasing the soil productivity. Research work done using soil test crop response approach in different parts of the country have shown that vegetable crops respond to the nutrients added through organic and chemical fertilizers. Therefore, in sandy soils of the poor fertility, it becomes pre-requisite to use organic manures along with fertilizers to achieve advancement in productivity of vegetable crops in an economically and ecologically sound manner.

Since, in Rajasthan veg. guar is being cultivated in an area of about 598 hectare with a production of 968 metric tones and average productivity of 16.19qha^{-1} (Anoymous 2010-11). Hence, in order to step up the productivity of the veg. guar in the state, soil test based balanced fertilization is essential. Currently, a general recommendation of 50:60:60 kg N, P_2O_5 and K_2O ha^{-1} with 25 tha^{-1} FYM, respectively is being followed. Fertilization based on blanket recommendation results in either over or under use of fertilizers, so balanced fertilization is must for realizing higher efficiency and economy of fertilizer use (Velayutham and Reddy, 1990). In fertilizing the crop, existing soil fertility and crop requirements should be taken into account (Ramamoorthy *et al.*, 1967). This demands the maintenance of optimum balanced between all essential nutrients as per the crop requirements of the nutrients and their availability in soil and possible recycling of organic sources.

Materials and Methods

A field experiment based on inductive methodology was conducted in Torripsamments of Bikaner during Kharif 2003 with vegetable guar (var. M-83). The soil of the experimental field is loamy sand in texture with pH 8.4 and non- saline (EC_2 0.25 dSm^{-1}). The initial $KMnO_4$-N, Olsen-P and NH_4OAc-K status were 82.40, 18.04 and 189.50 kg ha^{-1}, respectively. The P and K fixing retention capacity of the soil observed 62 and 80 kg ha^{-1}, respectively. Following the inductive methodology of the Ramamoorthy *et al*. (1967), four field gradients were created in the preceding season by dividing the experimental field into four equal strips which were fertilized with $N_0P_0K_0$, $N_{1/2}$ $P_{1/2}$ $K_{1/2}$, N_1 P_1 K_1 and N_2 P_2 K_2 levels. An exhaust crop barley (var. RD-2508) was grown so that the fertilizers could undergo transfomations in the soil with plant microbial agencies.

By growing the exhaust crop, the operational range of the soil fertility was created in the fertility stripes, which was evaluated in terms of variations in yield, uptake and soil test values. After the harvest of the exhaust crop, each strip of the fertility gradient was divided into four eqal blocks across the strip for farmyard manure (FYM) levels. Then each strip was divided into 32 plots and distributed fertilizer treatments in such a manner that every treatment was accommodated in each gradient strip as well as in

FYM block.

Pre-sowing soil samples were collected from each gradient plot before superimposition of the treatments and were analysed for alkaline $KMnO_4$-N (Subbiah and Asija, 1956), Olsen-P (Olsen, *et al*., 1954) and neutral N NH_4OAc-K (Hanway and Heidel, 1952). Vegetables guar (var. M-83) crop was grown with usual agronomic practices. The green pod yield and Stover yields of veg. guar were recorded plot wise. The plant samples from each plot were analysed for total N, P and K content (Piper, 1966) and total uptake was computed using veg. guar yield data.

Using the data of veg. guar yield, nutrient uptake, pre sowing soil available nutrients and fertilizer doses applied, the basic parameters viz., nutrient requirement (kgq^{-1}) contribution of nutrients from soil (C_s) and fertilizers (C_f) were calculated as described by Ramamoorthy *et al*.,(1967). The per cent utilization efficiency of nutrients from applied FYM was also estimated in the similar manner. These parameters were used for the formulation of fertilizer adjust equations for deriving fertilizer doses and soil test based fertilizer recommendations were prescribed in the form of a ready reckoner for desired yield target of vegetable guar under INPS.

Results and Discussion

Soil available nutriments and vegetable guar yield

The range and mean values of veg. guar yield, uptake and available soil nutrients of treated and control plots are furnished in table 1.$KMNO_4$-N ranged from 82.40 to 144.70 kg ha^{-1} with a mean of 107.80 kg ha^{-1}, Olsen. P ranged from 18.04 to 40.34 kg ha^{-1} with a mean of 27.28 kg ha^{-1} and NH_4OAc-K ranged from 189.50 to 249.98 kg ha^{-1} with a mean 212.35. The veg. guar yield in fertilizer treated plots ranged from 5.10 to 23.30 q ha^{-1} with and without FYM with a mean value of 13.47 q ha^{-1}, and in control plots ranged from 3.25 to 8.30 q ha^{-1} without FYM with a mean of 25.90 q ha^{-1} with FYM. The above data clearly indicate that a wide variability existed in the soil test values and veg. guar yield of treated and control plots, which is a pre-requisite for calculating the basic parameters and fertilizer adjustment equations for calibrating the fertilizer doses for specific yield targets.

Table 1. Range and mean values of available nutrients in the pre- sowing surface soil, uptake of nutrient and yield of vegetable guar (M-83)

Parameters	Range	Mean
Soil test values (Kg ha^{-1})		
$KMnO_4$-N	82.40-144.70	107.80
Olsen-P	18.04-40.34	27.28
NH_4OAc-K	189.50-249.98	212.35
Vegetable Guar yield (q ha^{-1})		
Treated plots	5.10-23.30	13.47
Control plots	3.25-8.30	5.90
Nutrients uptake (kg ha^{-1})		
Treated plots		
N uptake	33.21-157.00	73.56
P uptake	4.94-25.24	14.45
K uptake	20.68-104.97	58.49
Control plots		
N uptake	20.96-54.20	38.30
P uptake	2.70-8.80	5.62
K uptake	12.80-34.24	23.95

Basic parameters

The basic data viz., nutrient requirement for producing one quintal of veg. guar (M-83) yield, per cent nutrient utilization efficiency for soil, fertilizer and FYM have been calculated and presented in Table 2. For calculation of nutrient requirement of veg. guar, 32 plots (Response based) were selected (Ramamoorthy, 1993) and the uptake of nutrients regressed with the yield to obtain the nutrients requirement in kg q^{-1}. Similarly, for calculating the soil nutrient utilization efficiency (C_s), fertilizer nutrient utilization efficiency (C_f) and nutrient utilization efficiency from FYM (C_{fym}), the uptake of nutrients from all the 32 plots regressed with their respective soil nutrients value, fertilizer dose for particular nutrient and FYM dose for obtaining the respective regression coefficients, identified as Cs, C_f and C_{fym}.

The nutrient requirements of N, P_2O_5 and K_2O were 6.80, 1.17 and 4.62 kg q^{-1} of veg. guar, respectively. The per cent nutrient utilization efficiencies from soil and fertilizer nutrients were found to be 72.72 and 59.62 for nitrogen, 33.93 and 17.73 for phosphorus (P_2O_5) and 45.34 and 50.10 for potassium (K_2O) Similarly, the per cent contribution of N,P_2O_5 and K_2o from FYM was 200, 32.66, 137.92, respectively.

The data presented in Table 2 indicated that application of FYM not only contributes for particular nutrients but also improves the utilization efficiency of soil and fertilizer nutrients. The findings are in close agreement with those repoted by Reddy *et al*. (1994), Rao *et al.* (1997) and Santhi *et al*. (2002).

Table 2. Basic data for Vegetables Guar (M-83)

Parameters	N	P_2O_5	K_2O
Nutrient requirement (kg/qt)	6.80	1.17	4.62
Soil nutrient utilization efficientey (%)	72.72	33.93	45.34
Fertilizer nutrient utilization efficiency (%)	59.62	17.73	50.10
FYM Contribution (%)	200.00	32.66	137.92

Fertilizer adjustment equations for desired yield targets of vegetables guar

Soil test based fertilizer models or equations for targeted yield of vegetables guar were formulated using the basic parameters and are furnished in Table 3.

On the basis of these equations a ready reckoner was prepared for range of soil test values and for a yield target of 35.00 & 40 q ha^{-1} (Table 4) under different fertilization programmes. For producing 35.00 q ha^{-1} of vegetable guar in Torripsamments, the fertilizer doses required for the average soil test values 100, 20 and 190 kg ha^{-1} N, P_2O_5 and K_2O, respectively was found to be 60, 60 and 80 kg N, P_2O_5 and K_2O, respectively with 5 tone FYM. The finding of the above study indicate that in STCR-IPNS technology, the fertilizer doses are tailored to be requirements of specific yield targets of veg. guar taking into account the contribution from soil, fertilizers and organics. Hence, there will be a balanced supply of nutrients coupled with recycling of organic wastes avoiding either under or over uses of fertilizer inputs

Table 3. Soil test based fertilizer equations for targeted yield of vegetables guar (M-83)

FN= 11.40T-1.22SN-3.35FYM
FP=6.60T-1.91SP-1.84FYM
FK=9.22T-0.90SK-2.75FYM
Note: FN,FP and FK- fertilizer N, P_2O_5 & K_2O in kg ha^{-1}, respectively: T-yield target in q ha^{-1}, SN, SP & SK, $KMnO_4$-N, Olsen-P & NH_4OAc-K in kg ha^{-1}, respectively.

Conditions:

The yield targeting equations are valid under the following situation-

1. These should be used for similar soils occurring in a particular agro-climatic zone.
2. Targets chosen should not be unduly high or low and should be with in the range of experimental yields obtained.
3. Adjustment equations must be used within the experimental range of soil test values and cannot extrapolate.
4. Good and recommended agronomic practices need to be followed while raising crops.
5. Other micro and secondary nutrients should not be yield limiting.

Table 4. Estimates of soil test based fertilizer recommendations for 35 and 40 q ha^{-1} green pod yield of vegetable guar (M-83)

Available nutrients in soil (kg ha^{-1})			Quantity of nutrients required for yield targets (kg ha^{-1}) with 5 t ha^{-1} FYM					
			35 q ha^{-1}			40 q ha^{-1}		
N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O5	K_2O
90	20	170	60	60	10(20)	60	60	18(20)
100	25	190	60	60	10(20)	60	60	10(20)
110	30	210	53	52	10(20)	60	60	10(20)
120	35	230	41	43	10(20)	60	56	10(20)
130	40	250	29	33	10(20)	52	46	10(20)
140	45	270	17	24	10(20)	39	37	10(20)
150	50	290	10 (17)	20	10(20)	27	27	10(20)
160	55	310	10(17)	20	10(20)	15(17)	20	10(20)
170	60	330	10(17)	20	10(20)	10(17)	20	10(20)

Note: Values in parentheses indicate the maintenancedose of N, P_2O_5 & K_2O

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INDIAN JOURNAL OF
ARID HORTICULTURE
2012, Vol. 7 (1-2) : 26-27

Response of nitrogen and row spacing on quality and economics of Onion cv. N-53 under Arid environment

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Received: December, 2012; Accepted: March, 2013

Abstarct

An experiment was conducted to investigate the response of nitrogen and row spacing on quality parameters and economics of onion cv. N-53 under arid environment at Research Farm, College of Agriculture (Swami Keshwanand Rajasthan Agricultural University), Bikaner. The experiment was laid out in a Randomized Block Design with five levels of Nitrogen *viz.* 0, 50, 100, 150 and 200 kg ha^{-1} and three levels of spacing 10, 15 and 20 cm. The result indicated that the statistically maximum number of leaves (8.36 and 803), volume of bulb (54.89 cc and 51.70 cc), diameter of bulb(4.75 cm and 4.68 cm), weight of bulb (49.57 g and 45.77 g), allyl-propyl disulphide (6.29 mg/100g and 6.21 mg/100g) and nitrogen content in leaves (0.953% and 0.959%) and bulb (1.40% and 1.35%) were recorded with application of 150 kg nitrogen ha^{-1} and 15 cm row spacing, respectively. Whereas, chlorophyll content in leaves (1.58 mg/g and 1.47 mg/g) was recorded maximum with 200 kg nitrogen ha^{-1} and 15 cm row spacing, respectively. B:C ratio (2.08 and 2.17) was observed highest in 150 kg nitrogen ha^{-1} and 15 cm row spacing, respectively.

Key words: *Onion, nitrogen, quality characters*

Introduction

Onion (*Allium cepa* L.) is one of the most important bulb crop grown throughout the country for local consumption as well as export. It is belonging to family Alliaceae. In India, onion growing area is 1064 thousand ha with a production of 15118 thousand MT and productivity 14.2 MT/ha and in Rajasthan, it is grown in 47.8 thousand ha with 812.6 thousand MT production with productivity 17.0 MT/ha (Anonymous, 2011). There is an increase in demand both in internal and external market for onion bulbs but our major problem is low productivity of this crop in the arid region. However, arid region are most suitable for onion cultivation but the cultivation of this vegetable is handicapped by several factors, such as poor fertility, inadequate nutrient management and improper plant population per unit area. Thus, there is ample scope for increasing the productivity of this crop in arid region through application of nitrogen fertilizers and proper the row spacing. It is evident that additional dose of nitrogen may enhance its yield potential in poor soil of this region (Ramamoorthy and Bajaj, 1969). Thus, the present investigation was undertaken to find out the response of nitrogen and row spacing on quality parameters and economics of onion cv. N-53 under arid environment.

Material and Methods

The present investigation was conducted at the Research Farm, College of Agriculture (Swami Keshwanand Rajasthan Agricultural University), Bikaner, during the *Rabi* season. The soil of experiment field was sandy loam with 8.20 pH, 0.09 per cent organic carbon and 63.85 kg ha^{-1} available nitrogen. The experiment was laid out in Randomized Block Design with three replications. The treatments included five nitrogen levels (0, 50, 100, 150 and 200 kg ha^{-1}) and three levels of spacing (10, 15 and 20 cm.). However, plant to plant distance in all treatments was maintained 10 cm. The experimental plants were managed with uniform cultural practices as per the standard recommendations with respect to irrigation, plant protection measures etc. Data on number of leaves (90 DAT), chlorophyll content of leaves (60 DAT), volume of bulb, diameter of bulb, weight of bulb, allyl-propyl disulphide in bulb, nitrogen content in leaves and bulb and B:C ratio were recorded. The observation was taken from selected five plants and averages were calculated. The statistical analysis was carried out as per the methods suggested by Panse and Sukhatme (1967).

Result and Discussion

The data presented in Table 1 revealed that all quality parameters significantly increased with increasing dose of nitrogen upto 150 kg nitrogen ha^{-1} (except number of leaves) and upto 15 cm row spacing. The numbers of leaves (8.36) were significantly higher with application of 150 kg nitrogen ha^{-1} than the 200 kg nitrogen ha^{-1}. This results could be due to better nutritional availability especially nitrogen in the root zone as well as in the plant system which ultimately resulted into optimum vegetative

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growth. Chlorophyll content (1.58 mg/g) was highest at 200 kg nitrogen ha^{-1}. It may due to application of nitrogen which is an integral constituent of chlorophyll by promoting greater photosynthetic activity (Aswani, 2001). The numbers of leaves (8.03) and chlorophyll content (1.47 mg g^{-1}) were significantly higher with 15 cm row spacing. It might be due to above row spacing facilitates lesser competition for space and availability of more light and nutrients to plants, leading to increase in growth attributes and chlorophyll content (Panda and Mohanty, 2001).

Among quality attributes, volume of bulb (54.89 cc), diameter of bulb (4.75 cm) and weight of bulb (49.57 g) were significantly higher in 150 kg nitrogen ha^{-1} because of optimum vegetative growth and chlorophyll content in leaves which increases the mobilization and accumulation of photosynthates towards storage structures. Therefore, the volume of bulb (51.70 cc), diameter of bulb (4.68 cm) and weight of bulb (45.77 g) were recorded significantly higher with 15 cm row spacing. This result might be due to lesser competition for nutrients and sum light, increasing food assimilatory efficiency and thereby more food reserve in bulbs. This row spacing produced good quality marketable large size bulb under optimum plant population (Panda and Mohanty, 2001).

Table 1. Response of nitrogen and spacing on quality and economics of onion.

Treatments	No. of leaves	Chlorophyll content (mg g^{-1})	Volume of bulb (cc)	Diameter of bulb (cm)	Weight of bulb (g)	Allyl-propyl disulphide (mg/100g)	N content (%)		B:C ratio
							leaves	bulb	
Nitrogen level kg ha^{-1}									
0	6.20	1.14	40.93	3.38	36.66	6.00	0.878	1.14	1.57
50	7.32	1.29	48.18	4.34	41.87	6.08	0.908	1.21	1.98
100	7.68	1.38	51.79	4.56	45.16	6.19	0.929	1.31	2.03
150	8.36	1.52	54.89	4.75	49.57	6.29	0.953	1.40	2.08
200	8.41	1.58	55.17	4.78	50.88	6.30	o.959	1.41	2.06
C.D. at 5%	0.42	0.03	2.39	0.07	1.57	0.03	0.0214	0.03	
Row spacing cm									
10	6.65	1.36	45.94	3.68	42.27	6.10	0.855	1.17	1.54
15	8.03	1.47	51.70	4.68	45.77	6.21	0.959	1.35	2.17
20	8.11	1.32	52.93	4.73	46.45	6.21	0.961	1.36	2.13
C.D. at 5%	0.32	0.02	1.85	0.06	1.21	0.03	0.0165	0.02	

Table 1 shows that the application of 150 kg nitrogen significantly increased allyl-propyl disulphide (6.29 mg/100g) in bulb. High nitrogen application might be due to better plant growth and more absorption of nutrients especially sulphur from the soil which caused higher production of allyl-propyl disulphide (Yadav *et al*., 2003). Nitrogen content in leaves and bulb (0.953% and 1.40%, respectively) also recorded statistically higher with this treatment. In 15 cm row spacing, allyl-propyl disulphide (6.21 mg/100g) in bulb was recorded significantly higher but further increase in row spacing upto 20 cm could not increased allyl-propyl disulphide significantly. Further, nitrogen content in bulb (1.35%) and leaves (0.959%) was also recorded significantly higher with 15 cm row spacing. Allyl-propyl disulphide and nitrogen content were higher because the application of nitrogen which improved nutritional environment in the dense root zone of the plant, that leads to greater availability of nutrients in the root zone coupled with increased metabolic activity at the cellular level might have increased the nutrients uptake and accumulation in plant parts. This leads to more metabolic activities and greater translocation of nutrients to reproductive organs (bulb) of the crop (Kwon *et al*., 1995).

The B:C ratio was obtained maximum with 150 kg nitrogen ha^{-1} and 15 cm row spacing 2.08 and 2.17, respectively. This result might be due to the direct influenced of row spacing in maximizing good quality marketable yield at this level.

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INDIAN JOURNAL OF
ARID HORTICULTURE
2012, Vol.7 (1-2) : 28-33

Prediction of biophysical attributes for high yielding genotypes of bitter gourd (*Momordica charantia L.*) for rainfed condition

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Received: December, 2012; Accepted: March, 2013

Abstract

An investigation on prediction model to identify suitable genotype by character association and path analysis was undertaken with forty-six genotypes of bitter gourd. The results revealed that in general, the genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficient level. The fruit yield per plot had a strong positive and significant association with number of female flowers per plot, number of fruits per plot, fruit girth, fruit length, number of primary branches and main vine length. Node of first female flower appeared and days to first fruit harvest showed negative association with yield. The path analysis revealed that fruit length, 100 seed weight, no. of female flower per plot, no. of fruits per plot, no. of primary branches per plant and main vine length exhibited strong positive direct effect on yield per plot. Days to first fruit harvest, no. of seeds per fruit, fruit girth had direct negative effect on yield. Hence the selection based on these characters will be effective in formulating selection indices for improvement of high yielding genotypes in bitter gourd for zero irrigation system.

Key words: *Biophysical attributes, high yield, bitter gourd, rainfed condition*

Introduction

Bitter gourd (*Momordica charantia* L.) is an important vegetable crop among cucurbitaceous vegetables grown in the country for its nutritionally rich green edible fruits having tremendous medicinal value, in addition seed oil is of having export potential (Chang *et al*., 1996) in the paint industry and seed protein said to inhibit the growth of immuno deficiency virus (HIV-1) in human cells cultures (Singh *et al.*, 2001). Although the crop is cultivated widely in large parts of the country, the contribution from rainfed area is very meager due to lack of suitable variety, as yield is a polygenically controlled complex character affected by large number of components. Grafius (1959) suggested that there may not be one gene for yield per se, but rather for various components, the multiplicative interaction of which results in the artifact of yield. Inadequate moisture in the soil or loss of water through stomatal transpiration exceeds the plant capacity to compensate internal loss in the crop causes water stress and it affects plant survival, growth, flowering and produce quality lead the crop barren sometimes especially in the rain fed area (zero irrigation system), the farmers are compelled to prefer field crops rather to grow vegetables. A land race is a mixture of genotypes, which evolved largely as a result of natural selection over numerous generations, under the environmental conditions on which land races are presently grown. Rios Labrada *et al.* (1998) studied in this direction to assess the role of pumpkin land races for tolerance to marginal condition characterized by drought, high temperature and biotic stress interactions. Hence, the knowledge of correlation between yield and component characters and among component characters themselves and path analysis would give better appreciation of cause and effect relationship between pair of characters, are very much essential for a rational and directed improvement in yield under rain fed system.

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Material and methods

The present study was conducted at Central Horticultural Experiment Station (CIAH)(ICAR), Vejalpur (Gujarat), comprising forty-six diversified genotypes of bitter gourd collected from different parts of the country. The experimental site located at 22°41,33" and 73°33'22" and lies between 110-115M above mean sea level. The annual rainfall mainly confined to three months (July to September) with an average of 35 rainy days a year. The annual maximum and minimum temperatures ranges from 42-43C in May and 6-7C in January respectively. The annual potential evapotranspiration ranged from 1500-1600mm against the annual precipitation 750mm.The genotypes were assessed in the field experiment under randomized block design and the treatments were replicated thrice. Six plants were maintained in each plot per replication spaced at 3.5 x 1.0m between rows and plants respectively. All Cultural practices including need based plant protective measures were followed. The data were recorded for main vine length (m), no. of primary branches, days to first female flower anthesis, node of first female flowers appeared, no of female flowers per plant, days to first fruit harvest, no. of fruits per plot, fruit weight (kg), fruit length (cm), fruit girth (cm), fruit flesh thickness (cm), 100 seed weight (g) , no. of seed per fruit and yield per

Table 1. Genotypic (rg), phenotypic (rp) and environmental (re) correlation coefficients among 14 characters in bitter gourd.

Sl.No.	Characters		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Main vine length (cm)	rg		0.32	0.06	-0.29	0.49**	-0.06	0.26	0.28	0.19	0.20	0.12	0.30	0.26	0.38*
		rp		0.29	0.06	-0.24	0.46**	-0.04	0.23	0.26	0.18	0.14	0.11	0.25	0.23	0.36
		re		-0.01	0.04	-0.02	0.15	0.08	-0.14	-0.10	0.03	-0.02	-0.03	0.06	0.07	0.06
2	No of primary branches per plant	rg			0.06	-0.16	0.44**	-0.10	0.22	0.36	0.18	0.16	0.01	0.06	0.06	0.41*
		rp			0.05	-0.13	0.41*	-0.07	0.19	0.35	0.16	0.12	0.00	0.09	0.03	0.37
		re			-0.01	0.01	-0.00	0.09	-0.19	0.19	-0.03	0.01	-0.09	0.25	-0.14	-0.10
3	Days to first female flower anthesis	rg				0.05	0.21	-0.29	-0.05	0.11	-0.01	0.09	-0.15	0.02	-0.10	0.10
		rp				0.05	0.21	-0.22	-0.05	0.10	-0.01	0.08	-0.13	0.04	-0.02	0.08
		re				0.09	0.20	0.08	-0.04	0.03	-0.03	0.07	-0.01	0.08	0.26	-0.05
4	Node of first female flower appeared	rg					-0.01	0.43**	0.12	-0.61**	-0.27	-0.13	-0.05	-0.34	-0.48**	-0.12
		rp					0.01	0.35	0.11	-0.53**	-0.24	-0.04	-0.05	-0.22	-0.36	-0.12
		re					0.19	0.03	0.12	-0.08	-0.06	0.12	-0.05	0.06	-0.02	-0.13
5	No. of female flower per plant	rg						-0.07	0.55**	0.21	0.25	0.44**	0.27	0.10	0.06	0.61**
		rp						-0.07	0.52**	0.19	0.24	0.32	0.24	0.10	0.06	0.56**
		re						-0.11	0.00	-0.09	0.08	0.00	-0.11	0.14	0.07	-0.11
6	Days to first fruit harvest (Days)	rg							0.13	-0.21	0.07	-0.28	0.04	0.04	-0.05	-0.26
		rp							0.10	-0.20	0.04	-0.16	0.03	0.06	-0.04	-0.24
		re							-0.16	-0.12	-0.21	0.14	-0.05	0.12	-0.00	0.01
7	No. of fruits per plant	rg								0.08	0.25	0.32	0.34	0.22	0.08	0.52**
		rp								0.07	0.22	0.25	0.33	0.14	0.07	0.50**
		re								0.04	-0.19	0.10	0.11	-0.24	0.02	0.14
8	Fruit weight (kg)	rg									0.31	0.32	0.23	0.59**	0.59**	0.28
		rp									0.30	0.23	0.22	0.48**	0.50**	0.27
		re									0.01	-0.03	0.04	0.04	-0.00	-0.07
9	Fruit length (cm)	rg										0.02	0.37	0.24	0.50**	0.38*
		rp										0.00	0.35	0.20	0.40*	0.36
		re										-0.12	0.03	0.05	-0.10	0.11
10	Fruit girth (cm)	rg											0.40**	0.38*	0.02	0.47**
		rp											0.27	0.26	0.10	0.34
		re											-0.11	0.06	0.24	-0.01
11	Fruit flesh thickness (cm)	rg												0.41**	0.37	0.30
		rp												0.32	0.29	0.29
		re												-0.05	-0.10	0.11
12	100 seed weight (g)	rg													0.75**	0.19
		rp													0.55**	0.14
		re													0.05	-0.11
13	No. of seed per fruit	rg														0.05

Table 2. Estimates of (Direct and Indirect effects) path coefficients at genotypic level on yield of bitter gourd under zero irrigation condition.

Sl.No.	Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Main vine length (cm)	**0.118**	0.040	-0.009	-0.017	0.152	0.025	0.050	-0.010	0.079	-0.004	0.017	0.107	-0.180	0.338
2	No. of pri. branch / plant	0.038	**0.123**	-0.009	-0.010	0.138	0.038	0.042	-0.012	0.074	-0.003	0.001	0.024	-0.044	0.410*
3	Days to first female flower anthesis	0.008	0.008	**-0.138**	0.003	0.066	0.109	-0.011	-0.004	-0.006	-0.002	-0.021	0.009	0.067	0.101
4	Node of first female flower appeared	-0.035	-0.020	-0.006	**0.060**	-0.003	-0.163	0.023	0.021	-0.112	0.002	-0.008	-0.121	0.322	-0.128
5	No. of female flowers per plant	0.058	0.055	-0.029	-0.000	**0.309**	0.028	0.105	-0.007	0.101	-0.009	0.038	0.038	-0.041	0.613**
6	Days to first fruit harvest (Days)	-0.008	-0.012	0.040	0.026	-0.023	**-0.375**	0.025	0.007	0.028	0.005	0.006	0.015	0.033	-0.268
7	No. of fruits/ plant	0.031	0.027	0.008	0.007	0.171	-0.049	**0.190**	-0.002	0.101	-0.006	0.048	0.078	-0.058	0.524**
8	Fruit weight (Kg)	0.034	0.045	-0.015	-0.037	0.065	0.080	0.015	**-0.035**	0.126	-0.006	0.032	0.207	-0.396	0.285
9	Fruit length (cm)	0.023	0.022	0.002	-0.016	0.078	-0.026	0.047	-0.011	**0.403**	-0.000	0.052	0.087	-0.336	0.383*
10	Fruit girth (cm)	0.024	0.020	-0.013	-0.008	0.137	0.106	0.061	-0.011	0.010	**-0.020**	0.056	0.134	-0.018	0.475**
11	Flesh thickness (cm)	0.015	0.001	0.021	-0.003	0.086	-0.016	0.066	-0.008	0.150	-0.008	**0.139**	0.146	-0.253	0.306
12	100 seed weight (g)	0.036	0.008	-0.003	-0.020	0.033	-0.016	0.042	-0.020	0.100	-0.008	0.058	**0.351**	-0.504	0.194
13	No. of seed per fruit	0.031	0.008	0.013	-0.029	0.019	0.018	0.016	-0.021	0.202	-0.000	0.052	0.264	**-0.669**	0.055

*-Significant at 5% level and ** significant at 1 % level. Bold values are direct effects (Residual effect at genotypic level =0.575

plot (kg), The mean data were subjected for statistical analysis of genotypic ,phenotypic and environmental correlation coefficients following the method suggested by Al-Jibouri *et al.* (1958) and path coefficient analysis to partition the total correlation in to direct and indirect effects to assess the character association by following Deway and Lu(1959) method.

Results and discussion

The genotypic as well as phenotypic correlation coefficients among different pairs of characters are presented in Table 1. In general, values of correlations at the genotypic levels were higher than the corresponding characters at phenotypic level. This indicates an inherent association among various characters and the genotypic superiority through their phenotypic expression was lessened under the influence of environment. The yield had significant and positive relation with no of fruits per plant, no of female flowers per plot fruit length, fruit girth, no. of primary branches per plant and main vine length. Therefore, these characters should be given due care to improve the fruit yield per plant. This result suggested the effective improvement in bitter gourd yield could be achieved through these attributes by simple recurrent selection. This result is in concordance with the findings of Sharma and Bhutani (2001) in Bitter gourd, Pandey *et al* (2002) and Gopalkrishnan *et al.* (1980) in Pumpkin, Rolania *et al.* (2003) in watermelon, Rao *et al.*(2004) in cucumber. Node of first female flower appeared and days to first fruit harvest found to be negatively correlated with yield at genotypic and phenotypic levels despite of its non significant and it is contradicting with findings of Sharma and Bhutani(2001) in bitter gourd.

The vegetative characters appeared to be vital to consider with due emphasis to identify the best genotype at the early growth stage especially for zero irrigation system. In the present study, the main vine length had a significant positive correlation with no. of female flowers per plot and yield per plot. However, the no. of primary branches per plant, 100 seed weight and no. of seed per fruit, no. of fruits per plot and fruit weight associated positively and node to first female flower days to first fruit harvest showed negative and non- significant association with main vine length. Number of branches per plant had significant and positive correlation with no. of female flowers per plot, fruit weight and yield per plot. Prasad *et al.* (1993) and Gopal *et al.* (1996) have also reported similar results in watermelon. These results conclude the inclusion of number of branches per plant and main vine length could improve the higher no of female flowers and fruit weight under zero irrigation system to results higher yield per plot.

In fact, the relationship between earliness (node to first female flower appeared) and yield depends upon the timing of water stress. Node of first female flower appeared exhibited significant positive correlation with days to first fruit harvest and significant negative association with fruit weight and no. of seeds per fruit at genotypic and phenotypic levels. This result indicates the early appearance of first female flower found to facilitate early fruit harvest and delay or late appearance of flower would coincide with stress period and the plant might not produce marketable fruit size and less no. of seeds per fruit due to inadequate soil moisture, predicting the genotypes with longer node for first female flower tended to have lower yielder in the environment. Otherwise the earliness is preferred as it is considered as good drought escape mechanism in production area where the terminal drought is encountered because of early withdrawal of rains (1989). This result is in consonance with finding of Rajanarayanan *et al.* (1996) in bottle gourd. No. of female flowers per plot had strong significant positive correlation with no. of fruits per plot, main vine length, no. of primary branches per plant, fruit girth and yield per plot. This result is in consonance with Dahiya *et al.* (1989) in round melon. It is understood from the results that the higher number of female flower per plot and higher number of branches per plant is an indicator for early flowering as well as for higher number of fruits per plot.

Days to fruit harvest is an highly important character as for as zero irrigation system is concern, as the critical stage of the crop and the soil moisture deficit coincide together in this stage. Days to fruit harvest had significantly positive correlation with node of first female flower appeared and showed non-significant negative correlation with fruit weight, fruit girth, no. of seeds per fruit and yield per plot. From the results, it is understood that the late bearing genotype undergoes stress and thereby results lesser yield per plot. Hence early harvesting may boost the no of fruits per plant so as to ensure higher yield per plant. Dahiya *et al.* (1989) in round melon and Rao *et al* (2004) in cucumber also reported the similar results. Number of fruits per plot showed strong significant positive correlation with no. of female flowers per plot and yield per plot. Fruit weight showed positive significant correlation with 100 seed weight and no of seeds per fruit and significant negative association with node of first female flower appeared. Although, it showed positive correlation with fruit length, fruit girth, fruit flesh thickness and yield per plot, they were non significant. This result is in conformity with the findings of Sharma and Bhutani (2001) in bitter gourd, Mohanty (2001) in Pumpkin, Choudhary *et al.* (2003) in muskmelon and Rao *et al.* (2004) in cucumber.

Fruit length exhibited the positive significant association with no. of seeds per fruit and yield per plot. Fruit girth showed positive and significant correlation with fruit flesh thickness, 100 seed weight, no. of female flowers per plot and yield per plot. Flesh thickness had significant positive correlation with fruit girth and 100 seed weight. This result indicates the importance of plant health at fruit development stage to improve the flesh thickness under zero irrigation system. This result is in support with findings of Sharma and Bhutani (2001) in bitter gourd, Dhaliwal *et al.* (1996) and Choudhary *et al. (2003)* in muskmelon and Abusaleha and Dutta (1988) in cucumber. 100-seed weight had strong significantly positive correlation with fruit weight, fruit girth, fruit flesh thickness and no. of seeds per fruit. Cui shimao *et al.* (1996) also reported that 1000 seed weight had positive correlation with fruit weight, fruit width, fruit length, seed length and seed width in pumpkin.

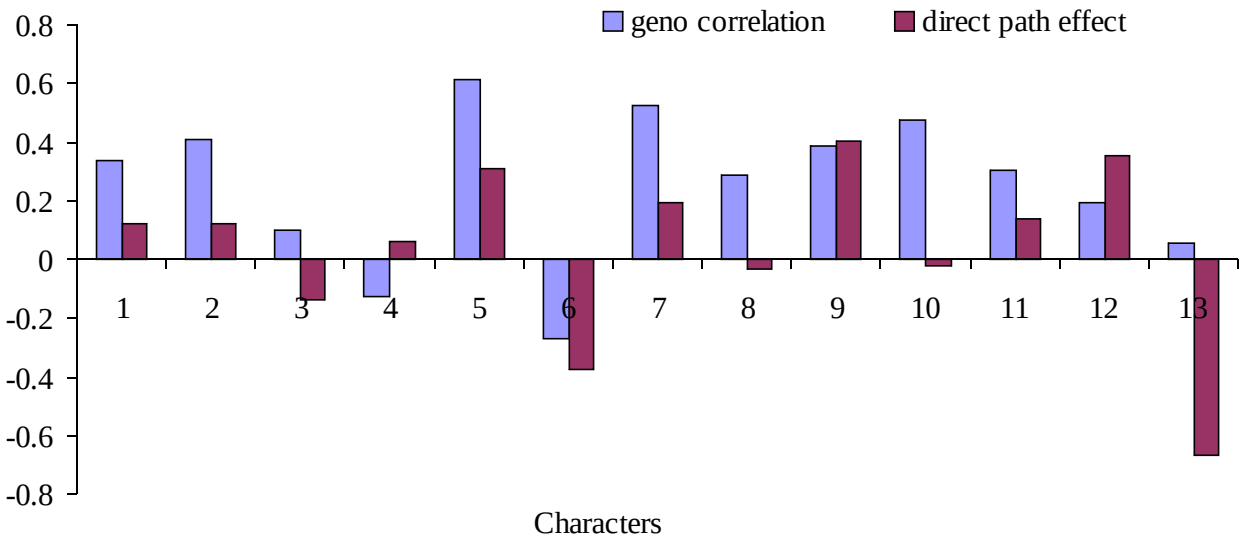

Fig. 1. Association of 13 yield components and their direct effects with yield at genotypic level in bitter gourd

The direct and indirect effects of various characters along with their genotypic correlation with yield are presented in Table 2. Correlation may not be much reliable and can misguide, as inclusion of more characters the indirect association becomes more complex, therefore to find out the actual dependence of yield on its components the path coefficient analysis is much essential which partition the correlation coefficients in to direct and indirect effects of various characters on yield. The results of path analysis revealed as that of highly significant correlation of yield with node of first female flower appeared (r=0.613), no. of fruits per plant (0.524), fruit length (0.383) and 100 seed weight (0.472) at genotypic level, the highest positive direct contribution (0.309, 0.190, 0.403 and 0.351 respectively) of these characters towards yield. This result is consonance with findings of Sharma and Bhutani (2001) in bitter gourd, Rao *et al*. (2004) in cucumber, Raj narayanan *et al*. (1996) in bottle gourd, Dahiya *et al.* (1989) in round melon and Kalloo *et al*. (1982) in muskmelon. Though, the no. of primary branches per plant and main vine length showed strong positive association (r=0.410 and r=0.338) with yield, the direct contribution towards yield was low (0.123 and 0.118) in path analysis .On the other hand it contributed indirectly via no. of female flowers per plot (0.138 and 0.152 respectively).

Days to first female flower anthesis (-0.138), days to first fruit harvest (-0.375) and no. of seeds per fruit (-0.669) showed direct negative effect on yield, although the days to first female flower anthesis and no of seeds per fruit exhibited non significant positive correlation, strongly indicates their negative direct effect contribute much in selecting genotypes with early flowering with lesser no. of seed per fruit as they indirectly contributed via days to first fruit harvest (0.109) and 100 seed weight (0.264) respectively. Fruit weight and fruit girth exhibited positive association with yield despite showed the negative direct effect indicating these two characters contributed indirectly via fruit length (0.126 and 0.105 respectively). This result is in conformity with report of Sharma and Bhutani (2001) in bitter gourd and Rajnarayanan *et al.* (1996) in bottle gourd. It is understood from the residual effect infers the total genotypic variability in yield has been explained by the characters associated in the study, however, some more factors, not considered here required to be included in the analysis to account fully for the variation in yield.

It is concluded (Fig. 1) that the high yielding genotype should possess higher main vine length with early days to first female flower anthesis and node of first female flower appeared, with optimum fruit weight with more flesh thickness are considered highly dependable and reliable for improving yield in bitter gourd under zero irrigation system.

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INDIAN JOURNAL OF
ARID HORTICULTURE
2012, Vol.7 (1-2) : 34-36

Effect of plant extracts on spore germination and severity of post harvest rots of fruits

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Received: January, 2013; Accepted: May, 2013

Abstract

Due to the environmental pollution, residue in soil water and food materials and effect on non-target organism, the use of chemical fungicides for disease management is being discouraged in the present day crop production. The opening-up of the global economy has enhanced the possibility of fruit-export. The fruit-exporting countries have strict requirements to meet health standards. These requirements have adversely affected the fungicide application on harvested fruits. Fortunately, the search for alternative treatments has yielded positive results with heat, plant extracts, radiation and some chemicals. Of these strategies, the use of plant extracts has proved safer and effective against certain diseases of harvested fruits. This investigation reports findings on efficacy of leaf extracts of *Tulsi* , *Sadabahar* , *Parthenium* , *Turmeric* and *Ginger* against important fruit rots of mango and citrus fruits. Application of leaf extract of *Tulsi* (10%) reduced disease severity and spore germination of Rhizopus rot, Penicillium rot and Botryodiplodia rot of mango and citrus fruits.

Key words: *Spore germination, post harvest rots, tulsi, Parthenium*

Introduction

Natural compounds have been used traditionally to preserve food in India (Singh *et.al.*, 1980), and other countries. Plant contains a variety of fungicidal compounds. Antifungal activity in leaf extracts have been reported by various investigators (Pathak & Jain, 1970). Babu & Reddy (1986) have reported that extracts of *Eucalyptus globulna, Punica granatum, Lawsonia inumis* and *Datura stramonium* were effective in checking fruit rot of lemon. Hasabnis & D'souza (1987) obtained best reduction in post-harvest storage rot by dipping mango fruits in garlic bulb extract or neem leaf extract. *Tulsi* leaf extract was found to reduce spore germination, growth, total proteins and pectinolytic and cellulolytic enzymes of various rot pathogens (Patel, 1991; Patil, 1992; Vyas, 1993 and Godara and Pathak, 1995). The extract can be processed to serve as an alternative to synthetic fungicides. It is estimated that less than 1% of the plants have been screened for antimicrobial activity. Ark and Thompson (1959) demonstrated that aqueous and organic solvent extracts of garlic contained potent fungicidal and bactericidal activity against several plant pathogens. They controlled post- harvest brown rot of peaches by dipping the fruit in an odourless garlic extract.

Materials and Methods

Leaf extracts of five plants viz. *Tulsi* (*Ocimum sanctum*), *Parthenium* (*Parthenium hysterophorus*), *Sadabahar* (*Vinca rosea*), *Ginger* (*Zingiber officinale*) and *Turmeric* (*Curcuma longa*) at 10 per cent (w/v) along with control treatments were tested against Rhizopus rot and Botryodiplodia rot of mango fruit and Penicillium rot and Botryodiplodia rot of sweet orange harvested fruits. Leaves and rhizomes were first washed with sterile distilled water and then air-dried, weighed plant material was crushed in warring blander and sterile distilled water (10 per cent = 1 gram plant material plus 9 ml sterile distilled water) was added. The material was homogenized for 5 minutes and the mixture was filtered through muslin cloth followed by filtration through Seitz filter.

Effect on spore germination

One drop of plant extract was mixed with a drop of spore suspension (10^6 spore/ml) on glass slide. The spore suspension was prepared in extract of ripe fruits. The slide was placed in an inverted position in a petri dish humid chamber. The slides were incubated at 28 ± 2^0C. Per cent spore germination was recorded after 24 hours in incubation. To assess spore germination, the slide was taken out, a drop of lactophenol was added to the spore suspension and per cent germination was assessed under the microscope. Each treatment was replicated three times.

Effect on disease severity

Mango and sweet orange fruits of nearly equal size harvested from orchards were brought to the laboratory. Fruits were surface sterilized and separately inoculated with each pathogen by prick-injury method. The injured and control fruits were surface sterilized and then separately inoculated with *Rhizopus arrhizus* and *Botrydiplodia theobromae* of mango *penicillium italicum* and *Botrydiplodia theobromae* of sweet orange by dipping them in spore suspension (10^6 spores/ml for 2 minutes)

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then treated with the plant extract for 5 minutes. The fruits were than air dried for 15-20 minutes. One fruit was accommodated in one bag. A piece of sterilized, wet, absorbent cotton was placed inside the bag and month of the bag loosely tied. The bagged fruits were kept at 28 2^0 C and 80-100 per cent RH. There were 20 fruits in each treatment. The disease severity was recorded on the basis of fruit area infected. This was assessed with the help of an assessment key devised for this purpose.

Results and Discussion

Effect on spore germination and severity of *Rhizopus arrhizus* and *Botryodiplodia theobromae* of mango fruits

Spores of both the rots started germination with in 6 hours in all the treatment of all the plant extract tested; only *Tulsi* extract proved effective against spore germination of both the pathogens after 24 hours of incubation. Significantly lowest disease severity of Rhizopus rot was recorded in fruits treated with *Tulsi* extract which was at par with severity in *Sadabahar* extract. In case of Botryodiplodia rot, significantly lowest severity was recorded in *Tulsi* extract treated fruits, which was at par with the severity in fruits treated with Sadabahar extract (Table 1). Similar results were also reported by Pandey *et al.* (1983) that leaf extracts of *Azadirachta indica* and *Ocimum sanctum* have been found effective against *Pestalotiopsis psidii*. However, Saks and Barkai-Galan (1995) reported that gel derived from Aloe-vera plants has been found to have antifungal activity against four common post-harvest pathogens : *Penicillium digitatum, P. expansum, B. cinerea* and *A. alternata*. The natural gel suppressed both germination and mycelial growth, with *P. digitatum* and *A. alternata* being the most sensitive species. The antifungal potential of the gel in decay suppression was exhibited on *P. digitatum* inoculated grapefruit, and was responsible for delay in lesion development as well as a significant reduction in infection process at shelf life conditions.

Effect on spore germination and severity of *Penicillium* rot and *Botryodilodia* rot of sweet orange fruits

Tulsi leaf extract proved highly effective against spore germination at 24 hours of incubation. *Tulsi* extract rendered significantly lowest severity against both the rots (Table 2).

In view of environmental pollution and the associated health hazards as well as the development of fungicide resistant strains of the pathogen, the emphasis is now gradually shifting from synthetic fungicides to natural products for management of various plant diseases. Hasabnis and D'souza (1987) obtained best reduction in post harvest storage rot by dipping mango fruits in garlic bulb extract or neem leaf extract. The results of present investigations corroborate with the findings of Meena (2006) who reported the efficacy of *Aloe barbadensis* leaf extract against spore germination of *Pestalotiopsis palmarum* and also rendered lowest severity of the rot of guava followed by *Ocimum sanctum* and *Azadirachta indica* leaf extracts. Similar observations were reported by Godara and Pathak (1995) who also observed that *Ocimum sanctum* leaf extract was highly effective against conidial germination and disease severity of *Penicillium italicum* and *B. theobromae* causing fruit rots of sweet orange. The present results also get support from the observations of Kumar (2002) who reported that the leaf extracts of *Azadirachta indica, Ocimum sanctum* provided effective control in pre-and post-inoculation treatment of *Alternaria* and *Aspergillus* fruit rots of ber.

In the present investigation, *Tulsi* extract was found to exert maximum inhibitory effect on germination of spores of the rot pathogens. The extract also proved highly effective against various rots of fruits. It appears that

Table 1. Effect of plant extract on spore germination and severity of *Rhizopus arrhizus* and *Botryodiplodia theobromae* of mango fruits

Plant extract (10 per cent)	Per cent spore germination after 24 hours		Severity (%)	
	R. arrhizus	*B. theobromae*	*R. arrhizus*	*B. theobromae*
Leaf extract of *Tulsi*	32.83	33.95	33.33	32.41
	(29.44)	(31.27)	(30.19)	(28.73)
Leaf extract of *Parthenium*	63.78	37.23	42.54	36.76
	(80.51)	(36.67)	(45.72)	(35.82)
Leaf extract of Sadabahar	34.59	37.89	37.40	35.52
	(32.31)	(37.84)	(33.55)	(33.75)
Rhizome extract of *Ginger*	46.93	38.61	41.41	42.07
	(53.39)	(39.24)	(43.75)	(44.90)
Rhizome extract of *Turmeric*	44.12	48.04	39.74	37.99
	(48.49)	(55.31)	(40.86)	(37.88)
Control	79.56	58.19	56.77	49.02
	(96.52)	(72.20)	(69.96)	(57.00)
SEm	0.55	1.06	2.90	1.30
CD at 5%	1.66	3.15	7.62	3.70

Figures in parentheses are retransformed values

Table 2. Effect of plant extract on spore germination and severity of *Penicillium* rot and *Botryodiplodia* rot of sweet orange fruits

Plant extract (10 per cent)	Per cent spore germination after 24 hours		Severity (%)	
	R. arrhizus	*B. theobromae*	*R. arrhizus*	*B. theobromae*
Leaf extract of *Tulsi*	47.49 (54.33)	42.91 (46.36)	28.45 (22.72)	26.63 (20.10)
Leaf extract of *Parthenium*	51.29 (60.78)	52.23 (62.44)	35.97 (34.50)	34.73 (32.48)
Leaf extract of Sadabahar	48.90 (56.78)	42.30 (45.28)	32.51 (29.91)	29.50 (24.27)
Rhizome extract of *Ginger*	55.68 (68.18)	59.16 (73.72)	40.80 (42.71)	31.99 (28.08)
Rhizome extract of *Turmeric*	54.71 (66.57)	55.68 (68.16)	37.70 (37.48)	34.15 (31.53)
Control	74.39 (92.51)	71.06 (89.35)	49.10 (57.11)	42.88 (46.28)
SEm	0.66	0.50	0.33	0.30
CD at 5%	1.87	1.44	0.97	0.88

Figures in parentheses are retransformed values

Tulsi (accorded highest religious honour in Hindu mythology) can serve as an important source of antimicrobial compounds. The anti-rot properties of this plant deserve in-depth investigations for its proper exploitation in fruit rot management.

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INDIAN JOURNAL OF
ARID HORTICULTURE
2012, Vol.7 (1-2) : 37-40

Genetic variability, heritability and genetic advance studies for yield and its contributing traits in Garlic *(Allium sativum)*

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Received: October, 2012; Accepted: May, 2013

Abstract

A field investigation was carried out to estimate the genetic variability, heritability and genetic advance in the garlic. The phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) in all the characters. The highest GCV associated with high heritability of with good genetic advance, was observed for weight of 10 uniform cloves followed dry weight of bulb. The lowest variability associated with low heritability and low genetic advance as percent of mean was observed for number of leaves per plant. Simultaneously, fresh weight of bulb, weight of 10 uniform cloves, dry weight of bulb and volume of bulb observed with high heritability coupled with moderate genetic advance. These traits were also governed by preponderance of additive gene effects and selection for these characters also rewarding to improve bulb yield. High heritability accompanied with low genetic advance observed for circumference of bulb, sulphur content (%), dry weight of leaves and fresh weight of leaves. It is indicative of non-additive gene action. The moderate to high heritability is being exhibited due to favourable influence of environment rather than genotype and selection for such traits may not be rewarding. Low heritability coupled with low genetic advance was found for number of leaves per plant, neck thickness, total soluble solids (TSS) and vitamin C were highly influenced by environmental effects and selection would be ineffective. High heritability in association with high genetic advance observed for plant height, number of cloves per bulb, bulb weight, and moderate heritability coupled with highest genetic advance observed for bulb yield. It indicates that most likely the heritable is due to the preponderance of additive gene effects and the potential of selection for these characters to improve bulb yield.

Key words: *Genetic variability, heritability, genetic advance, garlic, Allium sativum*

Introduction

Garlic (*Allium sativum* L.*)* is the second most important bulb crop after onion. It is an important spice crop belonging to family Alliaceae. It is hardy and grown extensively in Chittorgarh, Baran, Jodhpur, Jhunjhunu, Udaipur, Kota, Dungarpur, Bundi, Jaipur and Sikar districts of Rajasthan during *rabi* season. The economic yield is obtained from its underground bulb, which is consisted of bulblets, popularly known as cloves. Garlic is used in flavouring foods, preparing chutneys, pickles, curry powder, tomato ketchup etc. It contains a clourless as well as odourless water soluble amino acid called allin. Garlic contains volatile oil known as 'diallyl-disulphide', Which is the major flavouring component in garlic. Beneficial use of garlic extract has been found against many fungi and bacteria. Besides the nutritive value of garlic and its use in various forms, it is included in Indian system of medicine as carminative and gastric stimulant to help in digestion and absorption of food. Allicin present in aqueous extract of garlic reduces blood cholestrol concentration in human blood. Garlic oil or its juice is recommended to inhale in cases of pulmonary tuberculosis, rheumatism, sterility, impotency, cough and redness of eyes.

Evaluation of genotypes to assess the existing variability is considered as preliminary step in any crop improvement programme. To initiate an effective improvement programme in any crop, the first and foremost step is to build up a comprehensive germplasm. Information on the magnitude of variation in the available genetic material and the part played by the environment on the expression of plant characters are prime importance for the appraisal of the and magnitude of possible improvement. The prediction of genetic advance is a prerequisite for crop improvement breeding programs especially when large populations are subjected to selection. Facilitated by obtaining phenotypic and genotypic coefficients of variation in the absence of which field evaluation of every genotype would be physically less feasible. Hence there is need to study variability. Variability for different traits in the source population is a prerequisite for crop improvement since all attempts of breeding and selection would be futile unless major portion of variability is heritable. Further, estimate of genetic advance and heritability would give the best picture

of the extent of improvement expected from selection and reliability of selection based on phenotype. Garlic is an sexually sterile diploid vegetable bulb crop and its genotypes has tremendous variability for bulb weight, number of cloves per bulb, weight of 10 uniform cloves, weight, shape, taste etc. Inspite of being on important crop for cool season in plains, the research work on garlic is very scare. In order to pursue an effective breeding programme, the present investigation was made to estimate the genetic variability, heritability and genetic advance in the garlic.

Materials and Methods

The present investigation comprised of 25 genotypes of garlic collected from different parts of India. The genotypes were sown in randomized block design with three replications at Horticulture Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University Bikaner during *rabi* season 2009-10. Each genotype was planted in a double rows plot of 5 m length, maintaining row to row and plant to plant spacing 15 cm and 10 cm, respectively. Cloves of healthy bulbs 8-10 mm in diameter are dibbled at 5-7.5 cm deep keeping their growing ends upwards. All the recommended package of practices was given to raise a good crop. Observations on ten randomly selected plants from each replication were recorded for plant height at 90 days after sowing, number of leaves per plant, fresh weight of leaves (g), dry weight of leaves (g), number of cloves per bulb, weight of 10 uniform cloves (g), fresh weight of bulb (g), dry weight of bulb (g), neck thickness (cm), circumference of bulb (cm), volume of bulb (cc), total soluble solids (°brix), sulphur content (%), vitamin C (mg per 100 g), bulb weight (g) and bulb yield (qt /ha). Data recorded were subjected to statistical analysis. Genotypes coefficient variation (GCV) and phenotypic coefficient variation (PCV), broad sense heritability, genetic advance, were computed by the methods suggested by Al-Jibouri *et al.* (1958) and Devey and Lu (1959).

Results and Discussion

Genetic variability, heritability and genetic advance for sixteen characters in twenty five varieties / lines of garlic were studied. Analysis of variance revealed significant differences among the genotypes for all the sixteen characters studied (Table 1). Mean performance of all genotypes and GCV, PCV and genetic advance parameters for all the studied traits were given in Table 2 & 3, respectively. On the basis of per se performance, plant height was maximum (60.70 cm) in Bikaner local followed by Jobner local (58.40) and Vidisha local (58.37). The smallest plants (36.33 cm) were measure in Baran local. Maximum number of leaves per plant (10.13) was noted in G- 1 which was at par with Ladwa local and Jobner local and minimum leaves per plant (8.57) was recorded in Mahadev. Number of cloves per bulb was recorded highest in Bikaner local (38.27) followed by Ladwa local and Jobner local. Weight of 10 uniform cloves was highest in G-282 followed by Mahadev and Buccani local. Ladwa local was found maximum in fresh weight of bulb (31.60 g) followed by G-41 and Bikaner local. Buccani local contained highest dry weight of bulb (16.50 g) and was at par with Vidisha local and Phule Baswant. Neck thickness was maximum in G 51 followed by G-282, G- 41, G-50 and Amleta local. Ladwa local followed by Phule Baswant and Ooty- 1 was found with highest circumference of bulb. The maximum total soluble solid (TSS) (43.17 %) was observed in G41 and was at par with Mahadev, Vidisha local genotypes. Genotype Buccani local and G-323 were found with maximum sulphur content (%). G282 and Phule Baswant were also reported second highest in sulphur content. Vitamin C content was maximum in G282 followed by Vidisha local, G-1 and Phule Baswant. The highest bulb weight was recorded in Ladwa local (32.13) followed by G- 1 and Punjab garlic (30.13). The highest bulb yield (qt/ha) was recorded in G 1 (151.40) followed by Rulayata local, G 282, G- 323. Maximum range was recorded for bulb yield (82.60 - 151.40 q/ha) followed by plant height (36.33- 60.70 cm), number cloves per bulb (16.03- 38.27), bulb weight (12.50- 3213 g) fresh weight of bulb (14.97-31.60 g) and volume of bulb (12.37- 24.00 cc) indicating maximum variability present in these traits which showed a greater scope for selection among the existing genotypes while the low range was observed for sulphur content (0.31-0.35%). Singh and Chand (2004) were also found that bulb yield per hectare, followed by bulb weight and number of cloves per bulb, exhibited maximum diversity.

The magnitude of PCV as expected was greater than the corresponding GCV for all the characters indicating importance of environment in expression of characters. The GCV does not offer full scope to estimate the heritable variation and, therefore, estimation of heritability becomes necessary. In the present study, all the traits expressed low to high heritability which ranged from 21.81 per cent (number of leaves per plant) to 98.23 per cent (Plant height) suggesting thereby the major role of genetic constitution in the expression of these character and such traits are considered to be dependable for breeding point of view. The highest GCV (23.03) associated with high heritability of (86.29) with good genetic advance, was observed for weight of 10 uniform cloves followed dry weight of bulb (GCV = 2.522).

High values of PCV as well as GCV were recorded for weight of 10 uniform cloves, dry weight of bulb, number of cloves per bulb and bulb weight which revealed the great extent of variability present in characters. Earlier, Shri Dhar (2002) was also reported high magnitude of phenotypic (PCV) and genotypic (GCV) coefficients of variation were recorded for bulb yield, weight of 50 cloves and number of cloves per bulb. The lowest variability (GCV= 3.12) associated with low heritability (21.81%) and low genetic advance as percent of mean (5.66) was observed for number of leaves per plant. High heritability in association with high genetic advance observed for plant height, number of cloves per bulb, bulb weight, and moderate heritability coupled with highest genetic advance observed for bulb yield. These findings were in accordance with the findings of Raj Narayan and Khan (2002), Singh and Chand (2004), Khar *et al*. (2005) and Jabeen *et al.* (2010). It indicates that most likely the

Table 1. Analysis of variance for bulb yield and other traits in garlic

Source of variation	d.f	Plant height at 90 days after sowing (cm)	No. of leaves per plant	Fresh weight of leaves (g)	Dry Weight of leaves (g)	No. of cloves per bulb	Weight of 10 uniform cloves (g)	Fresh weight of bulb(g)	Dry weight of bulb(g)
Replication	2	0.15	0.91	0.47	0.19	4.32	0.14	3.60	1.18
Genotypes	24	86.40**	0.56*	9.40**	1.39**	91.13**	29.62**	69.90**	18.68**
Error	48	0.51	0.31	0.98	0.18	2.25	1.49	4.63	1.02

*, ** Significant at 5 % and 1 % level of significance, respectively

Source of variation	d.f	Neck thickness (cm.)	Circumference of bulb (cm)	Volume of bulb (cc)	TSS (%)	Sulphur content (%)	Vitamin C (mg/100g)	Bulb weight (g)	Bulb yield (q/ha)
Replication	2	0.000004	0.52	0.38	4.42	0.00005	0.02	6.35	110.79
Genotypes	24	0.0055**	3.63**	31.69**	10.17**	0.00043**	1.90**	84.98**	997.56**
Error	48	0.0026	0.70	2.92	2.98	0.00007	0.52	2.33	133.11

*, ** Significant at 5 % and 1 % level of significance, respectively

Table 2. Mean values for different metric characters of garlic genotypes

S. No.	Genotypes	Plant height at 90 days after sowing (cm)	No. of leaves per plant	Fresh weight of leaves (g)	Dry Weight of leaves (g)	No. of cloves per bulb	Weight of 10 uniform cloves (g)	Fresh weight of bulb (g)	Dry weight of bulb (g)	Neck thickness (cm.)	Circumference of bulb (cm)	Volume of bulb (cc)	TSS (%)	Sulphur content (%)	Vitamin C (mg/100g)	Bulb weight (g)	Bulb yield (q/ha)
1.	G-282	52.33	9.03	9.30	3.66	22.83	17.87	25.37	11.50	0.94	13.37	19.83	41.00	0.344	11.557	24.77	140.00
2.	Mahadeva	55.66	8.57	9.70	3.60	20.67	17.77	25.73	12.07	0.93	11.83	18.30	43.17	0.339	11.053	25.57	129.83
3.	Ringus Local	49.07	8.93	7.50	2.43	29.67	8.70	19.30	6.90	0.84	11.23	15.43	37.33	0.325	9.357	19.17	92.70
4.	Kota Local	55.56	9.67	8.20	3.88	22.97	15.87	25.43	11.70	0.90	12.82	19.20	40.33	0.337	10.700	25.50	124.70
5.	Buccani Local	56.80	9.60	9.93	4.43	22.40	17.33	29.37	16.50	0.91	12.19	24.00	42.50	0.345	10.993	29.50	131.17
6.	Rulayata Local	53.10	9.70	8.73	2.90	18.43	7.90	20.83	8.43	0.90	11.54	14.70	41.67	0.336	11.247	21.00	143.90
7.	G-41	50.60	8.77	10.97	4.29	23.60	12.83	30.27	12.53	0.94	12.43	23.47	43.17	0.341	11.003	29.70	120.27
8.	G-323	57.17	9.30	10.30	3.51	26.40	14.43	26.73	11.73	0.90	13.35	18.27	42.33	0.345	11.113	27.50	140.13
9.	Rajgarh Local	44.17	9.53	7.33	3.11	18.67	10.70	15.43	7.70	0.84	11.52	15.90	41.50	0.315	9.953	14.73	97.87
10.	G-50	52.58	9.43	11.30	4.83	23.47	14.30	26.73	9.90	0.94	12.80	16.57	42.33	0.337	11.320	26.73	128.90
11.	G-1	51.37	10.13	8.67	3.54	25.43	12.77	22.37	11.73	0.92	12.14	17.63	39.00	0.346	11.407	31.87	151.40
12.	Amleta Local	43.63	9.63	6.00	2.37	23.60	9.43	21.57	9.14	0.94	11.88	15.00	41.67	0.342	11.313	22.37	128.00
13.	Baran Local	36.33	9.33	7.67	2.71	16.03	8.43	14.97	6.05	0.81	8.76	12.73	39.83	0.316	9.477	12.50	93.30
14.	Bikaner Local	60.70	9.30	13.63	4.23	38.27	12.90	30.23	11.10	0.84	13.11	20.77	41.50	0.311	9.377	28.63	82.60
15.	Vidisha Local	58.37	9.33	9.07	3.83	17.53	16.57	28.47	15.13	0.93	12.53	20.67	43.00	0.336	11.427	27.90	130.83
16.	Phule Baswant	56.63	9.26	9.07	3.67	30.47	16.37	25.93	13.07	0.90	13.60	16.80	41.17	0.344	11.093	26.80	122.83
17.	Punjab Garlic	51.33	8.73	9.33	2.43	26.30	15.27	28.50	7.27	0.89	13.34	22.33	41.67	0.310	10.483	30.13	109.53
18.	Ooty-1	54.77	8.90	8.53	2.74	16.37	16.53	19.50	10.05	0.88	13.40	15.93	41.17	0.326	11.200	20.83	111.43
19.	Dausa Local	49.13	9.43	8.53	2.75	29.53	9.43	17.63	9.37	0.82	11.12	12.37	38.00	0.317	9.523	17.33	89.23
20.	Jobner Local	58.40	9.97	11.17	3.64	32.40	9.20	16.23	10.27	0.85	12.30	18.20	40.17	0.318	9.330	15.97	100.90
21.	Khandar Local	53.60	8.70	10.30	3.24	30.43	11.93	22.20	9.30	0.84	11.80	14.00	38.50	0.323	9.237	22.37	109.57
22.	Bhima Omkar	55.17	9.83	7.73	3.12	20.40	15.53	24.47	12.50	0.88	11.82	22.93	40.00	0.335	10.937	24.40	114.70
23.	Ladwa Local	57.07	10.00	10.27	4.25	30.53	12.57	31.60	11.30	0.92	14.35	21.27	36.50	0.344	10.893	32.13	122.60
24.	Jhalrapattan Local	54.67	9.74	9.60	3.45	24.00	13.47	24.07	13.60	0.91	12.71	18.37	41.17	0.339	10.630	25.20	132.07
25.	G-51	54.50	9.61	13.40	4.15	27.70	14.33	26.90	10.47	0.95	12.57	18.20	38.50	0.343	11.387	27.03	122.87
	Mean	52.91	9.38	9.45	3.47	24.72	13.30	23.99	10.77	0.89	12.34	18.11	40.69	0.33	10.64	24.39	118.85
	CV (%)	7.36	5.91	10.47	12.08	6.07	9.18	8.96	9.38	5.71	6.77	9.43	4.24	2.46	6.80	6.26	9.71
	CD at 5%	0.68	0.53	0.94	0.40	1.42	1.16	2.04	0.96	0.05	0.79	1.62	1.64	0.01	0.69	1.45	10.94

Table 3. Estimates of genetic parameters of variation for the different characters of garlic genotypes

Characters	Mean ±S.Em	Range	Genotypic variance	Phenotypic variance	Coefficient of variance		Heritability (%)	Genetic Advance	G.A. as % of mean
					Genotypic	Phenotypic			
Plant height at 90 days after sowing (cm)	52.91±0.24	36.33-60.70	28.63	29.14	10.11	10.20	98.23	10.92	6.25
No. of leaves per plant	9.38±0.18	8.57-10.13	0.09	0.39	3.12	6.68	21.81	0.28	5.66
Fresh weight of leaves (g)	9.45±0.33	6.00-13.63	2.81	3.79	17.73	20.59	74.17	2.97	18.25
Dry Weight of leaves (g)	3.47±0.14	2.37-4.83	0.41	0.58	18.36	21.98	69.78	1.10	30.17
No. of cloves per bulb	24.72±0.50	16.03-38.27	29.63	31.88	22.02	22.84	92.94	10.81	13.30
Weight of 10 uniform cloves (g)	13.30±0.41	7.90-17.87	9.38	10.87	23.03	24.79	86.29	5.86	18.20
Fresh weight of bulb(g)	23.99±0.72	14.97-31.60	21.76	26.38	19.44	21.41	82.47	8.73	12.31
Dry weight of bulb(g)	10.77±0.34	6.05-16.50	5.89	6.91	22.52	24.39	85.22	4.61	19.94
Neck thickness (cm.)	0.89±0.02	0.81-0.95	0.002	0.004	3.48	6.69	27.14	0.03	20.46
Circumference of bulb (cm)	12.34±0.28	8.76-14.35	0.98	1.67	8.01	10.49	58.38	1.56	10.11
Volume of bulb (cc)	18.11±0.57	12.37-24.00	9.59	12.51	17.10	19.53	76.67	5.59	13.05
TSS (%)	40.69±0.58	36.50-43.17	2.40	5.38	3.80	5.70	44.58	2.13	3.59
Sulphur content (%)	0.33±0.008	0.31-0.35	0.001	0.003	3.33	4.14	64.56	0.02	40.69
Vitamin C (mg/100g)	10.64±0.24	9.24-11.56	0.46	0.98	6.38	9.32	46.84	0.96	9.19
Bulb weight (g)	24.39±0.51	12.50-32.13	27.55	29.88	21.52	22.42	92.19	10.38	13.21
Bulb yield (q/ha)	118.85±3.85	82.60-151.40	288.15	421.26	14.28	17.27	68.40	28.92	4.52

heritable is due to the preponderance of additive gene effects and the potential of selection for these characters to improve bulb yield.

Simultaneously, fresh weight of bulb, weight of 10 uniform cloves, dry weight of bulb and volume of bulb observed with high heritability coupled with moderate genetic advance. These traits were also governed by preponderance of additive gene effects and selection for these characters also rewarding to improve bulb yield. High heritability accompanied with low genetic advance observed for circumference of bulb, sulphur content (%), dry weight of leaves and fresh weight of leaves. It is indicative of non-additive gene action. The moderate to high heritability is being exhibited due to favourable influence of environment rather than genotype and selection for such traits may not be rewarding. Low heritability coupled with low genetic advance was found for number of leaves per plant, neck thickness, total soluble solids (TSS) and vitamin C were highly influenced by environmental effects and selection would be ineffective. Shri Dhar (2002) also reported high estimates of heritability for all the studied traits except bulb diameter and number of leaves. Out of 16 characters studied, weight of 10 uniform cloves and dry weight of bulb showed high GCV and heritability coupled with high genetic advance as per cent of mean which showed that these two characters might be under control of additive gene effect and therefore, they are more reliable for effective selection.

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INDIAN JOURNAL OF
ARID HORTICULTURE
2012, Vol.7 (1-2) : 41-44

Effect of media composition on growth and development of acid Lime (*Citrus aurantifolia* Swingle) seedling with or without Azotobacter

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Received: September, 2012; Accepted: January, 2013

Abstract

The present investigation was carried out at the Fruits Research Farm, College of Horticulture & Forestry Jhalarapatan, Jhalawar during the year 2010. In this experiment, freshly extracted acid lime seeds were sown into different media with or with out Azotobacter to study their effect on growth and development acid lime seedlings. The results indicated that the medium combination soil + sand + vermicompost + vermiculite + cocopeat (1:1:1:1:1) with Azotobacter had given significantly better result among different combinations. Under this treatment the height of seedling (13.75 cm), number of leaves per seedling (22.46), diameter of stem (3.35 mm), fresh weight (2.77 g) and dry weight of seedling (1.18 g) were recorded significantly superior over other treatments used. Further it was also found superior with relation to length of longest tap root (19.76 cm), diameter of tap root (2.95 mm), number of secondary roots (40.66), root/shoot ratio (2.57), nitrogen content in leaf (1.86 %), chlorophyll content in leaf (5.44 mg/g) and leaf area of seedlings (1.43 cm^2).

Key Words: *Azotobacter, media, acid lime seedling, vermicompost*

Introduction

Acid lime is an important Sub-tropical fruit crop of the world. It is native of India and South-Eastern China. The trees medium sized, hardy and semi-vigorous, growth upright with an irregular and loose crown, foliage not dense, light green, thorns numerous, fruit round and oblong, greenish yellow in colour and juice is highly acidic and its seeds are highly polyembryonic in nature. Hence it is still commercially propagated by seed.

Propagation media play an important role in germination of seeds and for further growth and development of seedling. Among different media used vermicompost, cocopeat, sphagnum moss are organic in nature and vermiculite, perlite and sand are inorganic in nature. Many organic media decompose readily, get compact easily and thus decreases pore space and aeration in soil. Use of some coarse minerals component has been found useful in increasing aeration and improving drainage. Sand, vermiculite and perlite are useful in this regard. In addition to this, Azotobacter, a heterotrophic aerobic bacterium capable of fixing nitrogen as non-symbiotic is of wide occurrence in rhizosphere of many plants. There has been rise in the use of Azotobacter as biofertilizer as the ability of it to produce biologically active substances was ascertained, its effect on plants was associated not only with the process of nitrogen fixation and improving nitrogen of plants, but also with the supply of biologically active compounds such as vitamins and gibberellins. Therefore an attempt have been made to utilize the effect of different medium combination with or without Azotobactor for growth and development of acid lime seedlings.

Materials and Methods

This experiment was carried out to evaluate the effect of media on growth and development of acid lime (*Citrus aurantifolia* Swingle) seedling with or without *Azotobacter* during the year 2009-10 at the Fruits Research Farm, College of Horticulture & Forestry Jhalarapatan, Jhalawar (Rajasthan) India. District Jhalawar extends on 6.32 Lac hectare land among 23°4' to 24°52' N latitude and 75°29' to 76°56' E Longitude in South Eastern Rajasthan. Agro climatically, the district falls in zone V (Humid South Eastern Plain). About 84.22 per cent population is rural whose main occupation is agriculture and its related activities. Average rainfall is 954.7 mm. Maximum temperature range in summer is 43°-48°C and minimum 1°-2.6°C during winter. The meteorological data during the study are presented in table 4. The treatments consisted of five media (soil, sand, vermicompost, vermiculite, and cocopeat) and their combinations with or without Azotobacter with three replications. For this experiment freshly extracted seeds of acid lime variety "Kagzi gol" were sown in different media mixture filled in the pro-trays (9×7 cm sized). These portrays, after seed sowing were placed in open nursery, watered regularly with the help of watering rose can to keep medium moist and observations were recorded as per study schedule. Periodic observation on height of seedling was measured with the help of meter scale from ground level to growing tip, number of leaves per seedling were counted every month up to 150 days, diameter of stem was measured with the help of digital

verniear calliper, fresh and dry weight of seedling was measured by electronic balance and average weight calculated, length of longest tap root was measured from the point of initiation of roots to the tip of the root with the help of a meter scale, after washing the soil ball total number of secondary roots were counted, diameter of tap root was measured near the point of initiation of root with the help of verniear calliper. For estimation of nitrogen the powder of 10 fully grown leaves was used in laboratory and subjected to "Wet Digestion Method (Snell and Snell, 1955)" while chlorophyll content of leaves was measured as per method suggested by Sadasivam and Manickam (1997). Average leaf area was calculated with the help of non-destructive type of Laser leaf area meter Model No. CI-203, CID-INC, USA by taking randomly 10 fully grown and physiologically matured leaves in each treatmen.

Results and Discussion

Shoot parameters

Application of soil + sand + vermicompost + vermiculite + cocopeat (1:1:1:1:1) with Azotobacter treatment had given significantly maximum number of leaves per seedling (22.46), diameter of stem (3.35 mm), height of seedling (13.75 cm), fresh weight of seedling (2.77 g), and dry weight of acid lime seedling (1.18 g) after 150 days of sowing. However, minimum number of leaves per seedling (15.73), diameter of stem (2.18 mm), height of seedling (8.82 cm), fresh weight of seedling (1.35 g), and dry weight of seedling (0.45 g) were observed in medium soil without Azotobacter (Table 1). The increase in the shoot growth parameters due to application of soil + sand + vermicompost + vermiculite + cocopeat (1:1:1:1:1) with *Azotobacter* could be attributed to the conducive effect of this medium mixture on water holding capacity, porosity, soil aeration and supplying substantial amount of nutrient specially nitrogen and micro nutrients for good root and shoot growth over control (Chopde *et al.* 1999). Increase in number of leaves might be mainly due to corresponding increase in plant height (Govind and Chandra, 1993). This treatment also has higher leaf chlorophyll content which might certainly improved the photosynthetic rate, dry matter production and their by more fresh and dry weight of shoot. The increase in height of seedling with inoculation of Azotobacter may be due to fact that it stimulates nutrient uptake especially nitrogen which has role in the assimilation of numerous amino acids that are subsequently incorporated in proteins and nucleic acid, which provides framework for chloroplast, mitochondria and other structures in which the most of the biochemical reactions occurs (Awasthi *et al.* 1996).

The application of different media combination had significant effect on leaf area (cm^2) of acid lime seedling. The medium consisting of soil + sand + vermicompost + vermiculite + cocopeat (1:1:1:1:1) showed maximum leaf area (1.39 cm^2) and minimum leaf

Table 1. Effect of media with or without *Azotobacter* on shoot parameters of acid lime seedlings

Treatments	Height (cm)		Number of leaves per plant		Diameter of stem (mm)		Root/shoot ratio		Leaf area (cm^2)	
	Without Azotobacter	With Azotobacter	Without Azotobacter	With Azotobacter	Without Azotobacter	With Azotobacter	Without Azotobacter	With Azotobacter	Without Azotobacter	With Azotobacter
T_0 Control (soil)	8.82	10.27	15.73	16.40	2.18	2.46	1.31	1.93	1.12	1.30
T_1 Soil + Sand (1:1)	8.83	10.94	18.80	15.93	2.78	2.75	1.69	1.97	1.14	1.31
T_2 Soil + Vermicompost (1:1)	11.98	11.54	19.53	19.00	2.32	3.03	1.98	2.03	1.09	1.28
T_3 Soil + Vermiculite (1:1)	11.95	12.43	19.33	19.80	2.47	2.76	1.49	1.99	1.17	1.32
T_4 Soil + Cocopeat (1:1)	11.86	11.03	20.00	17.00	2.97	2.79	2.03	2.01	1.13	1.38
T_5 Soil + Vermicompost + Vermiculite (1:1:1)	10.96	10.56	19.93	17.13	3.11	3.09	2.04	2.06	1.18	1.37
T_6 Soil + Vermicompost + Cocopeat (1:1:1)	11.66	12.22	19.53	19.33	3.06	2.93	1.89	2.07	1.26	1.36
T_7 Soil + Vermicompost + Vermiculite + Cocopeat (1:1:1:1)	11.32	13.31	16.46	20.53	2.39	2.45	1.87	2.28	1.23	1.37
T_8 Soil + Sand + Vermicompost + Vermiculite (1:1:1:1)	10.01	13.68	17.00	20.86	2.90	3.29	2.30	2.35	1.27	1.39
T_9 Soil + Sand + Vermicompost + Vermiculite	13.08	13.75	20.46	22.46	3.12	3.35	2.47	2.57	1.35	1.43

Table 2. Effect of media with or without *Azotobacter* on bio -chemical parameters of acid lime seedlings

Treatments	Per cent nitrogen content		Chlorophyll content (mg/g)					
	Without Azotobacter	With Azotobacter	Without Azotobacter			With Azotobacter		
T_0 Control (soil)	1.30	1.43	Chlorophyll-a	Chlorophyll-b	Tatal chlorophyll	Chlorophyll-a	Chlorophyll-b	Total chlorophyll
			1.42	0.69	2.11	1.59	1.70	3.29
T_1 Soil + Sand (1:1)	1.31	1.46	1.41	0.70	2.12	1.54	2.02	3.55
T_2 Soil + Vermicompost (1:1)	1.28	1.40	1.42	0.73	2.16	1.64	2.01	3.65
T_3 Soil + Vermiculite (1:1)	1.36	1.53	1.42	0.80	2.22	1.62	2.11	3.73
T_4 Soil + Cocopeat (1:1)	1.38	1.65	1.44	0.91	2.35	1.70	2.03	3.73
T_5 Soil + Vermicompost + Vermiculite (1:1:1)	1.33	1.60	1.44	0.80	2.25	1.83	1.85	3.68
T_6 Soil + Vermicompost + Cocopeat (1:1:1)	1.48	1.66	1.45	1.06	2.51	2.00	2.04	4.04
T_7 Soil + Vermicompost + Vermiculite + Cocopeat (1:1:1:1)	1.51	1.70	1.49	0.79	2.28	2.29	2.06	4.63
T_8 Soil + Sand + Vermicompost + Vermiculite (1:1:1:1)	1.57	1.76	1.40	1.79	3.19	2.44	2.63	5.07
T_9 Soil + Sand + Vermicompost + Vermiculite + Cocopeat (1:1:1:1:1)	1.65	1.86	1.59	1.88	3.47	2.54	2.90	5.44
Mean	1.41	1.60	1.44	1.01	2.46	1.91	2.13	4.08

M = Media, A = Azotobacter and M x A = Interaction of Media and Azotobacter

	Per cent nitrogen content			Chlorophyll content								
				Chlorophyll-a			Chlorophyll-b			Total chlorophyll		
	M	A	M x A	M	A	M x A	M	A	M x A	M	A	M x A
SEm ±	0.040	0.018	NS	0.043	0.019	0.061	0.036	0.016	0.051	0.080	0.035	0.113
CD at 5 %	0.118	0.052	NS	0.127	0.056	0.179	0.106	0.047	0.150	0.234	0.104	0.331

Table 3. Effect of media with or without *Azotobacter* on root parameters of acid lime seedlings

Treatments	Number of secondary roots		Length of the longest tap root (cm)		Fresh weight (g)		Dry weight (g)		Diameter of tap root (mm)	
	Without Azotobacter	With Azotobacter	Without Azotobacter	With Azotobacter	Without Azotobacter	With Azotobacter	Without Azotobacter	With Azotobacter	Without Azotobacter	With Azotobacter
T_0 Control (soil)	30.93	31.13	12.60	17.26	1.35	1.53	0.45	0.52	2.14	2.21
T_1 Soil + Sand (1:1)	32.46	32.00	16.73	17.43	1.68	1.99	0.53	0.57	2.16	2.40
T_2 Soil + Vermicompost (1:1)	36.26	35.93	17.16	16.66	1.93	2.25	0.59	0.60	2.70	2.83
T_3 Soil + Vermiculite (1:1)	34.93	33.86	18.03	18.70	1.97	2.02	0.57	0.58	2.57	2.60
T_4 Soil + Cocopeat (1:1)	36.13	34.33	18.46	17.60	2.16	2.08	0.62	0.70	2.66	2.60
T_5 Soil + Vermicompost + Vermiculit e (1:1:1)	34.06	37.66	16.70	17.20	1.69	2.06	0.63	0.76	2.83	2.35
T_6 Soil + Vermicompost + Cocopeat (1:1:1)	34.86	33.73	16.16	17.06	2.39	2.43	0.78	0.92	2.71	2.63
T_7 Soil + Vermicompost + Vermiculite + Cocopeat (1:1:1:1)	37.20	38.53	18.00	19.30	2.36	2.64	0.83	1.00	2.36	2.89
T_8 Soil + Sand + Vermicompost + Vermiculite (1:1:1:1)	33.86	39.06	17.66	19.36	1.87	2.67	0.87	1.03	2.43	2.91
T_9 Soil + Sand + Vermicompost + Vermiculite	37.66	40.66	19.06	19.73	2.56	2.77	1.11	1.18	2.86	2.95

area was observed in medium soil + vermicompost -1:1 i.e. 1.18 cm^2.The leaf size and chlorophyll content were maximum in *Azotobacter* treatment (Table 2), it may be because of synthesis of chlorophyll and the higher absorption of nutrients especially nitrogen as a result of inoculation with Azotobacter (Joolka *et al.* 2004).

Root parameters

The length of longest tap root, diameter of tap root, number of secondary roots and root/shoot ratio increased significantly due to application of soil + sand + vermicompost + vermiculite + cocopeat (1:1:1:1:1) with Azotobacter. Likewise, at 150^{th} day of sowing the length of longest tap root (19.73 cm), diameter of tap root (2.95 mm), number of secondary roots (40.66) and root/shoot ratio (2.57) were found maximum at medium treatment T_9 consisting of soil + sand + vermicompost + vermiculite + cocopeat (1:1:1:1:1) with Azotobacter. Whereas, the minimum length of longest tap root (12.60 cm), diameter of tap root (2.14 mm), number of secondary roots (30.93) and root/shoot ratio (1.31) were recorded in soil without *Azotobacter* (Table 3).

The beneficial effect on root growth parameters due to application of the medium treatment consisting of soil + sand + vermicompost + vermiculite + cocopeat (1:1:1:1:1) with Azotobacter might be due to improved soil texture, structure, porosity, water holding capacity, activity of useful soil micro fauna and flora, maintained soil temperature and improved soil health and nutrient status of medium (Hartmann and Kester, 1997). Further the vermicompost also provides close contact between seed and media, increases steady moisture supply facilitates root respiration and encourages overall root growth (Chatterjee and Choudhari, 2007).

Biochemical analysis

The nitrogen content in leaves of acid lime as affected by different rooting media reveals that it had significant effect on nitrogen content in leaves of acid lime (Table-3). The medium consisting of soil + sand + vermicompost + vermiculite + cocopeat (1:1:1:1:1) had estimated significantly maximum nitrogen content (1.75%) in leaves of acid lime seedling and minimum nitrogen content was observed in control (1.36%). The increase in nitrogen content of leaves in acid lime seedling might be due to application of Azotobacter along with suitable media mixture had fixed sufficient quantity of atmospheric nitrogen for which it is known.

These results are in line with the findings of Joolka *et al.* (2004) in pecan and Rao and Dass, (1989) in fruit plants, they reported increased per cent nutrient content particularly nitrogen in the leaves of plants by inoculation of *Azotobacter.*

Similarly, the this medium treatment had estimated maximum Chlorophyll-a (2.06 mg/g), Chlorophyll-b (2.39 mg/g) and thereby total chlorophyll (4.45 mg/g) content of acid lime seedling leaves which were significantly superior over all other their respective treatments including control. However, minimum Chlorophyll-a (1.47 mg/g) content was estimated in treatment soil + sand (1:1) which was statically at par with control (soil) while minimum Chlorophyll-b (1.19 mg/g) and total chlorophyll (2.70 mg/g) content of acid lime seedling leaves were recorded in medium soil (control). The increase in chlorophyll content in leaves of seedling with application of medium combination along with vermicompost and Azotobacter may be due to stimulated nutrient uptake specially nitrogen and synthesis of chlorophyll which have role in the assimilation of numerous amino acids that are subsequently incorporated in proteins and nucleic acid, which provides framework for chloroplast results into better Chlorophyll content in leaves of treated plant (Awasthi *et al.*, 1996).

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INDIAN JOURNAL OF
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2012, Vol.7 (1-2) : 45-48

Effect of organic manure and biofertilizers on soil properties and growth of aonla under rainfed conditions of hot semi-arid environment

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Abstract

The experiment was conducted on seven and eight years old trees of NA-7 *aonla* to evaluate the influence of various levels of organic (FYM, biofertilizers) and inorganic (NPK) sources of nutrients on morphometrix, productivity and quality attributes of aonla and soil quality during 2009-10 and 2010-11 under hot semi-arid ecosystem. Significant improvement was recorded in soil quality by application of different combinations of N P K, FYM and biofertlizers. The vegetative growth and soil quality were influenced significantly by different sources of nutrients. Maximum vegetative growth was recorded in the plants which were applied with standard doses of N P K which was closely followed by Farm Yard manure plus 50% of the standard dose NPK. The soil properties in terms of *pH,* EC showed declining trend whereas level of hydraulic conductivity, organic carbon increased with the application of various combinations of FYM and biofertilizers, whereas pH, EC, hydraulic conductivity, bulk density and organic carbon of the basin soil applied with standard dose of NPK were not improved considerably.

Key words: *Aonla, organic, inorganic, nutrients, FYM, biofertilizers.*

Introduction

Aonla or Indian gooseberry (*Emblica officinalis* Gaertn), is hardy known for its highly nutritive fruit. The tree is being grown successfully across the country in varied agro-climatic conditions in an area of more than 50,000 ha area in the country with 1.75 lakh tones production (Pathak *et al.,* 2005). Its cultivation has gained significance in Gujarat because of its wider adaptability to harsh edepho-climatic conditions; higher productivity and general freedom from sever attack of insect, pest and diseases. In the recent years, aonla has been identified as an ideal plant for various kinds of wastelands of arid and semi-arid ecosystem (Korwar *et al.,* 2006*;* Pathak and Pathak, 2001). The demand of *aonla* fruit is increasing day by day owing to its utilization in cosmetic, pharmaceutical and processing industries (Ranjan and Ghosh, 2006). Since *aonla* is consumed for its medicinal and nutraceutical properties, its organic production has gained great significance during the recent years.

In recent years, decline in soil health with respect to physical, chemical and biological properties is evident owing to indiscriminate use of fertlizers. Continuous use of chemical fertilizers without organic fertilizers causes problem of soil health, while use of organic fertilizers without augmentation of inorganic fertilizers may not be able to meet the high nutrient requirement of the crop due to low nutrient content and slow acting in nature. (Marathe *et al.,* 2009). Application of biofertilizers into the soil enhances microbial activity and soil fertility. Further, due to increase in the cost of chemical fertilizer coupled with their limited production, it has become essential to evolve low cost input management practices for sustainable production of quality fruit (Pathak, *et al.,* 2005 and Pathak, 2003). Like other crops, in aonla too, integrated nutrient management is the key factor to achieve higher yield per unit area with improved produce quality. Integrated nutrient management encourages integration of different sources of nutrients such as organic, biological and inorganic fertilizers etc. In view of the factors like increasing demand of organically grown fruits by consumers coupled with unsustainable productivity of fruits, organic farming is claimed to be most benign alternative, for which role of organic manure and biofertilizers become important for sustainable production with quality fruits. Keeping the utility of organically produced *aonla* in view, an experiment was initiated by integrating the microbial and chemical fertilizers to find out its effect on soil properties and plant health, fruit yield and quality of aonla variety AN-7.

Material and Methods

A field experiment was conducted on *aonla* trees of

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aonla cv. NA-7 at Central Horticultural Experiment Station (CIAH), Vejalpur, Panchamahals (Godhra), Gujarat. The treatments were; T_1, standard dose of N P K, T_2, FYM + 50 % of recommended dose of N P K, T_3, FYM + *Azotobactor* + PSB, T_4, FYM + *Azospirillum* + PSB, T_5, FYM + *Azotobactor* + VAM, T_6, FYM + *Azospirillum* + VAM. Biofertlizers; A*zotobactor, Azospirillum*, PSB and VAM were applied @ 250g per tree/year soon after first rain in monsoon season. FYM @ 30 kg/tree and NPK @ 100, 75 and 50 g were applied during first year. The FYM @ 5 kg/ tree/ year and NPK doses were increased in same proportion every year. Thus the dose of FYM was applied @ 60 kg and 65 kg per tree during 2009-10 and 2010-11, respectively, while chemical fertilizer *viz*, N P K were applied at the rate of 700, 525 and 350 g / tree during 2009-10, and 800, 600 and 400 g/ tree during 2010-11, respectively in two split doses (last week of June and first week of September). The soil was analyzed for organic carbon, EC, p^H, N, P and K (Bhargava and Raghupati, 1393), and soil bulk density and hydraulic conductivity (Page *et al.*, 1982) before the initiation of the experiment. The soil was characterized with low organic carbon (4.3g kg^{-1}), low N (180.65 kg ha^{-1}) and medium K (115.10 kg ha^{-1}) and medium P (11.00 kg ha^{-1}). The initial values of pH, EC, Bulk density, hydraulic conductivity (H.C.) were recorded to the tune of 7.60, 0.13 dS m^1, 1.39 Mg $m^{-1}$and H. C. 0.32 cm / hr, respectively. The experiment was laid out in randomized block design with six treatments and four replications considering two plants as unit. The soil depth ranged from 0.70 to 1.0 m and it is derived from mixed alluvial basalt, quartzite, granite, and layers of limestone, and the region falls under semi-arid hot climate. The uniform cultural practices were applied to the experimental trees, which were grown purely under rainfed condition of hot semi-arid ecosystem of western India.

Results and Discussion

Perusal of data indicated that the physico-chemical properties of soil were influenced significantly by use of different kind of sources of nutrients (Table 1). The results of the study of various organic and inorganic sources of nutrients on soil reaction (pH) revealed that the treated basin soil declined from its initial value of 7.60 to 6.60, 6.70, 6.71 and 6.72 during 2009-10 whereas it was declined from its initial value to 6.52, 6.62, 6.64 and 6.65 during 2010-11with T_5, T_3, T_6 and T_4, respectively while pH of the basin soil was not influenced significantly with the application of NPK alone (T_1). The EC of the soil decreased from its initial value 0.13 dS m^{-1} to 0.11 and 0.10 dS m^{-1} in being lowest in T_6, but the differences among the treatments were found to be non significant. This decrease in soil pH and EC may be attributed to the continuous use of organic manure which releases various organic acids upon its decomposition and leaching of salts to the lower layers of the soil during rainy season. A decrease in pH of soil under Farm Yard manure may be due to the activation of Al^{3+} and continuous release of basic cation upon its decomposition and gravitational movement of those cations in to lower horizons of soil. These results are in close conformity with the findings of Marathe *et al. (2009*) and Srikanth *et al*. (2000). In the tree basin, addition of Farm Yard Manure and biofertlizers decreased the bulk density from its initial value1.39 Mg m^{-3} to 1.28, 1.29, 1.32 and 1.33 Mg m^{-3} in 2009-10 with the treatments T_5,T_3, T_6 and T_4 and 1.25,1.27,1.25,1.30 Mg m^{-3} in 2010-11 with T_5, T_3,T_4 and T_6, respectively, while bulk density was recorded maximum in T_1(1.36 Mg m^{-3}) which may be due to increase in organic matter in soil. Hydraulic conductivity was observed the highest in FYM + *Azotobactor* + VAM (T_5) followed by FYM + *Azotobactor* + PSB (T_3) and it was recorded lowest in T_1 (NPK alone). The bulk density and hydraulic conductivity were not much influenced by treatments comprising the inorganic sources of nutrients (T_1). The results suggested that the application of manures reduced the bulk density and compactness of the soil particles and improved the hydraulic conductivity. These findings are in agreement with the results of Srikanth *et al.* (2000) and Ram and Rajput (2000). Organic carbon and NPK content of basin soil was enhanced by the application of various types of manure used in different combinations (Table 2). The organic carbon increased from its initial value 4.30 g kg^{-1} to 5.25, 5.20, 5.15, 5.10, 5.00 and 4.33 kg^{-1} (2009-10) and 5.35, 5.30, 5.23 5.21, 5.20 and 4.40 kg^{-1} in the treatment T_6, T_3, T_4, T_6, T_2 and T_1, respectively, which may be due to application of farmyard manure and different biofertilizers. However, maximum build up of organic carbon was observed in FYM + *Azotobactor* + VAM (T_5), which were found to be 22.09 and 24.41 per cent increment from their initial value. Organic manure may have increased organic carbon content by adding organic matter directly in the basin soil. These results are in accordance with the findings reported by Korwar *et al.* (2006). Available N was recorded maximum with the application of standard dose of NPK (T_1) followed by FYM+ 50 % of the standard dose of NPK (T_2), FYM + *Azotobactor* + VAM (T_6) and FYM + *Azotobactor* + PSB (T_3). Addition of organic manure improved the physical properties of soil thus creating favourable conditions for microbial activity resulting to an increase in the nutrient availability. These

Table 1. Effect of various organic and inorganic sources of nutrients on physical properties of soil.

Treatments	pH(1:2:5)			EC (dS $m^{-1)}$			Bulk density (Mg m^{-3})			H.C. (cm/hr)		
	2009-10	2010-11	Mean	09-10	10-11	Mean	09-10	10-11	Mean	09-10	10-11	Mean
T_1	7.25	7.30	7.28	0.13	0.12	0.125	1.37	1.35	1.36	0.35	0.37	0.360
T_2	6.85	6.73	6.79	0.12	0.11	0.115	1.33	1.30	1.32	0.41	0.41	0.410
T_3	6.70	6.62	6.66	0.12	0.10	0.110	1.29	1.27	1.28	0.42	0.44	0.430
T_4	6.72	6.65	6.68	0.11	0.11	0.110	1.32	1.30	1.31	0.40	0.43	0.420
T_5	6.60	6.52	6.56	0.11	0.10	0.105	1.28	1.25	1.26	0.45	0.47	0.460
T_6	6.71	6.64	6.67	0.12	0.11	0.110	1.32	1.30	1.31	0.43	0.44	0.435
C D at 5%	0.38	0.32	-----	NS	NS	---	0.06	0.05	---	0.09	0.07	----

findings are in agreement with the results of Srikanth *et al*. (2000), Yaday *et al*., 2007 and Ranjan and Ghosh (2006). Available P concentration increased to 16.00, 15.50, 15.25, 14.78 kg per ha from the initial value 11.00 kg per ha in T_1, T_2, T_5 and T_3, respectively in 2009-10, while it was increased from its initial value 11.00 kg per ha to 19.85, 17.00, 16.80, 16.12, 15.43 and 15.00 kg per ha with the treatments T_1, T_2, T_5, T_3, T_4, and T_6, respectively in 2010-11. Release of P in the soil from unavailable to available forms because of reaction of organic acids produced after decomposition of organic manure. More or less similar results have been reported by Korwar *et al.* (2006) and Srikanth *et al*. (2000). The average increase in available K was observed the maximum in standard dose of NPK(T_1), whereas it increased from initial value 116.60 to 129.31, 123.28 and 121.36 kg per ha in T_1, T_2 and T_5, respectively. There was slight increase in soil K content might be due to release of fixed K owing to reaction of organic acids. These results are in consonance with the findings as reported by Korwar *et al.* (2006), Manjunath *et al*., (2006), Ranjan and Ghosh (2006) and Patel *et al*. (2010).

An effect of application of various kinds of manures, biofertilizers and fertilizers significantly influenced the vegetative growth of plant (Table 3). Among the different combinations of organic and inorganic sources of nutrients evaluated, the growth in terms of plant height, root stock girth, scion girth and plant spread was recorded the highest from the plants treated with standard dose of NPK (T_1) followed by FYM + 50 % of standard dose of NPK (T_2), FYM + *Azotobactor* +VAM (T_5) and the minimum growth was recorded with FYM + *Azospirillim* +VAM (T_4). The average annual extension of plant height (61.25 cm), rootstock girth (5.57 cm), scion girth (4.77 cm) and plant spread (50.85 cm) were recorded with T_1 followed by T_2, T_5 and T_3.The plant height (57.47cm), was recorded minimum in T_6, while root stock girth (5.04 cm), scion girth (3.94 cm)and plant spread (43.03 cm) were the minimum in T_4. Differences in the growth among various treatments might be due to availability of nutrients by various sources of nutrients. These results are in accordance with the findings reported by Korwar *et al.* (2006), Balota *et al.* (1995), Patel *et al.* (2009), Dev *et al.*, (2005), Pathak and Tiwari (2002) and Srikanth *et al.* (2000).

Thus, it may be concluded from the present study that the use of Farm Yard Manure, biofertilizers and NPK in different combinations improved the soil physico-chemical properties and nutrients availability to the plants, which resulted into better plant growth of aonla variety NA-7 under rainfed conditions of hot semi-arid ecosystem.

Table 2. Effect of various organic and inorganic sources of nutrients on chemical pro perties of soil.

Treatments	O.C. (g kg^{-1})			Available N(kg ha^{-1})			Available P (kg ha^{-1})			Available K(kg ha^{-1})		
	2009-10	2010-11	Mean	09-10	10-11	Mean	09-10	10-11	Mean	09-10	10-11	Mean
T_1	4.33	4.40	4.36	200.35	208.35	204.35	16.00	19.85	17.93	128.45	130.16	129.31
T_2	5.00	5.20	5.10	196.14	205.14	200.64	15.50	17.00	16.25	121.43	125.12	123.28
T_3	5.20	5.30	5.25	192.13	196.13	194.13	14.78	16.12	15.45	116.00	123.52	119.76
T_4	5.15	5.23	5.19	191.15	195.00	193.07	13.00	15.43	14.22	117.84	121.45	119.64
T_5	5.25	5.35	5.30	194.15	198.00	196.08	15.25	16.80	16.03	118.00	124.72	121.36
T_6	5.10	5.21	5.16	190.00	194.15	192.08	13.87	15.00	14.44	115.89	120.00	117.95
C D at 5%	0.20	0.23	------	8.40	7.50	------	1.35	1.48	------	8.30	8.91	------

Table 3. Effect of various sources of nutrients on annual extension of vegetative growth of aonla (2009-2011).

Treatments	Plant height (cm)			Root stock girth (cm)			Scion girth (cm)			Plant spread (cm)		
	2009-10	2010-11	Mean	09-10	10-11	Mean	09-10	10-11	Mean	09-10	10-11	Mean
T_1	60.15	62.34	61.25	5.53	5.60	5.57	4.13	5.40	4.77	50.00	51.70	50.85
T_2	59.00	61.00	60.00	5.40	5.30	5.35	4.10	5.20	4.65	49.55	49.12	49.33
T_3	58.14	59.12	58.63	5.00	5.23	5.12	3.95	4.05	4.00	46.00	47.03	46.51
T_4	55.14	56.12	55.63	4.90	5.19	5.04	3.88	4.00	3.94	42.00	44.05	43.02
T_5	59.73	59.95	59.84	5.43	5.50	5.47	4.00	4.09	4.05	47.34	48.13	47.73
T_6	56.15	58.79	57.47	5.12	5.00	5.06	3.87	4.02	3.95	43.00	45.50	44.25
C D at 5%	2.45	2.63	---------	0.42	0.46	---------	0.22	0.26	---------	2.36	2.75	---------

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2012, Vol.7 (1-2) : 49-51

Impact of biofertilizers and organic inputs on biomass, quality and yield parameters of vegetable pea

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Received: January, 2013; Accepted: April, 2013

Abstract

A field experiment was conducted in a Typic Ustochrept soil of Varanasi region ($83^0$0' E longitudes and $25^0$10' N latitude) with Arkel, Azad P_1 and Azad P_3 varieties of pea under treatment combination of low cost organic inputs plus biofertilizers and compared to standard packages of practices. The total biomass, vegetable pea and grain yield of Azad P1 was significantly higher compared to Arkel and Azad P3. The supplementation of sulphur nutrient through pressmud significantly enhanced the yield attributes in all the three tested varieties. Application of *Azotobacter* alone or in combination with *Rhizobium* significantly influences the quantitative and qualitative traits in pea. The dual inoculation of *Rhizobium* / *Azotobacter* @ 200 g/10 kg seeds and PSB plus soil application of pressmud @ 5t/ha significantly enhanced the yield and quality traits of vegetable and grain pea.

Key words: *Pea, organic manures, bio-fertilizer*

Introduction

Pea (*Pisum sativum* L.) has become a popular winter vegetable crop of eastern Uttar Pradesh. The farmers of Varanasi region are inclined towards the cultivation of vegetable pea because of consistent market demand and high economic return compared to other crops. Further, incorporation of legume in an intensive cropping system is preferred by the growers of this region for *in situ* N replenishment in the soil. The farmers of this region, however, were not acquainted with the uses of biofertilizers particularly *Azotobacter/Azospirillum* and phosphate-solubilizing bacteria (PSB) besides *Rhizobium* coupled with application of sulphur (S) in pea. The incorporation of locally available low cost organic inputs like pressmud (sulphinated by product of sugar factory) which is a rich source of S besides other major and micronutrients can accelerates the productivity of pea besides maintaining the soil health. The scientific literature on biomass, quality and yield parameters of vegetable pea as effected by free N fixers, P solubilizers and S nutrition through pressmud is limited especially with references to eastern Uttar Pradesh. The recycling of disposable organic waste and their utilization in crop production is gaining momentum with the increasing awareness in soil and environmental pollution. Hence, the present study was planned to generate information on the effectiveness of the integrated use of organic source and biofertilizers on the productivity and residual soil fertility status for widely grown pea varieties of eastern Uttar Pradesh.

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Materials and Method

A field experiment was conducted for three consecutive years during rabi season of 2001-02, 2002-03 and 2003-04 at the *Indian Institute of Vegetable Research* farm ($83^0$0' E longitudes and $25^0$10' N latitude), Varanasi, with three prominent varieties of pea (Azad P_1, Azad P_3 and Arkel). The soil of the experimental site was sandy loam, Indo-Gangetic alluvium of Inceptisol origin (Typic Ustochrept) with pH varying between 7.6-7.8, EC 0.410.52 dSm^{-1}, Organic carbon 0.380.41 % and available nitrogen 270310 kg/ha, available phosphorus 1823 kg/ha, potassium 297310 kg/ha and sulphur 1416 kg/ha. Seeds of these varieties were sown during 2 November 2001, 6 November 2002 and 8 November 2003. The treatment includes: T_1control, T_2Pressmud @ 5t/ha + *Azotobacter* @200 g/10 kg seed, T_3Pressmud @ 5t/ha + *Rhizobium* @ 200 g/10 kg seed, T_4Pressmud @ 5t/ha+PSB @ 5kg/ha soil application, T_5Pressmud @ 5t/ha+*Azotobacter* @200 g/10 kg seed+ PSB @ 5kg/ha soil application, T_6Pressmud @ 5t/ha+*Rhizobium* @ 200 g/10 kg seed+ PSB @ 5kg/ha soil application, T_7Pressmud @ 5t/ha, T_8FYM @ 5t/ha, in a split plot design with three replication. The full amount of FYM and pressmud were applied 20 days before sowing followed by pudding to ensure optimum soil moisture during land preparation and seed sowing of pea. Certified seeds were treated @ 200g /10 kg with individual N fixers, *Azotobacter* +PSB and *Rhizobium* +PSB, sown in each plot at a spacing of 30 x 10 cm and then

covered with soil plus PSB @ 5 kg/ ha and finely ground compost mixture. The recommended fertilizer doses (N @ 30 kg/ha, P @ 60 kg/ha and K @ 60 kg/ha) were applied during the field preparation through urea, diammonium phosphate and muriate of potash. All the standard agronomic production and plant protection practices were followed for the better crop stand. The soil moisture regime was maintained by providing sprinkler irrigation at 28 and 49 days after sowing. The plants were uprooted at physiological maturity stage and observation related to biomass, yield and quality parameters were recorded and analyzed statistically**.** Ascorbic acid content of pea was estimated by titrimetry (AOAC, 1990), and carbohydrate content by both phenol sulfuric acid method and anthrone method (Sadasivam and Manickam, 1996) and the mean of replicate samples was reported. Total nitrogen was estimated by the micro-kjeldhal method according to AOAC (1990) and used for estimation of protein content by multiplying with a factor of 6.25 in a Kel Plus 1002 model of FOSS-TECATOR

Result and Discussion

Genetic performance of pea cultivars

The plant height of Azad P_3 and Arkel was at par and significantly higher to Azad P_1. The fresh root weight / plant, pod length, number of grain per pod, grain yield and fresh pod yield in Azad P_1 showed significantly higher value (0.718g, 9.1cm, 6.8, 11.98 q/ha and 99.6 q/ha, respectively) as compared to Azad P_3 and Arkel (Table 1). The Arkel and Azad P_1 showed significantly higher number of pod per plant as compared to Azad P_3.

Treatment impact

Biomass and yield

The yield and yield attributes under lone and combined application of organic nutrients and biofertilizers was significantly different as compared to control (Table 2). A significantly higher plant height, fresh shoot weight, fresh root weight, fresh pod yield and seed yield was obtained when the crops grown under the combined application of pressmud @ 5t/ha, single and or dual inoculation of N fixers i.e. *Rhizobium, Azotobacter* @ 200 g/10kg seed and soil application of PSB @ 5 kg/ha. The inoculation of *Rhizobium* and/or *Azotobacter* incorporated in pea rhizosphere through seed treatment probably induced more amount of nitrogen fixation in nodules of pea *vis-a-vis* solubilisation of fixed N from non-available to exchangeable pool, which impart more vegetative growth. This corroborates with the findings of Daweny and Vankessel 1990, George and Vessey 2006. The significantly highest number of pod /plant (11.6), pod length (9.2 cm), number of grain/pod (6.7), fresh pod yield (95.3 q/ha) and grain yield (12.8 q/ha), was observed with the dual inoculation of *Rhizobium* @ 200g/10 kg as seed treatment and PSB @ 5 kg/ha as soil application. All the yield attributes was significantly improved by dual inoculation of *Rhizobium* and PSB. This result is also in conformity with the work of Bhandal et al 1989, Rudresh *et al.* 2005. The dual inoculation of *Rhizobium* and PSB resulted more availability of nitrogen and phosphorus because of their associative effect plus solubilisation from non-exchangeable to labile form, which leads to significant increase in growth, and yield attributes as compared to single or un-inoculated plot. The increased availability of nitrogen and phosphorus in root zone of pea was favoured by combined inoculation has been reported in literature (Pers *et al.*, 1989, Singh and Singh 1992 and Rudresh *et al.* 2005).

Quality attributes

The effect of dual inoculation of *Rhizobium* and

Table 1. Genotypic performance on biomass, yield and quality of green pea

Varieties	Plant height (cm)	Fresh shoot weight /plant	Fresh root weight /plant (g)	Number of Fresh Pod/plant	Fresh weight/ 10 pod (g)	Pod length (cm)	Number of grain/ pod	Grain yield q/ha	Fresh pod yield q/ha	Vitamin C (mg/100gm)	Carbohydrate (mg/gm)	Protein (%)	Phosphorus (%)	Sulphur (%)
Arkel	54.3	14.0	0.51	10.4	41.0	8.3	5.2	8.95	82.57	25.1	22.1	22.7	0.56	0.32
AP_1	42.3	12.7	0.71	9.6	45.2	9.1	6.8	11.98	99.6	23.7	21.9	22.7	0.60	0.36
AP_3	55.1	12.2	0.61	7.7	42.7	8.6	5.7	9.55	87.9	26.1	22.7	23.0	0.55	0.30
LSD=0.05	3.70	3.10 (ns)	0.08	1.6	3.2 (ns)	0.40	0.7	0.42	11.5	1.2	0.9 (ns)	0.4 (ns)	0.05 (ns)	0.02

Table 2. The combined impact of FYM, PM and biofertilizers on pod biomass, yield and nutritional status of pea grain

Treatments	Plant height (cm)	Fresh shoot weight /plant (g)	Fresh root weight /plant (g)	Number of Fresh Pod /plant	Fresh Pod weight /plant (g)	Pod length (cm)	Number of grain /pod	Grain yield (q/ha)	Fresh pod yield (q/ha)	Vitamin C (mg/100gm)	Carbohydrate (mg/gm)	Protein (%)	Phosphorus (%)	Sulphur (%)
Control	44.9	30.6	0.84	8.2	32.1	7.9	4.9	9.6	58.3	23.7	18.0	21.8	0.47	0.22
PM + Azo	55.3	36.3	1.01	9.6	44.3	8.8	6.1	11.9	87.9	25.4	20.9	23.0	0.53	0.33
PM + Rhz	56.4	48.2	1.44	9.4	53.0	8.6	6.1	11.2	92.0	27.6	21.1	22.9	0.57	0.36
PM + PSB	55. 4	39.1	1.06	9.1	45.8	8.7	6.4	12.3	92.4	24.0	25.0	22.8	0.64	0.35
PM +Azo + PSB	55.1	39.6	1.34	8.4	45.4	8.8	6.5	12.4	95.2	25.0	23.3	23.2	0.58	0.37
PM +PSB + Rhz	55.9	42.2	1.26	11.6	45.8	9.2	6.7	12.8	95.3	30.0	25.7	23.8	0.67	0.39
PM	50.4	33.9	1.18	9.0	39.6	8.4	6.1	11.4	79.6	23.0	21.2	22.5	0.53	0.33
FYM	50.1	33.3	1.24	8.8	37.9	8.8	6.1	10.8	79.1	21.3	22.0	22.4	0.53	0.26
LSD = $_{0.05}$	3.20	6.10	0.16	2.2	7.9	0.6	1.5	1.74	27.5	1.6	2.1	0.7	0.05	0.04

Azotobacter along with the pressmud was found superior on the performance of quality traits of pea grain (Table 2) Kumawat and Khorgarot, 2002. Significantly highest vitamin C content (30.0 mg/100gm), carbohydrate (25.7 mg/gm), protein (23.8 %), phosphorus (0.67 %), and sulphur (0.39 %), in grain was obtained when the crops were grown under dual inoculation of *Rhizobium* and PSB along with the press mud @ 5t/ha**.** Associative effect of *Rhizobium* and PSB in dual inoculation treatment was resulted in significant increase in nitrogen content, which directly reflected in protein content, and the protein levels in grains. Further PSB mobilises more p in the labile pool, which accentuated the activity of N and S by synergistic mechanism. More pronounced effect of combined inoculation over single inoculation was observed by (Alagawadi and Gaur, 1988, Tyagi *et al.* 2003, Rudresh *et al.*, 2005). No significant variation in terms of carbohydrate, protein contents and phosphorus was noted among the tested varieties except a comparatively low, vitamin C contents in Azad P_1.

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INDIAN JOURNAL OF
ARID HORTICULTURE
2012, Vol. 7 (1-2) : 52-56

Studies on the effect of times of patch budding in Aonla

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Received : January, 2013; Accepted: March, 2013

Abstract

The present experiment was carried out at Fruit Research Station, Kuthulia, College of Agriculture, Rewa (M.P.) during 2008-09. The investigation was carried out on ten treatments i.e., 21st September, 01st October, 11th October, 21st October, 01st November, 11th November, 21st November, 01st April, 11th April and 21st April in a randomized block design with four replications. The results showed that the maximum bud sprouting percentage (69.25 %), survival percentage (64.50 %), bud take success percentage (58.75 %), leaf chlorophyll content (5.65), shoot length, shoot diameter and number of leaves per sprouted shoot were recorded in the month of 21st April. However, maximum time taken for bud sprouting (30.75 days) was found in 21st November. Whereas, minimum bud sprouting percentage (24.75 %), survival percentage (22.50 %), bud take success percentage (14.25 %), shoot length, shoot diameter and number of leaves per sprouted shoot were recorded in the month of 21st November. However, minimum time taken for bud sprouting was found in 21st April and leaf chlorophyll content (3.04) in 1st November. The results reveal that date of budding 21st April was significant superior to all other date of budding. However shoot length per sprout at 90 days after operation, shoot diameter per sprout at 15, 45, 60 and 90 days after operation and number of leaves sprouted shoot at 60, 75 and 90 days after operation were non- significant. The patch budding given best suitable period obtained from the month 11th April to 21st April.

Key words: *Aonla, patch budding, time of propagation*

Introduction

Aonla (*Emblica officinalis* Gaertn.), belonging to the family Euphorbiaceae, is also known as Indian Gooseberry is a minor sub tropical deciduous tree indigenous to Indian sub-continent. This is a minor sub-tropical deciduous indigenous tree of Indian sub-continent. It can be grown successfully in dry and neglected region owing to its hardy nature, suitability to various kinds of wasteland. A mature aonla tree can tolerate freezing as well as high temperature of 46^0 C. In Madhya Pradesh it is potentially cultivated in Dewas, Seoni, Tikamgarh, Betul, Shivpuri, Panna, Rewa, Satna district etc. Aonla is propagated through seed as well as vegetative method. Among vegetative methods, patch budding, wedge and veneer grafting are widely employed in aonla. Upright growth habit of tree limits availability of scion shoots at convenient height and hence budding is more preferred commercially. It is propagated through patch/ modified ring budding in north India during mid May to September with 60-100 % success. Considering the efficiency and requirements of single bud, budding is an ideal method of propagation. Limited systematic work on this important aspect has yet been done in different region of Madhya Pradesh looking to the importance the vegetative propagation, different date of budding were taken to find out the best time of operation to get maximum success and survival.

Material and Methods

The present experiment was carried out at Fruit Research Station, Kuthulia, College of Agriculture, Rewa (M.P.) under Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) during 2008-09. Rewa is situated in the North- Eastern part of Madhya Pradesh at latitude 24.31'N', longitude 81.5'E' and altitude of 365.7 meters above the mean sea level. The climate of Rewa region is semi arid and sub-tropical having hot and dry summer followed by rainy season and cold winter. In general, the highest and lowest rainfall reaches above 900 mm to 1150 mm. the rainfall is observed mainly from July to September and sometimes winter showers are also received. The investigation was carried out on ten treatments i.e., 21st September, 01st October, 11th October, 21st October, 01st November, 11th November, 21st November, 01st April, 11th April and 21st April. The experiment was arranged in a randomized block design with four replications. The aonla seed were sown in well manured nursery. After germination the seedling were lifted out carefully and shifted in the final nursery beds and planted in the month of September, 2007. The seedlings were properly maintained in the nursery beds up to July, 2008. The seedlings were selected and operated as per treatment in the year 2008. The NA-7 variety of aonla was chosen as bud stick for budding. Observation were recorded on growth characters i.e., bud sprouting %, survival %, bud take success %, time taken for bud sprouting (days), leaf chlorophyll content, shoot length (cm), shoot diameter (cm) and number of leaves per shoot from twenty randomly selected plants in each plot. Sprouting of bud-scions were observed everyday and number of days taken for sprouting was counted back to date of budding. Survival percentage of sprouted buds was calculated for each replication of buds sprouted out of total number of buds prepared. The chlorophyll content of leaf

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was measured with the help of chlorophyll meter. The per cent data were angularly transformed before statistical analysis and both original as well as transformed values are presented. The final data of each characters recorded during the investigation were analysis statistically by the method of "Analysis of variance".

Results and Discussion

The results reveal that date of budding 21st April was significantly superior to all other date of budding. The data presented in (Table 1) indicate that maximum bud sprouting was found in the month of 21st April (69.25 %), which was *at par* 11th April (63.75 %), 1st April (60.00 %) and 21st September (55.00 %), whereas minimum bud sprouting were recorded in 21st November (24.75 %), which was *at par* with the month of 11th November (28.25 %), 1st November (33.75 %) and 21st October (39.25 %). However, the differences amongst the treatment were significant. The higher percentage of bud sprouting obtained in 21st April date of budding may be due to the favourable weather condition during this sprouting period the temperature was average and humidity was high and the weather was cloudy. These results are in conformity with the finding of Pathak *et al.,* (1991) who reported that at 15 days intervals from 1st April to 15th September were studied. The highest bud sprouting (83.3 %) and highest bud survival (73.02 %). The present findings have also been supported by Wagh *et al.*, (2001), Prasad *et al.*, (2003) and Singh *et al.*, (2003).

The data presented in (Table 1) indicate that maximum survival percentage were recorded in the month of 21st April (64.50 %), which was *at par* with 11th April (60.00 %), 1st April (56.25 %) and 21st September (50.00 %), whereas minimum survival percentage were found in 21st November (22.50 %), which *at par* with 11th November (25.00 %), 1st November (30.00 %) and 21st October (35.00 %). However, the differences amongst the treatments were significant. The increase in survival of budded plants seem to be due to meteorological factors especially mid temperature and high relative humidity on 21st April as compared to 21st September and 11th April. Mid temperature and high relative humidity might have reduced the desiccation of tissues and facilitates faster cell division. These results are in conformity with finding of Rai *et al.*, (1999) higher percentage of survival was recorded with patch budding performed on 30th June in 'Pant Apna' and patch budding on 8th July in 'Pant Shivani'. The similar results were reported by Shrivastava *et al.*, (2002), Prasad *et al.*, (2003) and Negi *et al.*, (2010).

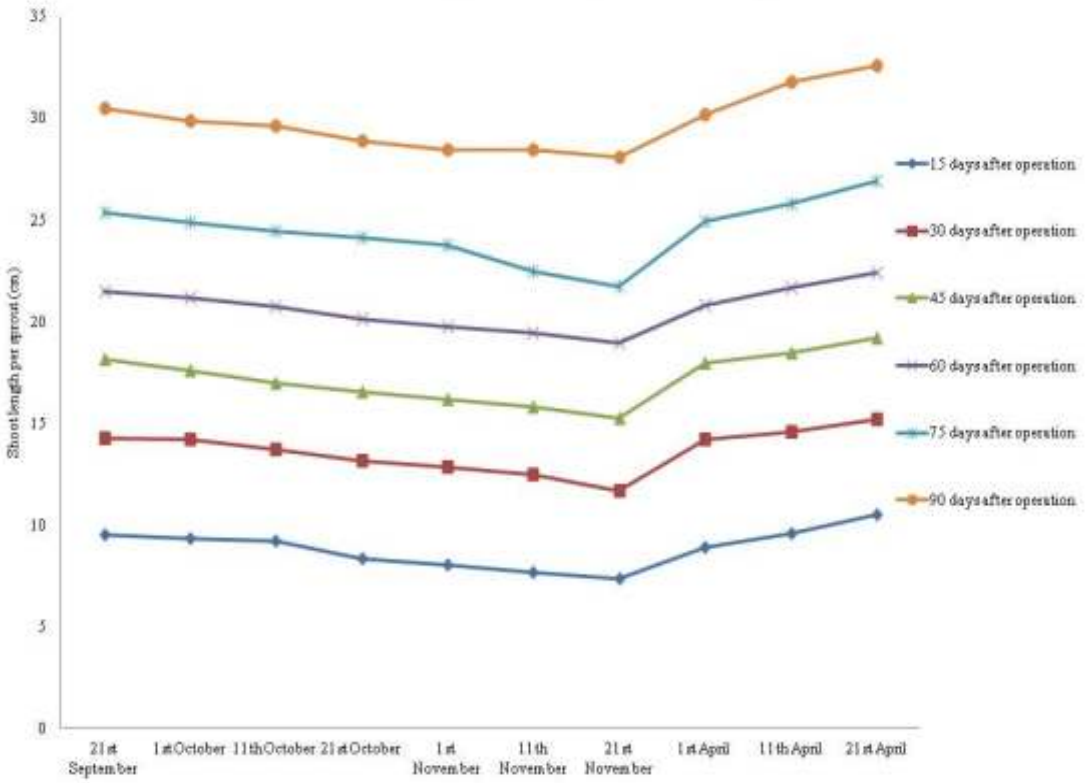
. The data presented in (Table 1) indicate that maximum percentage of bud take success were found in the month of 21st April (58.75 %), which was *at par* with 11th April (52.50 %), 1st April (50.00 %) and 21st September (45.00 %), whereas minimum percentage of bud take success were recorded in 21st November (14.25 %), which was *at par* with the month of 11th November (22.50 %), 1st November (25.00 %) and 21st October (30.00 %). However, the differences the treatments were significant. These results are in conformity with the finding of Upadhyay and Prasad (1988) they found that in patch budding the success was highest in July (85 %) followed by August and September, each with (80 %). The present findings have also been supported by Singh and Parmar (1998), Shalini *et al.,* (2000), Prasad *et al.,* (2003), Patil (2004) and Negi *et al.,* (2010).

The data on time taken for bud sprouting (Table 1) showed that maximum time taken for bud sprouting were recorded in the month of 21st November (30.75 days), which was *at par* with 11th November (28 days), 1st November (27.50 days) and 21st October (24.25 days), whereas minimum time taken for bud sprouting was found in 21st April (14.75 %), which was *at par* with the month of 11th April (15.50 days), 1st April (17.75 days) and 21st September (17.50 days). However, the differences the treatments were significant. These finding were conformed to findings of Kumar *et al.,* (2004) sprouting was earliest (20.6 days) in the plant budding during the September. The similar results were reported by Negi *et al.,* (2010).

The data on leaf chlorophyll content (Table 1) showed that the maximum leaf chlorophyll content were found in the month of 21st April (5.65), which was *at par* with 11th April (5.60), 21st September (5.45) and 1st October (5.42), whereas minimum leaf chlorophyll content were recorded in 1st November (3.04), which was *at par* with the month of 21st November (3.80), 21st October (3.82) and 11th October (4.63). However, the differences the treatments were significant. The similar results were reported by Prasad *et al.,* (2003)

The data presented in (Fig.1) indicate that the maximum shoot length per sprout at 15th days after operation was found in the month of 21st April (10.50 cm), which was *at par* with 11th April (9.60 cm), whereas minimum shoot length per sprout at 15th days after operation was recorded in 21st November (7.34 cm), which was *at par* with the month of 11th November (7.70 cm). However, the differences amongst the treatments were significant. The maximum shoot length per sprout at 30th days after operation was found in the month of 21st April (15.20 cm), which was *at par* with 11th April (14.60 cm), whereas minimum shoot length per sprout at 30th days after operation was recorded in 21st November (11.68 cm), which was *at par* with the month of 11th November (12.46 cm). However, the differences amongst the treatments were significant. The maximum shoot length per sprout at 45th days after operation was found in the month of 21st April (19.20 cm), which was *at par* with 11th April (18.49 cm), whereas minimum shoot length per sprout at 45th days after operation was recorded in 21st November (15.24 cm), which was *at par* with the month of 11th November (15.80 cm). However, the differences amongst the treatments were significant. The maximum shoot length per sprout at 60th days after operation was found in the month of 21st April (22.40 cm), which was *at par* with 11th April (21.65 cm), whereas minimum shoot length per sprout at 60th days after operation was recorded in 21st November (18.94 cm), which was *at par* with the month of 11th November (19.48 cm). However, the differences amongst the treatments were significant. The maximum shoot length per sprout at 75th days after operation was found in the month of 21st April (26.90 cm), which was *at par* with 11th April (25.80 cm), whereas minimum shoot length per sprout at 75th days after operation was recorded in 21st November (21.73 cm), which was *at*

Fig. 1: Effect of different date of patch budding on shoot length (cm) at 15th day's interval



par with the month of 11th November (22.45 cm). However, the differences amongst the treatments were significant. The maximum shoot length per sprout at 90th days after operation was found in the month of 21st April (32.60 cm), which was *at par* with 11th April (31.80 cm), whereas minimum shoot length per sprout at 90th days after operation was recorded in 21st November (28.10 cm), which was *at par* with the month of 1st November (28.43 cm). However, the differences amongst the treatments were non-significant. The maximum shoot length of sprout obtained in 21st April budding may be due to earlier bud sprouting and survival. The present findings have also been supported by Rajamanickam *et al.*, (2002) and Kour and Singh (2009).

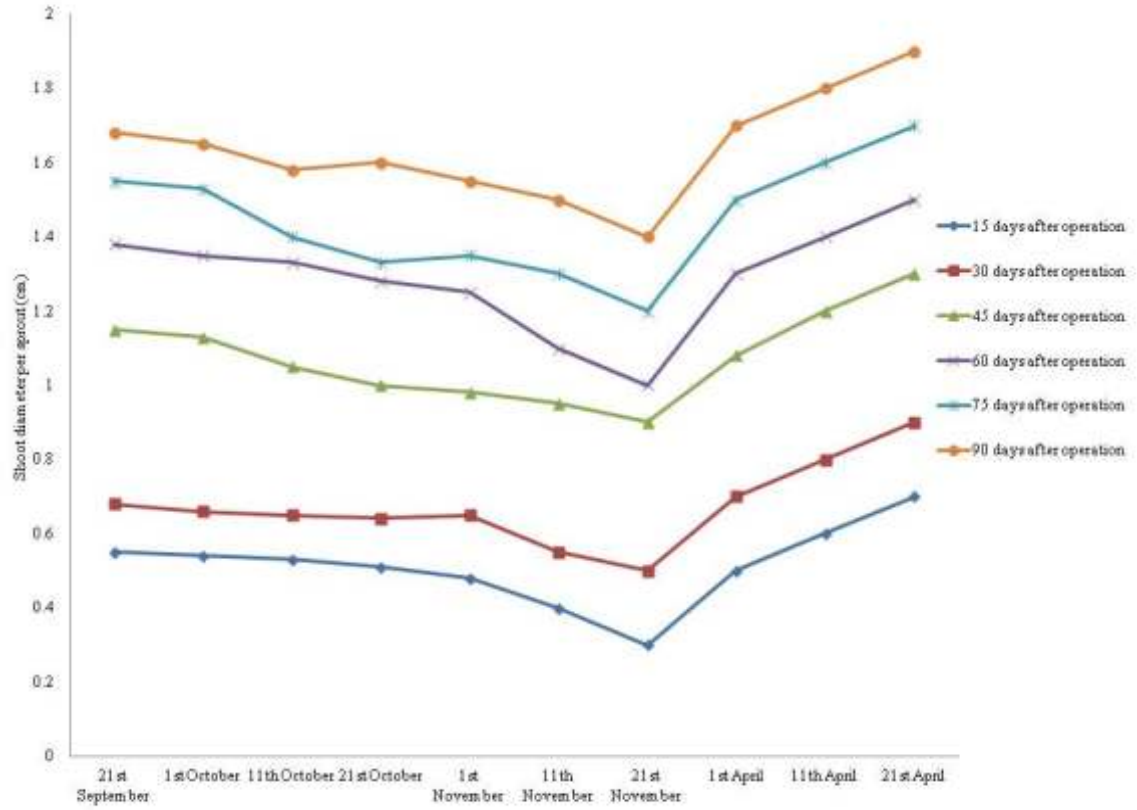
The data presented in (Fig. 2) indicate that the maximum shoot diameter per sprout at 15th days after operation was recorded in the month of 21st April (0.70 cm), which was *at par* with 11th April (0.60 cm), whereas minimum shoot diameter per sprout at 15th days after operation was found in 21st November (0.30 cm), which was *at par* with the month of 11th November (0.40 cm). However, the differences amongst the treatments were non-significant. The maximum shoot diameter per sprout at 30th days after operation was recorded in the month of 21st April (0.90 cm), which was *at par* with 11th April (0.80 cm), whereas minimum shoot diameter per sprout at 30th days after operation was found in 21st November (0.50 cm), which was *at par* with the month of 11th November (0.55 cm). However, the differences amongst the treatments were significant. The maximum shoot diameter per sprout at 45th days after operation was recorded in the month of 21st April (1.30 cm), which was *at par* with 11th April (1.20 cm), whereas minimum shoot diameter per sprout at 45th days after operation was found in 21st November (0.90 cm), which was *at par* with the month of 11th November (0.95 cm). However, the differences amongst the treatments were non-significant. The maximum shoot diameter per sprout at 60th days after operation was recorded in the month of 21st April (1.50 cm), which was *at par* with 11th April (1.40 cm), whereas minimum shoot diameter per sprout at 60th days after operation was found in 21st November (1.00 cm), which was *at par* with the month of 11th November (1.10 cm). However, the differences amongst the treatments were non-significant. The maximum shoot diameter per sprout at 75th days after operation was recorded in the month of 21st April (1.70 cm), which was *at par* with 11th April (1.60 cm), whereas minimum shoot diameter per sprout at 75th days after operation was found in 21st November (1.20 cm), which was *at par* with the month of 11th November (1.30 cm). However, the differences amongst the treatments were significant. The maximum shoot diameter per sprout at 90th days after operation was recorded in the month of 21st April (1.90 cm), which was *at par* with 11th April (1.80 cm), whereas minimum shoot diameter per sprout at 90th days after operation was found in 21st November (1.40 cm), which was *at par* with the month of 11th November (1.50 cm). However, the differences amongst the treatments were significant. It may be due to earlier sprouting and rapid growth of shoot. The similar results were reported by Rajamanickam *et al.*, (2002) and Kour and Singh (2009).

The data presented in (Fig. 3) indicate that the maximum number of leaves per sprouted shoot at 15th days after operation was recorded in the month of 21st April (7.54), which was *at par* with 11th April (7.42), whereas minimum diameter of per sprouted shoot at 15th days after operation was found in 21st November (6.10), which was *at*

Table 1. Effect of different date of patch budding on bud sprouting percentage, survival percentage, bud take success percentage, time taken for bud sprouting and leaf chlorophyll content.

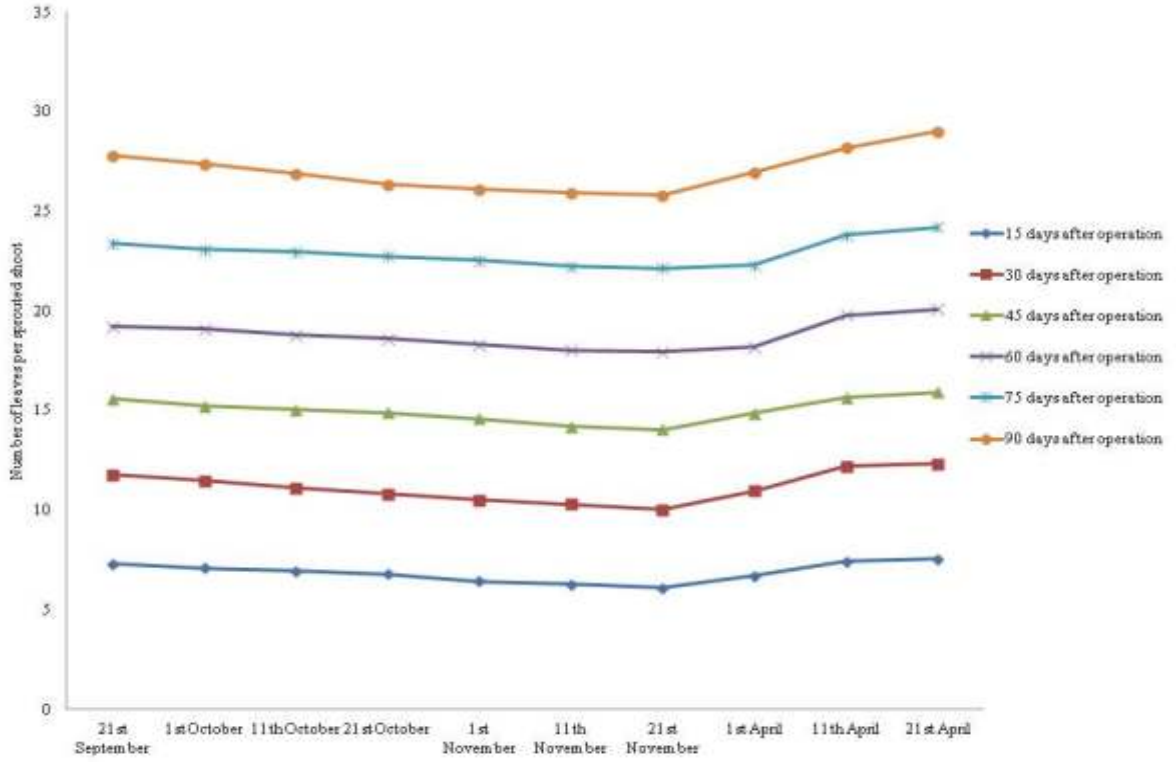
Treatment	Bud sprouting Percentage	Survival percentage	Bud take success percentage	Time taken for bud sprouting (days)	Leaf chlorophyll content
21st September	55.00	50.00	45.00	19.50	5.45
1st October	48.75	44.75	41.75	22.00	5.42
11th October	44.25	40.00	35.00	22.25	4.63
21st October	39.25	35.00	30.00	24.25	3.82
1st November	33.75	30.00	25.00	27.50	3.04
11th November	28.25	25.00	22.50	28.00	4.20
21st November	24.75	22.50	14.25	30.75	3.80
1st April	60.00	56.25	50.00	17.75	4.90
11th April	63.75	60.00	52.50	15.50	5.60
21st April	69.25	64.50	58.75	14.75	5.65
S. Em+	2.28	2.29	1.99	0.90	0.41
CD (5%)	6.62	6.65	5.79	2.62	1.21

Fig. 2: Effect of different date of patch budding on shoot diameter (cm) at 15th day's interval



par with the month of 11th November (6.30). However, the differences amongst the treatments were significant. The maximum number of leaves per sprouted shoot at 30th days after operation was recorded in the month of 21st April (12.31), which was *at par* with 11th April (12.22), whereas minimum diameter of per sprouted shoot at 30th days after operation was found in 21st November (10.05), which was *at par* with the month of 11th November (10.30). However, the differences amongst the treatments were significant. The maximum number of leaves per sprouted shoot at 45th days after operation was recorded in the month of 21st April (15.92), which was *at par* with 11th April (15.66), whereas minimum diameter of per sprouted shoot at 45th days after operation was found in 21st November (14.05), which was *at par* with the month of 11th November (14.20). However, the differences amongst the treatments were significant. The maximum number of leaves per sprouted shoot at 60th days after operation was recorded in the month of 21st April (20.10), which was *at par* with 11th April (19.80), whereas minimum diameter of per sprouted shoot at 60th days after operation was found in 21st November (17.95), which was *at par* with the month of 11th November (18.05). However, the differences amongst the treatments were non-significant. The maximum number of leaves per sprouted shoot at 75th days after operation was recorded in the month of 21st April (24.20), which was *at par* with 11th April (23.80), whereas minimum diameter of per sprouted shoot at 75th days after operation was found in 21st November (22.15), which was *at par* with the month of 11th November (22.25). However, the differences amongst the treatments were non-significant. The maximum number of leaves per sprouted shoot at 90th days after operation was recorded in

Fig. 3: Effect of different date of patch budding on number of leaves per sprouted shoot at 15th day's interval



the month of 21st April (29.00), which was *at par* with 11th April (28.20), whereas minimum diameter of per sprouted shoot at 90th days after operation was found in 21st November (25.80), which was *at par* with the month of 11th November (25.95). However, the differences amongst the treatments were significant. However, the differences amongst the treatments were non-significant. The maximum number of leaves per sprout obtained in 21st April budding may be due to earlier bud sprouting and survival. The probable reason may be due to the earlier sprouting and better growth of the scion shoot. The present findings have also been supported by Rajamanickam *et al.*, (2002) and Kour and Singh (2009).

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ARID HORTICULTURE
2012, Vol. 7 (1-2) : 57-59

Response of plant density on growth, yield and quality of Pomegranate cv. Ganesh

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Abstract

An experiment on response of planting density on growth, yield and quality of pomegranate cv. Ganesh was conducted during 2001 to 2004 in the Experimental field of Central Horticultural Experiment Station, Vejalpur, Panchmahals, Gujarat under JVG-NATP-HFNS project. Pomegranate variety cv. Ganesh was planted at four different spacing levels i.e. 5m x 5m (T_1), 5m x 3m (T_2), 4m x 2m (T_3) and 2.5m x 2.5m (T_4) having density of 400, 666, 1250 and 1600 plants per ha, respectively in randomized block design with five replications purely under rainfed conditions of hot semi-arid ecosystem. Maximum plant height was recorded with planting density 2.5 m x 2.5m, while plant spread and stem girth was observed with 5m x 5m spacing during 3rd year. With regard to spacing, yield (3680 kg) per ha was recorded the maximum with plant density 2.5m x 2.5m, whereas size (6.50 cm x 6.90cm) of the fruit and quality characters were recorded the maximum in the planting density 5m x 5m under rainfed conditions of semi-arid ecosystem of western India.

Key words: *Pomegranate, density, yield, quality*

Introduction

The pomegranate is commercially grown for sweet and delicious taste. The versatile adaptability, hardy nature, low maintenance cost, steady and high yield, fine table and therapeutic value, better keeping quality and possibilities to thrive in the rest period when irrigation potential is generally low, are the main feature responsible for its spread on wide scale in varied edepho-climatic and soil conditions particularly under semi arid ecosystem of the country (Khodake *et al.*, 1990 and Prasad and Banker, 2000).

Planting density is the important yield-contributing factor, which can be manipulated to attain the maximum production per unit area. High-density orcharding makes maximum use of land to achieve high yield in early period of orchard life. Such orchards ensure better utilization of land labour, fertility, pesticides, solar radiations and high yield. In present scenario, closer spacing is need of hours to harvest high production per unit area. Extensive studies have been conducted on these aspects in temperate fruit crops like apple and peach while very little work has been conducted on pomegranate under semi-arid ecosystem of Gujarat. With growing emphasis on high productivity per unit area, high density planting is already successful in mango (Ram and Shirohi, 1991). Spacing between the trees has significant effect on vegetative growth, fruit yield and quality. To get higher yield of quality fruits and maximum profit, there is a need to deter- mine proper density. Keeping these points in view, the present study was planned to investigate the response of planting density on growth, yield and quality of pomegranate Cv. Ganesh under semi-arid ecosystem of Gujarat.

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Material and Methods

The studies were conducted on uniformly grown trees of cv. Ganesh planted in 2000 at four different spacing viz, 5m x 5m, 5m x 3m, 4m x 2m and 2.5m x 2.5m which were replicated five times in randomized Block Design. The area is characterized by semi-arid hot climate. The annual potential evapotranspiration of the area ranges between 1500 to 1600 mm, whereas actual mean usual precipitation is about 831 mm. The mean monthly maximum temperature ranges from 26 and 42^{0}C, while the minimum monthly temperature varies between 10^{0}C and 26^{0}C. The observations on tree character like plant spread, root stock girth, scion girth, and plant spread were recorded in the last week of September every year. Two shoots in each direction of the plant were tagged to record the growth parameters viz, plant height, stem girth and plant spread. The experiment was laid out in randomized block design, which was replicated five times. The soil type was clay-to-clay loam with available N 153.00, P 8.53 and K 169.50 kg/ha, while pH and EC of the experiment soils were 7.80 and 0.12 dsm^{-1} respectively. The soil depth ranged from 0.75 to 1.0 meter, and is derived from mixed alluvial basalts, quartzite, granite, and having layers of limestone just below the soil depth. Uniform cultural practices were

followed during the course of study in all the trees. The data on qualitative characters were determined by the methods as suggested by AOAC (1990).

Results and Discussion

Effect of high density planting systems density on growth

Planting density had no significant effect on plant height, stem girth and scion girth of pomegranate plants during initial years. The maximum rootstock girth, scion girth were recorded within 5m x 5m (T1) spaced plants while plant height was recorded the highest in the 2.5m x 2.5m (T4) spacing during 4th year (Table-1). It is established fact that plant grows towards the light with increase with the number of trees per hectare, increase in the height may be due to the competition for light nutrients, an availability of spaces for spread of branches, restricting the spreading of trees, but sufficient open space is available to grow upwards resulting taller trees. However in wider spacing owing to increase in the availability of light thereby carbohydrates reserves resulted in vigours growth of the trees. The results in agreement of the findings of Rathore et al. (2003), Mahajan et al. (2005), Stamper *et al.* (1996) and Ram and Sirohi (1991) in litchi, guava, apple and mango, respectively. Plant spread was also observed maximum in the spacing of 5mx5m. Reduction in rootstock girth scion girth and plant spread in close spacing were observed due the competition for light, nutrient and water between the plants (Prasad and Banker, 2000; Chundawat *et al*., 1992).

Effect of planting systems and densities on yield

All the parameters of yield and yield attributing characters were influenced by different plant densities (Table 2). All the treatments failed to exert significant differences on yield per tree under different planting densities. However, yield per ha was significantly affected by different densities and it was recorded highest in plants spaced 2.5m x 2.5m (3680 kg/ha) followed 4mx 2m (3025 kg/ha) and the lowest was recorded in normal planting densities 5mx5m (1488 kg/ha). The increment in the yield in closer spacing is due to accommodation of more nuber of trees per unit area. These findings are in agreement with results of Rathore *et al*., 2003, Mahajan *et al*., 2005, Stamper *et al*., 1996 and Ram and Sirohi, 1991 in litchi, guava, apple and mango, respectively.

Effect of density on the quality attributes

Various planting system had profound effect on quality characters of pomegranate fruits under different planting system (Table 2). Physical parameters in terms of fruit weight (218.70g), fruit length (6.5cm) and fruit diameter (6.9cm) were recorded significantly maximum in under spacing 5m x5m and it was recorded lowest in closer spacing (2.5mx2.5m), but the differences among the treatments T1, T2 and T3 were found to be non significant up to 3th year orchard lifer. The tree with bigger dimension

Table 1. Effect different plant densities on growth parameters of pomegranate, cv. Ganesh .

Treatment (Spacing)	Stem girth (cm)			Plant height (cm)			Plant spread (cm)		
	2002	2003	2004	2002	2003	2004	2002	2003	2004
T_1 (5mX5m)	6.25	12.20	22.69	105.05	127.00	220.45	78.82	129.50	205.00
T_2 (5mX3m)	6.21	11.70	21.53	104.80	125.46	217.12	76.00	127.10	201.15
T_3 (4mX2m)	5.82	11.40	19.90	103.20	124.23	218.19	75.40	125.30	192.30
T_4 (2.5mX2.5m)	5.88	10.65	19.59	104.20	126.39	221.14	76.90	123.60	189.00
C.D. (5%)	NS	NS	1.85	NS	NS	3.00	NS	NS	8.30

Table 2. Effect plant density on qualitative attributes of pomegranate Cv. Ganesh.

Treatment Spacing	Yield /plant (kg)	Yield kg/ha	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Juice (%)	T.S.S. (^{0}Brix)	Acidity (%)
T_1 (5mx5m)	3.72	1488	218.70	6.50	6.93	47.32	15.45	0.45
T_2 (5mx3m)	3.59	1725	217.00	6.35	6.76	45.22	15.25	0.43
T_3 (4m x2m)	3.12	3025	215.20	5.82	6.05	44.23	15.20	0.41
T_4 (2.5mx2.5m)	2.98	3680	213.04	5.71	5.92	43.07	15.40	0.44
C. D. at 5%	0.45	----------	4.03	0.47	0.52	2.37	NS	NS

and high leaf and fruit ratio, more availability of water, less competition for nutrients may be reasons to be larger fruits. This might be owing to and light in wider spacing during initial years. The present findings are in close conformity with the results reported by Anbu *et al*. (2001) in mango, Bal and Dhaliwal (2005) in guava. The quality of fruits in term of TSS, acidity and juice per cent were also estimated, but the differences for TSS and acidity among the treatment could not reach the level of significance. The fruit quality in terms of juice percent was observed highest in the plant given 5m x 5m spacing during the initial years. The reason for more juice content in wider spacing may be due to full exposure of trees to sun light to synthesis of photosynthatess, and more availability of nutrient and water (Singh *et al*., 2001, Singh and Singh, 2007, Pandey *et al*., 1997 and Gupta and Bist, 2005).

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ARID HORTICULTURE
2012, Vol. 7 (1-2) : 60-61

Short Communication

Economic losses caused by brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen (Lep.: Pyralidae)

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Received: April 2013, Accepted: May 2013

Brinjal has been a stable vegetable in our diet since ancient time and being grown in all cropping seasons round the year. It has several vernacular names viz., egg plant, aubergine, baingan badone, kausi, vangi, vazhuthana (Yawalkar, 1985). Brinjal is highly productive and usually find its place as the poor man's crop. It is rich source of minerals (calcium, magnesium, phosphorus, sodium, potassium, chlorine, iron etc.), vitamins and also has some medicinal importance (Choudhary, 1967). In production and productivity, India stands second in the world after China. The total area under cultivation of this crop in our country is 6.12 lack hectares with an annual production of 105.63 lack tones with a productivity of 17.3 Mt / ha. In Rajasthan, it is grown in an area of 5560 hectare with an annual production of 0.22 lack tones with a 3.941 Mt/ ha productivity (Anonymous, 2010). It is generally grown in all districts of Rajasthan during summer and rainy seasons. The brinjal crop is attacked by a number of insect pests right from germination to harvesting, namely, jassids, *Amrasca biguttula biguttula* (Ishida); whitefly, *Bemisia tabaci* (Genn.); aphid, *Aphis gossypii* Glover; lace wing bug, *Urentius sentis* Distant; Hadda beetal, *Henosepilachna vigintioctopunctata* (Fab.), shoot and fruit borer, *Leucinodes orbonalis* Guen.; and stem borer, *Euzophera perticella* Rag.

Among major insect pests of brinja , the brinjal shoot and fruit borer. *L. orbonalis* has become a serious pest around Jobner (Jat, 2001). Crop losses due to shoot and fruit borer have been reported to the tune of 20.89 per cent in various parts of India only. Varma *et al*. (2009) conducted a field experiment for two years at Allahabad (UP) and reported that the damaged fruits and fruit weight loss in brinjal crop due to *L. orbonalis* varied from 3.76 to 45.45 per cent and 3.00 to 67.71 per cent in 1st year and 5.71 to 44.26 per cent and 3.00 to 51.33 per cent in 2nd year, respectively.

No systematic work has been carried out to estimate the extent of losses caused by brinjal shoot and fruit borer under the local environment of Jobner. The present investigations were, therefore, undertaken to estimated the loss caused by brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen.

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Preparation of nursery bed and sowing of seeds

One raised nursery bed of 3.0 m x 0.15 m in size was prepared for raising seedling of brinjal. The seeds of variety 'Pusa Purple Round' were sown in one bed on 16th June, 2010. The seeds were sown in shallow furrows by dropping the seed at 1-2 cm depth. Before sowing, the seeds were treated with 0.02 per cent Thiram to check the infection of damping off. A thin layer of well rotten manure and fine soil were applied to cover the seeds. Regular watering, hoeing, weeding, plant protection measures, etc. were done from time to time. The seedlings were ready for transplanting within five weeks of sowing.

Layout of experiment in field

The losses on brinjal due to shoot and fruit borer were estimated by comparing the pest losses due to the pest under protected and unprotected conditions. For estimating the losses , a field experiment was laid out in a paired plot design with variety Pusa Purple Round in field with a spacing of 60 x 50 cm in 100 sq m area each in protected and unprotected conditions following all the recommended package and practices. The protected plots were sprayed with Endosulfan 35 EC @ 0.05% solution (Anonymous, 2004), while unprotected plots were left without spraying insecticides.

Methods of observation

Numbers of healthy and wilted shoots / plant as well as damaged and healthy fruits were recorded at weekly interval on randomly selected 50 plants in both protected and unprotected plots till harvesting of the crop. Yield of each plot was recorded at the time of harvesting.

Interpretation of data

The data on per cent shoot damage as well as fruit damage were subjected to angular transformation before analysis of variance. To interpret the result of crop loss inflicted by incidence of shoot and fruit borer on brinjal, paired't' test was applied.

The avoidable loss and increase in yield of fruits

Brinjal has been a stable vegetable in our diet since ancient time and being grown in all cropping seasons round the year. It has several vernacular names viz., egg plant, aubergine, baingan badone, kausi, vangi, vazhuthana (Yawalkar, 1985). Brinjal is highly productive and usually find its place as the poor man's crop. It is rich source of minerals (calcium, magnesium, phosphorus, sodium, potassium, chlorine, iron etc.), vitamins and also has some medicinal importance (Choudhary, 1967). In production and productivity, India stands second in the world after China. The total area under cultivation of this crop in our country is 6.12 lack hectares with an annual production of 105.63 lack tones with a productivity of 17.3 Mt / ha. In Rajasthan, it is grown in an area of 5560 hectare with an annual production of 0.22 lack tones with a 3.941 Mt/ ha productivity (Anonymous, 2010). It is generally grown in all districts of Rajasthan during summer and rainy seasons. The brinjal crop is attacked by a number of insect pests right from germination to harvesting, namely, jassids, *Amrasca biguttula biguttula* (Ishida); whitefly, *Bemisia tabaci* (Genn.); aphid, *Aphis gossypii* Glover; lace wing bug, *Urentius sentis* Distant; Hadda beetal, *Henosepilachna vigintioctopunctata* (Fab.), shoot and fruit borer, *Leucinodes orbonalis* Guen.; and stem borer, *Euzophera perticella* Rag.

Among major insect pests of brinja , the brinjal shoot and fruit borer. *L. orbonalis* has become a serious pest around Jobner (Jat, 2001). Crop losses due to shoot and

Table 1. Estimation of loss caused by brinjal shoot and fruit borer, *Leucinodes orbinalis* Guen. on brinjal crop in 2010

S.No.	Group	Average shoot infestation (%)	Average fruit infestation (%)	Yield (q / ha)	Increase in yield over control (%)	Avoidable loss (%)
1.	Treated Plot	2.23 (8.52)	5.07 (12.98)	253.2	50.71	33.65
2.	Untreated Plot	29.89 (33.14)	53.91 (47.24)	168	-	-
	Cal. t value Tab. t value	144.4 2.01	172.15 2.01			

*Values given in parentheses are angular transformed values

Acknowledgement

The authors are thankful to Dean, S K N college of Agriculture, Jobner, for providing the facilities for carrying out the study.

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INDIAN JOURNAL OF
ARID HORTICULTURE
2012, Vol. 7 (1-2) : 62-63

Short Communication

Characterization and evaluation of ber genotypes in hot arid regions of Tamil Nadu

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Ber (*Ziziphus mauritiana* Lamk.) is an economically important tropical fruit tree, which is grown all over the drier parts of the Indian subcontinent, Africa and northern Australia for its fresh fruits. It is one of the suitable trees to grow in dry regions, because it can withstand long periods of drought. *Ber* (Chinese date, Chinese Fig or *bore*) also known as poor man's fruit is most widely cultivated in Punjab, Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Bihar, Gujarat, Maharashtra etc. Liu and Cheng (1995) reported that Indo-Malaysia region is the centre of both evolution and distribution of the genus *Zizyphus*. In India, a number of *ber* cultivars have been developed largely by the growers through selection in different regions. Maximum variability of *ber* is observed in Rajasthan, Gujarat, Haryana, Punjab and Madhya Pradesh and Uttar Pradesh. In Gujarat, Mehsana, Anand, Panchmahal, Patan and Sabarkatha districts are having rich diversity of *ber* (Shukla *et al*., 2003).

The experimental investigation was carried out in the orchard of B3 block in an area of hactares at Regional Research Station, Aruppukottai during the period of 2005 to 2009. Twenty six genotypes were assessed in randomized block designs, which were replicated thrice. The following were the genotypes:

Source	Accession No.
Banarsi	ZM-1
Umran	ZM-2
Kaithali	ZM-3
Gola	ZM-4
Kathapal	ZM-5
Safeda	ZM-6
Aruppukottai local	ZM-7
Kakadia I	ZM-8
Kakadia II	ZM-9
Periyakulam Local	ZM-10
Ilaichi RS.	ZM-11
Ilaichi RS	ZM-12
Ilaichi RS	ZM-13
Ilaichi RS	ZM-14
Sendurai RS	ZM-15
Sendurai RS	ZM-16
Sendurai RS	ZM-17
Sendurai RS	ZM-18
Sendurai RS	ZM-19
Sulakarai	ZM-20
Seb	ZM-21
Mundia	ZM-22
Guli	ZM-23
Sivakasi	ZM-24
Kalayamputhur	ZM-25
Periyakulam Local	ZM-26

These genotypes were evaluated for their yield characters *viz.*, yield per tree, fruit weight, pulp weight and TSS (^{0}Brix). The Total Soluble Sugars (TSS) was estimated using a hand refractometer. The pooled data of five years (2005-2009) were statistically analyzed by following the method of Gomez and Gomez (1984). The observations were recorded after the receipt of monsoon rains during September October.

In *ber*, there were twenty six genotypes collected from different parts of India and were maintained in the orchard for biometric evaluation and the pooled results of 2005 to 2009 stated that among the twenty six genotypes evaluated, Kaithali registered maximum yield of 5.5 kgs/tree followed by Gola (4.6 kg). Gola recorded maximum fruit weight of 18.8 g followed by Kaithali (17.3 g). In respect of pulp weight, the same trend was noticed in Gola (17.6 g) followed by Kaithali (16.1 g). Kathaphal recorded maximum TSS of 15.3 ^{o}Brix followed by Kaithali (14.4 ^{o}Brix) (Table 1).

These results were in conformity with the findings of Pareek and Dhaka (2008) reported that the fruit yield of *ber* had significantly positive correlation with pulp: stone ratio, TSS, acidity, ascorbic acid, total sugars and reducing sugars which indicated that selection for these traits would lead to an improvement in yield, while it was significantly and negatively associated with TSS: acid ratio.

Table 1. Evaluation of ber germplasm for yield and quality attributes

Source	Acc No.	Pooled Mean (2005-2009)			
		Yield (Kgs /tree)	Fruit weight (g)	Pulp weight (g)	TSS (^{O}Brix)
Banarsi	ZM -1	4.30	13.65	12.38	13.4
Umran	ZM -2	3.22	14.68	13.25	12.7
Kaithali	ZM -3	5.55	17.32	16.10	14.3
Gola	ZM -4	4.61	18.83	17.59	12.5
Kathapal	ZM -5	3.64	12.87	11.64	15.3
Safeda	ZM -6	3.24	7.40	6.33	12.1
Aruppukottai local	ZM -7	2.26	8.99	7.80	12.4
Kakadia I	ZM -8	2.20	16.09	14.70	12.6
Kakadia II	ZM -9	3.25	13.69	11.34	13.0
Periyakulam Local	ZM -10	2.00	4.48	4.11	4.6
Ilaichi RS.	ZM -11	4.52	7.97	7.05	12.1
Ilaichi RS	ZM -12	3.36	10.40	9.44	13.1
Ilaichi RS	ZM -13	2.96	10.81	9.74	13.2
Ilaichi RS	ZM -14	3.90	10.43	8.63	13.8
Sendurai RS	ZM -15	3.40	9.49	7.46	13.2
Sendurai RS	ZM -16	3.07	8.37	7.29	12.0
Sendurai RS	ZM -17	3.80	12.35	11.14	12.0
Sendurai RS	ZM -18	3.48	10.56	9.26	13.2
Sendurai RS	ZM -19	3.77	9.64	8.35	12.4
Sulakarai	ZM -20	3.01	9.29	8.36	12.4
Seb	ZM -21	3.55	11.33	10.47	12.7
Mundia	ZM -22	2.73	12.91	11.55	12.9
Guli	ZM -23	3.57	9.77	8.86	12.3
Sivakasi	ZM -24	2.70	9.00	9.79	12.2
Kalayamputhur	ZM -25	3.35	10.04	8.81	11.2
Periyakulam Local	ZM -26	2.51	7.19	7.43	12.8
SEd		0.43	0.79	0.52	0.47
CD (0.05%)		0.87	1.59	1.05	0.94

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ARID HORTICULTURE
2012, Vol. 7 (1-2) : 64-65

Short Communication

Influence of plant growth regulators on severity of post harvest fruit rots of guava and citrus fruits

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Received: February, 2013; Accepted May, 2013

Post-harvest disease management is one of the biggest challenges in intensive fruit production systems. Compare to the vast production of fruits in India, the fruit export from the country has been negligible. A major constraint has been the enormous losses to fruits have been estimated to be in the range of 5-50% or more of the harvest. The fruit-exporting countries have strict requirements to meet health standards. These requirements have adversely affected the fungicide application on harvested fruits. The search for alternative treatments have yielded positive results with homeopathic drugs, hot water treatment, plant growth regulators has proved effective against post harvest diseases of harvested fruits. Applications of Gibberallic acid reduced diseases incidence and severity of Botryodiplodia rot and Penicillium rot of guava and orange fruits. Rhizopus rot (*Rhizopus arrhizus* Fischer) and Botryodiplodia rot (*Botryodiplodia theobromae* Pat.) of guava and Penicillium blue mould (*Penicillium italicum* Wehmer) and Botryodiplodia rot (*B. theobromae* Pat.) of sweet orange fruits were most prevalent in the markets. An attempt was made in this study to assess the efficacy of two plant growth regulators on spore germination and disease severity of the fruit rots. Plant growth regulators are known to delay senescence and the onset of fruit rot (Eckert and Sommer, 1967; Gupta and Pathak, 1990; Patel, 1991; Godara, 1994). Gupta and Pathak (1990) reported that IAA and MH were most effective against Aspergillus and Rhizopus rots of Papaya fruits while Planofix (NAA, used at 0.01%) checked all the rots except Fusarium rot in post-inoculation treatment.

Plant growth regulators, planofix (I-Naphthalene-acetic acid) 100 ppm and Gibberellic acid (2, 4a, 7-Trihydroxy-l-methyl-8-methylene gibb-3-ene-l, 10-carboxylic acid-1, 4-lactone) 40 ppm along with control treatments were tested against Rhizopus rot and Botryodiplodia rot of guava and Penicillium rot and Botryodiplodia rot of sweet orange harvested fruits.

One drop of plant growth regulators was mixed with a drop of spore suspension (10^6 spores/ml) on glass slide. The spore suspension was prepared in extract of ripe fruit. The slide was placed in an inverted position in a Petri dish humid chamber. The slides were incubated at 28 ± 2^0 C. Percent spore germination was recorded 24 hours after incubation. To assess spore germination, the slide was taken out, a drop of lactophenol was added to the spore suspension and per cent germination was assessed under the microscope. Each treatment was replicated three times.

Guava & sweet orange fruits of nearly equal size harvested from orchards were brought to the laboratory. Fruits were surface sterilized & separately inoculated with each pathogen by prick-injury method. The injured and control fruits were surface sterilized and then separately inoculated with *Rhizopus arrhizus*, *Botryodiplodia theobromae* of guava and *Penicillium italicum* and *Botryodiplodia theobromae* of sweet orange fruits by dipping them in spore suspension (10^6 spores/ml) for 2 minutes. Each compound with recommended dose was tested against the rots in pre-and post-inoculation treatments. In the pre-inoculation treatment, the fruits were first dipped in the test chemical for 5 minutes, air dried for 15 minutes and then inoculated, while in the post-inoculation treatment, the fruits were first inoculated and then treated with the chemical. The interval between inoculation and chemical treatment or vice-versa was of 12 hours. After inoculation or chemical treatment, fruits were placed at 28 ± 2^0C & 80-100 per cent RH. Proper controls were maintained. Each treatment had 20 fruits. The disease severity was recorded on the basis of fruits area infected.

Effect on spore germination & severity of *Rhizopus arrhius* and *Botryodiplodia theobromae* of guava fruits.

Spores of *Rhizopus arrhizus* and *Botryodiplodia theobromae* started germination within 6 hours of incubation in all the treatments. Of all the plant growth regulators tested, Gibberallic acid proved most effective against spore germination of both the pathogens after 24 hours incubation. Both the plant growth regulators tested against spore germination of *B. theobromae* differed non-significantly from each other but were significantly superior over control. The spore germination increased with time (Table 1).

The lowest severity was noticed in GA against both the rot pathogens, but the severity differed non-significantly from other treatments in pre-and post-inoculation treatments.

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Effect on spore germination & severity of *Penicillium italicum* and *Botryodiplodia theobromae* of sweet orange fruits

Spores of Penicillium italicum and Botryodiplodia theobromae started germination within 6 hours of incubation in all the treatments. GA proved significantly more effective against spore germination of both the rot pathogens of sweet orange after 24 hours of incubation (Table 2).

The lowest disease severity was noticed in GA treatment against both the rot pathogens in pre-inoculation treatment, but both the plant growth regulators differed non-significantly from each other in case of Botryodiplodia rot. In post-inoculation treatments, the severity was lowest in GA treatment against both the rot pathogens.

Of different plant growth regulators screened, GA caused maximum inhibition of spore germination of different rot pathogens of guava and sweet orange fruits at 24 hours of incubation. Gupta and Pathak (1990) found that planofix (NAA) to be most effective against Rhizopus rot of papaya. In the present investigation, GA proved highly effective against various rots of both the fruits. Further studies on mode of action and different concentrations of these compounds may prove a rewarding pursuit.

Table 1. Effect of plant growth regulators on spore germination and severity of *Rhizophus arrhizus* and *Botryodiplodia theobromae* of guava fruits.

Plant growth regulators	Per cent spore germination after 24 hours		Severity			
			Pre-inoculation		Post-inoculation	
	R. arrhizus	*B. theobromae*	*R. arrhizus*	*B. theobromae*	*R. arrhizus*	*B. theobromae*
Planofix	62.32 (78.42)	56.54 (69.60)	35.41 (33.57)	35.29 (33.38)	33.67 (30.74)	35.09 (33.05)
Gibberallic acid	54.16 (65.72)	55.94 (68.63)	33.94 (31.17)	35.68 (34.02)	32.15 (38.32)	33.04 (29.73)
Control	80.49 (97.27)	83.40 (98.68)	52.94 (63.68)	48.00 (53.23)	52.94 (63.68)	46.78 (53.10)
SEm.	0.58	1.11	2.32	2.31	1.97	2.24
CD at 5%	2.01	3.85	6.42	6.40	5.46	6.22

Figures in parentheses are retransformed values

Table 2. Effect of plant growth regulators on spore and severity of *Penicillium italicum* and *Botryodiplodia theorbromace* of sweet orange fruits.

Plant growth regulators	Per cent spore germination after 24 hours		Severity			
			Pre-inoculation		Post-inoculation	
	R. arrhizus	*B. theobromae*	*R. arrhizus*	*B. theobromae*	*R. arrhizus*	*B. theobromae*
Planofix	54.43 (66.15)	52.97 (63.66)	35.79 (34.26)	32.74 (29.27)	37.10 (36.40)	36.74 (29.27)
Gibberallic acid	46.54 (52.82)	48.06 (55.33)	29.08 (24.98)	30.91 (26.41)	35.66 (34.02)	31.62 (27.48)
Control	74.71 (92.80)	67.94 (85.67)	49.00 (56.97)	44.15 (48.54)	49.04 (56.63)	42.93 (46.39)
SEm.	0.57	0.46	0.51	0.71	0.53	0.53
CD at 5%	1.66	1.35	1.59	2.19	1.66	1.65

Figures in parentheses are retransformed values

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ARID HORTICULTURE
2012, Vol. 7 (1-2) : 66-67

Short Communication

Studies on physio-chemical changes during development and maturity in fruits of karonda (*Carissa carandas*)

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Received: November, 2012; Accepted: March, 2013

Karonda (*Carissa carandas* L.) is an important minor fruit crop of India. The plants are used as hedge, orchard and ornamental purposes. The fruits are used for the preparation of number of products as chutney, pickles, jam, jelly, beverages, nakal cherry, candy and coloured wines. The quality of the fresh fruits is the expression of physio-chemical changes that occur during various phases of fruit development. Such studies are important in determining the proper harvesting time. Only meager information is available on the changes in physical parameters of developing fruits of Karonda seedlings (Uthaiah, 1988). But the information on the physiochemical changes in developing fruits of Karonda is lacking in recently developed varieties. The investigation was therefore undertaken to find out the physio-chemical changes occurring during the development of fruits of Karonda cv. Pant Sudarshan in order to establish the maturity standard for the harvesting of Karonda fruits under *tarai* conditions of Uttarakhand.

The experiment was conducted at Horticultural Research Centre, Patharchatta, Govind Ballabh Pant University of Agriculture & Technology, Uttarakhand during fruiting season of the year 2007. The experiment was conducted on fifteen years old bush of Karonda cv. Pant Sudarshan in completely randomized design using twenty fruits per treatment per replication. The bush was devided into four parts i.e., east, west, north, south and each part was considered as a replication. The fruits were tagged two weeks (15th May) after anthesis when they appear as tiny fruits. The first observation was made on 22nd May. Thereafter, the observations were taken at weekly intervals tills complete ripening stage was reached (13th week after anthesis). The observations were recorded on each date for fruit length, diameter, shape index (length/diameter), weight, volume, specific gravity (weight/volume), T.S.S., acidity and T.S.S.: acid ratio. For recording observations, fruits were picked, brought to the laboratory and washed with tap water. Fruit length and diameter were recorded with Vernier's caliper while fruit weight was recorded on electronic balance. Fruit volume was measured by water displacement method. Ten fruits were chopped into small pieces and blended into a homogenous pulp in a mortar for estimation of T.S.S. and acidity. T.S.S. of fruit juices were determined in per cent by hand refractometer while the acidity of fruit pulp as per cent citric acid was estimated by titrating clear fruit extract against 0.1N NaOH using phenophthalene as indicator (Ranganna,1986). The T.S.S. : acid ratio was determined by dividing T.S.S. with acidity.

A close examination of the data presented in Table 1 and Fig.1 showed that fruit length increased significantly upto 10th week after anthesis. Thereafter, the fruit length decreased. Fruit diameter also increased upto 11th week after anthesis. However it decreased at 12th week and remain constant at the 13th week. Bal and Singh (1978) reported a similar type of increase in ber. The mean fruit weight and volume were increased upto 11th week after anthesis and thereafter the mean fruit and volume decreased with retention of fruit on the tree. The increase in fruit size and weight can be attributed to an increase in the size of the cells and accumulation of food substances in the intercellular spaces in fruit pulp (Bollard, 1970). Similar results were also reported by Soni and Randhawa (1975) in lemon and Jawanda and Bal (1980) in ber cv. ZG-2. Data presented in Table 1 showed that specific gravity of the fruits did not differ significantly.

Data depicted in Table 1 and Fig. 2 showed that T.S.S. of the fruits increased upto 8th week after anthesis and gradually decreased upto maturity i.e. 13th week after anthesis. A decline in T.S.S. at later stage might be due to the utilization of carbohydrates and possibly the oxidation of fats and protein as the respiratory substrate in the respiration process. A close perusal of the data presented in Table1 and Fig 2 showed that acidity of the fruits gradually increased upto 8th week after anthesis and remain constant upto 10th week after anthesis and after gradually decreased upto ripening stage i.e. 13th week after anthesis. The non volatile organic acids are among the major cellular constituent undergoing changes during the ripening of fruits (Pantastico, 1975). Data presented in Table 1 showed that T.S.S. : acid ratio was decreased significantly upto 9th week after anthesis and it increased significantly from 10th week to maturity statge i.e. 13th week after anthesis.

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Table 1. Physico-chemical changes in developing fruits of Karonda cv. Pant Sudarshan

Weeks after anthesis	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (gm)	Fruit volume (ml)	Specific gravity	T.S.S. (%)	Acidity (%)	T.S.S./Acidity ratio
3	1.11	0.78	0.45	0.43	1.05	5.10 (13.10)	1.00 (5.70)	5.10
4	1.45	1.08	1.12	1.07	1.05	5.80 (13.90)	2.80 (9.60)	2.07
5	1.63	1.24	1.47	1.43	1.03	5.90 (14.10)	2.90 (9.90)	2.03
6	1.70	1.33	1.48	1.45	1.02	6.10 (14.30)	3.20 (10.40)	1.91
7	1.78	1.43	2.07	2.05	1.01	6.10 (14.30)	3.30 (10.50)	1.85
8	1.85	1.49	2.31	2.26	1.02	6.20 (14.40)	3.40 (10.60)	1.82
9	1.91	1.53	2.58	2.55	1.01	6.00 (14.20)	3.40 (10.60)	1.77
10	2.10	1.64	3.10	3.07	1.01	6.00 (14.20)	3.40 (10.60)	1.77
11	2.07	1.68	3.17	3.14	1.01	6.00 (14.20)	3.30 (10.50)	1.82
12	1.98	1.61	3.04	2.98	1.02	5.90 (14.10)	2.50 (9.20)	2.36
13	1.96	1.61	2.73	2.66	1.03	5.80 (13.90)	2.40 (8.90)	2.42
S.Em.±	0.05	0.04	0.09	0.08	0.06	(0.20)	(0.10)	0.03
C.D. at 5%	0.17	0.12	0.28	0.27	NS	(0.50)	(0.30)	0.13

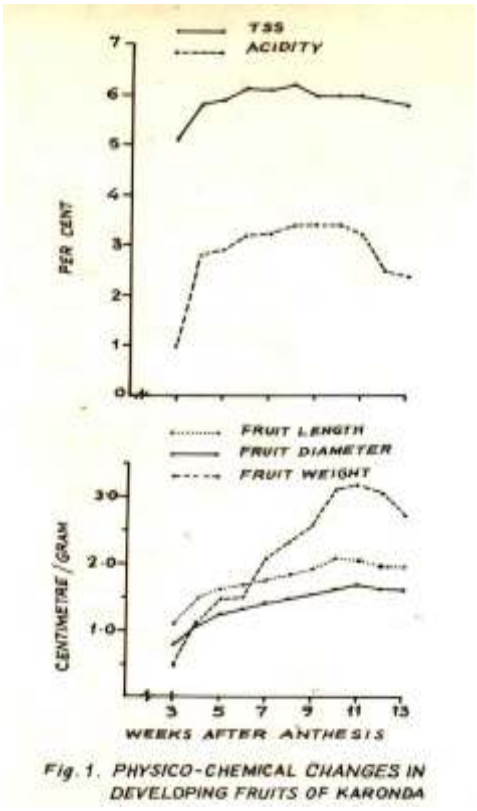

Fig. 1. PHYSICO-CHEMICAL CHANGES IN DEVELOPING FRUITS OF KARONDA

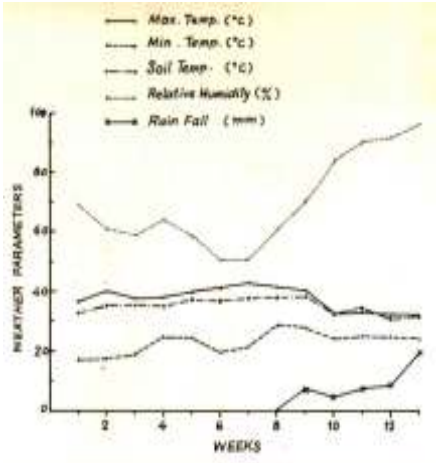

Fig. 2. WEATHER CONDITION DURING EXPERIMENTAL PERIOD

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ARID HORTICULTURE
2012, Vol. 7 (1-2) : 68-70

Short Communication

Morphological and physical changes associated with growth and development of Pomegranate fruit

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Received: April, 2013; Accepted: May, 2013

Pomegranate (*Punica granatum* L.) is thought to be indigenous to the region of Iran where it was first cultivated in about 2000 B.C., but it spread to the Mediterranean countries at a very early date. Pomegranate is an important commercial fruit in India which is mainly grown in the Maharashtra, Gujrath, Karnataka, Rajasthan etc. Pomegranate flowers from late April until mid May, whereas maturity and ripening extends from mid September to November depending on the cultivars. Fruit growth is typically described as a single or double sigmoid curve reflecting changes in organ fresh weight. Other measures of growth (e.g. length, diameter) may give quite different growth curves (Commbe, 1976).

In the epidermis of pomegranate seeds, the cells are relatively very elongated in a radial direction and are rod-shaped and form edible parts termed arils. In recent times, the export of pomegranate from Maharashtra for world market has increased. Every year cracking, bruising, sunscald and variation in fruit size at harvest time render some fruits unmarketable. Therefore, some growers prefer to harvest large fruits sooner and allow others to grow more to obtain a bigger size. In order to maximize yield and get equal size of fruits, it is necessary to know the morphological and physical changes attributed during growth and development. There is little information available on the morphological and physical of fruit growth and development of pomegranate fruit. In view of the potential importance of this fruit, present study was conducted to study in detail its growth and development.

The two cultivars *viz.*, newly recommended variety Phule Bhagwa and promising Selection-4 were selected for the present studies along with cultivar Mridula. The trees were spaced 4.5 and 3 m between and along the rows respectively and received routine cultural care suitable for commercial fruit production including pruning, fertilization and irrigation. For studying the morphological and physical changes associated with growth and development of fruit, a large number of hermaphrodite flowers at uniform stage of development *i.e.* at anthesis stage were tagged in all the cultivars under study. For the assessment of various morphological and physical changes of fruit during the growth and development, five fruits were selected randomly from each cultivar at monthly interval upto 180 days. The duration from anthesis is taken upto 150 days in cv. Mridula and upto 180 days in Cv. Bhagwa and Sel-4. The observations were recorded at thirty days interval from anthesis till harvest maturity.

During the growth and development of pomegranate fruits significant morphological and physical changes were observed and presented in Table 1.

Morphological changes

The shape of pomegranate fruit changed from elongated oval to oval within 90 days period during the growth period and further it changed to spherical within 30 to 45 days when almost 70 to 80 per cent of the fruit growth was completed. After 150 days, slight suppressions were formed on the sides and angular edges were developed on fruit surface. At 180 days stage, the fruits had round shape with prominent suppressions on sides and the colour of rind became further intense.

The colour of fruit and arils are the two important factors which govern the consumers appeal. The colour of fruit changed from initial green to orange red and high red at maturity stage. As the fruits matured, orange colour intensified turning to high red with reddish patches in Sel-4 and cv. Bhagwa, while it was vivid or deep red with coral red in cv. Mridula.

Fruit colour of cv. Mridula at maturity stage was more intense than that noticed in Sel-4 and Bhagwa. With the development of fruit, the green colour started fading and turned to olive yellow with reddish brown and vivid red in cv. Mridula at 180 days. The changes in colour were indicative of fruit maturity. However, the colour acceptable for marketing was developed only after 150 days and it reached to intense level at 180 days stage in cv. Bhagwa and Sel-4 whereas the same was developed after 120 days and reached to intense level at 150 days stage in cv. Mridula.

These morphological changes are in confirmation with those of Al-Yahyai *et al.* (2009), Darade (1995), Shulman *et al.* (1984) who reported that the fruit colour, aril colour and shape changes with advancement maturity.

Physical changes

The results obtained in respect of physical exhibited continuous increase in these parameters from

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Table 1. Morphological and physical changes associated with growth and development of Pomegranate fruit

Cultivar	Days after anthesis	Morphological changes			Physical changes				
		Shape of fruit	Colour of fruit	Colour of arils	Length of fruit (cm)	Diameter of fruit (cm)	Weight of fruit (g)	Volume of fruit (ml)	Specific gravity fruit (g/ml)
Sel-4	30	Elongated oval	Green with Cuba	Pearl white	5.80	4.10	25.63	26.67	0.978
	60	Elongated oval	Olive yellow with reddish orange	Yellowish white	7.77	5.20	70.12	69.17	1.013
	90	Oval	Orange red with yellow shed	Reddish gray	8.47	7.33	148.11	141.23	1.049
	120	Spherical	Maize yellow with Scarlet and raspberry red tinge	Pinkish	8.70	7.40	149.76	142.07	1.054
	150	Round with suppressions on sides	Reddish yellow	Reddish pink	9.50	8.43	227.59	223.56	0.985
	180	Round with prominent suppressions on sides	High red with light orange	Red	10.43	9.27	358.69	370.00	0.970
Bhagwa	30	Elongated oval	Green with cuba	Milky white	6.43	4.37	34.30	33.67	1.027
	60	Elongated oval	Olive yellow	Yellowish white	8.03	5.27	78.46	79.95	0.981
	90	Oval	Brownish orange with Reddish Yellow	Yellowish white	8.47	7.23	141.04	130.73	1.079
	120	Spherical but slight suppressions on sides	Maize Yellow with High Red	Patel Red	8.90	7.43	168.83	174.33	0.969
	150	Round with suppressions on sides	Brownish Red with Reddish Yellow	Cherry Red	9.53	7.53	214.48	219.74	0.976
	180	Round with suppressions on sides	High Red with Reddish orange	High Red with deep Red	9.50	8.80	272.87	288.67	0.947
Mridula	30	Elongated oval	Dark brown	Dull white	5.73	3.77	22.86	22.00	1.040
	60	Oval	Olive Yellow with brownish Red	Yellow white	7.53	5.50	72.42	71.59	1.011
	90	Oval	Olive Yellow with Reddish brown	Pastel Red	8.40	6.73	136.73	126.70	1.080
	120	Spherical	Deep Red	Pastel Red with Vivid red	8.47	7.40	168.43	144.70	1.165
	150	Round with prominent suppressions on sides	Vivid Red with Coral Red	Violet brown with Cherry Red	9.83	9.40	312.87	315.04	0.993
	S.E. ±	-	-	-	0.21	0.14	6.21	7.42	0.04
	CD at 5 %	-	-	-	0.61	0.39	17.92	21.40	0.12

anthesis till the harvest maturity in all the cultivars of pomegranate. The growth and development of pomegranate fruit was rapid during initial period, from anthesis upto 90 days. During this period maximum fruit size was attained in all the cultivars (*viz*., Sel-4, Bhagwa and Mridula) of pomegranate. Similar to the fruit length and diameter, the weight and volume of fruit was found to increase upto 150 days stage. The weight of fruit attained during this period was to the extent of 78.60 per cent in cv. Bhagwa and 63.45 per cent in Sel-4. At 150 days of fruit development the maximum weight of fruit was observed in cv. Mridula. The volume of the fruit at 150 days of fruit development was 76.12 per cent in cv. Bhagwa and 60.42 per cent in Sel-4. At 150 days of fruit development the maximum fruit volume was observed in cv. Mridula.

These results showed that within a period of 150 days from anthesis, the growth of fruit to the extent of about 70 to 90 per cent was completed. The growth rate in respect of length of fruit was faster than that of diameter and this was evidenced in all the cultivars. The growth in respect of weight and volume of the fruit was slightly slower than that of the length and diameter of fruit. The specific gravity increased upto 90 days in cv. Bhagwa and upto 120 days in cv. Mridula and Sel-4 and then decreased to less than one. At 150 days stage, specific gravity was less than one in all cultivars and declined further with the advancement in the age of fruit. This indicated that the fruits became more puffy with the advancement of maturity.

The results indicated that remaining 10 to 15 per cent growth of fruit was completed within a period of last 45 days. However, at 180 days stage, the fruit growth to the extent of 98 to 99 per cent was completed in cultivar Bhagwa and Sel-4, while in Mridula 98 to 99 per cent growth was completed at 150 days stage. Hence, this indicated that the fruits of cv. Bhagwa and Sel-4 were fully matured and ready for harvest at this stage. At maturity stage at 180 days of fruit development the fruit of Sel-4 were more in length and diameter, heavier in weight and bigger in volume as compared to those of cv. Bhagwa. At 150 days of fruit development the fruits of cv. Mridula were more in length and diameter, heavier in weight and bigger in volume as compared to cv. Bhagwa and Sel-4.

These results are in agreement with several earlier workers and prominent amongst them are Kumar and Purohit (1989), Malhotra *et al*. (1983), Mirdehghan and Rahemi (2006), Varasteh et al. (2008) who reported that the fresh weight of the pomegranate fruit increased continuously till harvest time and the growth pattern followed a simple sigmoid curve.

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INDIAN JOURNAL OF
ARID HORTICULTURE
2012, Vol. 7 (1-2) : 71-73

Short Communication

Role of NHM trainings to rural masses in value addition of underutilized fruits and vegetables

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Received: September, 2012; Accepted: February, 2013

Horticultural produces grown in Rajasthan are of explicit quality with great nutritional, meditational and economic importance. Some of the fruit like aonla, jamun, tamarind, phalsa, custard apple, karonda, kainth and bael etc. and vegetables such as kachri, beans, bakla, kakora, guar and moringa etc. are successfully grown with minimum care on waste land and provide food and nutritional security to the rural masses.

Most of the horticultural crops are available in plenty during particular season, but all cannot be utilized to the fullest extent due to many reasons. Thus people residing in remote areas hardly get on considerable advantage from the abundantly available resources. Rural masses consume these food resources as such available to them in the form of simple vegetable or by simply in the form of dehydrated product or fruits are consumed in raw (Sareen and Chandra, 2008). Various standardized techniques are practiced commercially for processing of underutilized fruits and vegetables (Table1). However, there is much scope in evolving the techniques of value addition and providing market to such underutilized commodities for more net returns.

The study was conducted at Krishi Vigyan Kendra, Anta during the year 2005 to 2009 on 30 practicing farmers under National Horticulture Mission started during 2005 in Baran district of Rajasthan. Pre and post test experimental design was used to study gain in knowledge by the trainees in different aspects of value addition products. For the purpose of data collection a schedule was developed with the help of horticulturist of Agriculture Research station, Kota and K.V.K., Rajsamand. Questionnaire technique was used for collection of requisite information as all of them were up to secondary class education.

The maximum possible score was 40 for the knowledge test (Table 2). The responses of the respondents were checked with the recommendations of scientists. The responses were converted into mean percent score (MPS) for the purpose of analysis and comparison. Paired t' test was used to analyse data statistically. Rural youth farmers were selected on the basis of the availability of land, owner of orchards, tube well and boundary wall etc for the cultivation of vegetables and plantation of orchards.

Knowledge input forms the foundation of any training programme, which needs to be measured in terms of overall gain in knowledge level. In the present study, knowledge of the trainees was judged before and after their exposure to the training programme in order to know the enhancement in knowledge due to their participation and exposure to the training courses. Data in table 3 clearly reveal the improvement in knowledge of the trainees as their mean percent score increased from 18.74 to 31.89 with overall gain of 13.05 MPS.

Appraisal of data in table 4 highlights that there was significant difference in the before and after exposure score of the participants in all the aspects of making of value addition products of fruits and vegetables as the calculated 't' value was found to be significant at 0.01 per cent level. The aspect wise gain in knowledge by the trainees indicates that they gained maximum knowledge in aspect of labelling of products (38.25 MPS). This might be due to the reason that trainees were very much interested in this aspect and they actively participated in practical session of the training programme. Similar observations were reported by Singh, (2001) in training of plant propagation of fruits and vegetables. Respondents also gained knowledge in the aspect like cleaning of utensil, storage of product and grading of fruits and vegetables (30.30, 30.24 and 27.85 respectively). Least gain in knowledge of the trainees was observed in the price of commodities i.e. 10.32 MPS. This was because of the reason that price of the commodities was not controlled by producers of fruits and vegetables. In rest of the aspects, the gain in knowledge ranged from 17.70 to 24.21 per cent. Thus, the after exposure score of the trainees clearly depicts that the training was beneficial to acquire knowledge. The informal discussion with participants during the concluding session also indicated that they acquired practical knowledge and skill in different aspects of making of value addition products and were confident enough to perform these skills back at their village. The results are in line with the study conducted by Verma *et.al.* (1989) who concluded that there was significant gain in knowledge by the farmwomen in various home science aspects. Intodia *et .al.* (1998) also found significant increase in knowledge of the trainees in various aspects of

ornamental gardening as the result of their participation in the training course.

Negligible quantities of value added products from underutilized fruits and vegetables compared to their production are available in the market. Thus rural masses can choose this enterprise for their employment and income generation. It requires proper technical knowledge and skill for preparing these value added products. Trainings can be helpful in creating awareness among the rural masses as well as can provide technical knowledge and skill in specific aspect. Krishi Vigyan Kendra, Anta organizes various types of trainings as 2 vocational, 16 on campus and 30 off campus trainings in which 1738 farmers are benefited (Table 5).

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Table 1. Value added processed products of underutilized fruits and vegetables.

S.No.	Crops	Value added products
1.	Aonla	Preserve, candy, shreds, powder, squash, RTS, jam, chutney, pickle, chyawanprash
2.	Jamun	RTS, squash, vinegar
3.	Tamarind	Chutney
4.	Phalsa	RTS, squash
5.	Custard apple	RTS, jam
6.	Karonda	Jelly, jam, murabba, pickle
7.	Bael	Squash, murabba
8.	Kainth	Jelly, jam, chutney, sherbet, dried product
8.	Kachri	Dried vegetable, pickle, chutney
9.	Beans	Seed used in vegetable as well as pulse
10.	Guar	Gum, Dried vegetable
11.	Kakora	Dried vegetable
12.	Moringa	Dried vegetable

Table 2. Scoring patterns of value addition products

S.No.	Aspects	Max. Score
1.	Cleaning of utensil	4
2.	Grading of fruits and vegetables	5
3.	Preparation techniques	10
4.	Knowledge of preservatives	6
5.	Price of commodities	1
6.	Packing of products	4
7.	Labelling of products	2
8.	Blanching of vegetables	3
9.	Storage of product	1
10.	Marketing of product	4
	Total	40

Table 3. Overall gain in knowledge by the trainees in plant propagation

S.No.	Particulars	MPS	t value
1.	Before exposure knowledge	18.84	
2.	After exposure knowledge	31.89	10.41
3.	Gain	13.05	

Table 4. Knowledge gain in different aspects of value added products by the trainees

S.No.	Aspects	Mean percent Score			t value
		Before exposure	After exposure	gain	
1.	Cleaning of utensil	64.00	94.30	30.30	8.76**
2.	Grading of fruits/ vegetables	28.35	56.20	27.85	5.47**
3.	Preparation techniques	25.20	48.10	22.90	4.78**
4.	Knowledge of preservatives	71.23	91.02	19.79	5.61**
5.	Price of commodities	40.11	50.43	10.32	6.04**
6.	Packing of products	26.41	44.11	17.70	5.14 **
7.	Labelling of products	10.22	48.47	38.25	5.27**
8.	Blanching of vegetables	44.38	68.59	24.21	6.09**
9.	Storage of product	31.47	61.71	30.24	5.71**
10.	Marketing of product	14.15	36.15	22.00	4.16**

** Significant at 1 per cent level

Table 5. Type of number of trainings on preparation of value added products organized by K.V.K., Anta (Baran) during 2005 to 2009.

S.No	Type of training	Duration(Days)	No. Of trainings	No. of participants
1.	On campus	3	30	1328
2.	Vocational training	15	2	30
3.	Off campus	1	16	480

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INDIAN JOURNAL OF
ARID HORTICULTURE
2012, Vol. 7 (1-2) : 74-75

Short Communication

Efficacy of fungicides against black leaf spot of ber caused by *Isariopsis indica*

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Received: December, 2012; Accepted: February, 2013

Ber (*Zizyphus mauritiana* Lamk.) occupies as an important fruit crop of arid and semi-arid region and its plantation is increasing gradually every year in India. Its cultivation on marginal land with poor soil conditions can give very good revenues with less input. However, the major constraints in higher production are attack of diseases and it has been observed that some of the diseases (leaf spot and fruit rot) and post harvest diseases are concern with productivity and economic yield in this crop.

Black leaf spot is caused by *Isariopsis indica* var. *ziziphi*, one of the serious diseases in ber which can cause an economical yield loss upto 60 per cent. Gupta and Madaan (1977) have reported this disease for the first time from Haryana. It is common in southern and northern parts of the country. Black spots, which are sooty, tuft like circular to irregular black spots develop on leaf surface. During advanced stage, the lower surface of leaves also covered in larger area and corresponding upper surface shows brownish discoloration. In severe infection, leaves and twigs are dried rapidly causing necrosis and browning.

The experiments were conducted from 2005 to 2009 on the effect of fungicides, botanicals and biocontrol agents against black leaf spot disease of ber in B2 block of Regional Research Station, Aruppukottai. There were ten treatments replicated thrice by adopting randomized block design. The treatment comprises of,

1 Mancozeb 0.2%
2 Carbendazim 0.1%
3 Copper oxychloride 0.2%
4 Tilt 0.1%
5 Score 0.1%
6 NSKE 5.0%
7 Neem oil 3.0%
8 Untreated control
9 *Prosopis julifera* 10% LE
10 *Trichoderma viride* 0.2%

The black leaf spot symptoms usually occur during November December. The first foliar spray was given immediately after the occurrence of black leaf spot and the second spray was given at an interval of 10 days after the first spray. The disease intensity was assessed based on the grade (0 to 4) and the per cent disease index was calculated by using the formula,

$$\text{Per cent Disease Index (PCI)} = \frac{\text{Sum of numerical ratings}}{\text{Total number of ratings}} \times \frac{100}{\text{Maximum grade observed}}$$

The per cent disease reduction over the control was also calculated by using the formula,

$$\text{Per cent disease reduction over control} = \frac{\text{Control} - \text{Treatment}}{\text{control-treatment}} \times 100$$

The pooled data (2005 2009) were statistically analysed by following the method of Gomez and Gomez (1984).

The fungicides, bioagents and botanicals have been evaluated for their efficacy against this disease and among them, Propiconazole (Tilt) and Difenconazole (Score) each at 0.1per cent were found effective in reducing the disease index to 10.7 and 11.6 PDI, respectively as against untreated control which recorded 40.8 PDI (Table 1). Two foliar sprays of either Propiconazole (Tilt) or Difenconazole (Score) at 0.1 per cent given immediately after the disease appearance and another at 10 days interval which were found effective recording 74 and 72 per cent disease reduction over control.

The results were found similar with the findings of Kumar and Godara (2008) revealed that two foliar sprays of Difenconazole (Score) at 0.1 per cent was found effective in reducing the intensity of *Alternaria* leaf blight of cumin followed by 0.1 per cent Tilt (Propiconazole). Similarly the *in vitro* results of Nallathambi and Thakore (2003) supported that propiconazole and tridemorph completely inhibited the mycelial growth of *Alternaria* causing fruit rot in ber with the inhibition range of 72.52 to 98.63 per cent.

Table 1. Effect of fungicides, biocontrol agents and botanicals on leaf spot of ber.
(Pooled mean of 2005 2009)

Treatments	Black leaf spot (PDI)*	Per cent reduction over control
1. Mancozeb 0.2%	22.8	44.1
2. Carbendazim 0.1%	17.8	56.3
3. Copper oxychloride 0.2%	19.3	52.6
4. Propiconazole 0.1%	10.7	73.7
5. Difenconazole 0.1%	11.6	71.5
6. Neem Seed Kernel Extract 5.0%	21.4	47.5
7. Neem oil 3.0%	19.9	51.2
8. Untreated control	40.8	-
9. *Prosopis julifera* 10% LE	25.8	36.7
10. *Trichoderma viride* 0.2%	23.7	41.9
CD (P=0.05)	**0.45**	

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