INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-9

Pollination and pollenization in fruit crops

Jitendra Singh* and Kalpana Choudhary
Department of Fruit Science, College of Horticulture and Forestry, Agriculture University, Kota Campus, Jhalarapatan, Jhalawar- 326 023 (Rajasthan)
Corresponding author's e-mail: jsingh_rau2s@rediffmail.com
(Received: 30.01.2018; Accepted: 6.03.2018)

Abstract

Some fruit crops are monoecious in nature, while many others possess hermaphrodite flowers. On the contrary, there are fruit crops which are dioecious in nature. There may be various kinds of situations which mar effective pollination. Diploid plants produce abundant pollen, however triploid plants fail to do so. The flowers some time bloom earlier to critical period of receptivity of stigma and some time it may flower beyond the receptivity of stigma. All these contraventions distract the process of pollination and consequently, pollenization becomes inevitable. In present article attempt has been made to cover all such related aspects of pollination and pollenization so as to have better understanding of these phenomena towards better fruit set.

Key words: *Pollination, pollenization, pollenizers, pollinator effective pollination period, transference of pollen, and pollinator effectivity.*

Introduction

Pollination is the act of transferring of pollen grains from anther to the stigma of the flowers. It is one of the first and most important steps in successful fruit production, and for almost 90 per cent of angiosperms (Ollerton *et al.* 2011) this vital ecological service is facilitated through insect vectors, mainly bees (Kevan and Baker 1983; Michener 2007). When the pollen grains of anther is transferred to the stigma of same flower, or different flowers on the same plant, the process is referred to as self pollination or autogamy, e.g. citrus, guava, grape, etc. Autogamy occures within hermaphrodite flowers or perfect flowers. However, transfer of pollen grains from anther of one flower to the stigma of the another flower located on different plant of the different cultivar of same/related species, is referred to as cross pollination or allogamy, e.g. apple, pear, mango, walnut, aonla, etc. The mode of pollination is influenced by several factors cleistogamy, homogamy and geitonogamy are notable factors in self pollination. In cleistogamy condition the pollination and fertilization occur within the closed flower, e.g. grape. The plants expressing homogamy have male and female gametes matured at same time which favours self pollination, e.g. citrus, peach, apricot, etc. Plants follow geitonogamy mode of pollination. Actually, geitonogamy is a greek word derived from *geiton* which means neighbour and *gamein* which means to marry. Thus, it is the process of pollination of flower by another flower of same flowering plant. This process leads to reduce outcrossing, e.g. orchids. Chasmogamy, self incompatibility, male sterility, dichogamy are important determinant of cross pollination. Some plants produce flower which possess either of male or female sexes. It is also known as dicliny. This is of two types a) monoecy- in this condition the male and female flowers are produced on the same plant at different locations, e.g. walnut, jackfruit, aonla, pecannut, hazelnut, chestnut etc. b) dioecy- in this condition the male and female flowers are produced on different plants, e.g. date palm, papaya, kiwifruit, persimmon, pistachio nut, etc. In case of chasmogagamy, the flowers open and their reproductive organs are exposed to external environment and subsequently they are cross pollinated (Simpson, 2006). These flowers are attractive so, they attract insects (like- bees, butterflies, moths etc.), birds, bats, squirrels and animals for pollination. In some cases self incompatibility is encountered. In this situation pollens are unable to fertilize the ovule upon self pollination. It is found in important fruits such as apple, pear, apricot, almond, cherry, mango, pineapple, etc. It is mainly classified as sporophytic self incompatibility- a kind in which the incompatibility reaction of the pollen is determined by the genotype of the plant on which it is produced, e.g. mango; and gametophytic self incompatibility- a mechanism in which incompatibility reaction of the pollen is determined by its own genotype rather than the plant on which it is produced, e.g. apple, pear, almond, cherry, loquat, pumelo, etc. Male sterility makes the plant inclined to cross pollination. The plant expresses failureness to produce functional anthers/pollens, e.g. triploid banana, triploid apple varieties such as King of Topkins, Blenheim Orange, etc. In some instance dichogamy leads to cross pollination. The plants have differential in time of maturity of male or female gamete. It is of two types a) protoandry- in which anthers mature before the pistil, e.g. walnut, coconut, etc., and b) protogymy- in which pistils mature before the anthers, e.g. banana, annona, pomegranate, plum, avocado, fig, sapota etc.

In control of these set of mechanism plants undergo self and cross pollination. The uncertainty of no fruitfulness/poor fruit set is more in case of cross pollination which is very often susceptible to failure. But,

it can be arrested falling preservation of pollen. Pollen storage is a useful technique to establish a pollen bank which can be used to store genetic diversity and it can be used by plant breeders for plant improvement. This technique may be very helpful for monoecious plants to avoid hybridization barriers. Pollen bank can provide the viable pollen to commercial growers of fruits.

Pollen storage can be considered as a new emerging technology for genetic conservation (Roberts, 1975; Omura and Akihama, 1980; Akihama and Omura, 1986). Also since pollen is available easily in large quantity on most of the fruits trees and is a compact gene material, variable gene pool representing species and location can be stored, especially in cryogenic containers, occupying a relatively smaller space. The National Seed Storage Laboratory at Frot Collins, Kolorado, USA, has started pollen storage as one of the components of germplasm preservation (Standwood *et al.*, 1986). Cryogenic storage of pollen is easy and has been considered of great value in supplementing the usual germplasm preservation techniques by seed and clonal storage, and for enriching haploid gene pool.

Effective pollination period (EPP)

During every time and also at the very movement of receptivity of stigma, availability of viable pollen is not always assured. In order to help facilitate the pollination especially during lean period of availability of pollen grains, preservation is inevitable. The concept of effective pollination period (EPP) was developed by Williams in 1965 to asses flower receptivity. Effective pollination period is defined as the number of days during which pollination is effective in producing a fruit and is determined by the longevity of the ovules minus the time lag between pollination and fertilization. If effective pollination period is longer, chances of fertilization and seed development are greater. Pollination must occur within 2 to 4 days after anthesis otherwise the embryo sac will degenerate before fertilization. EPP plays a very important role in fruit set especially in temperate fruits and can be as short as 3 days and as long as 12 days. Williams developed a temperature response index for the estimation of time required for a pollen tube to grow and reach to the embryo sac. The index is based on the daily mean temperature over a period of time and when the pollen tube growth index reach to 100 per cent or above, the pollen tube should have reached the embryo sac and fertilized the ovule.

Transference of pollen/techniques of pollination

A pollen grain produced by the anther of the male flower, must be transferred to a stigma of the female flower, is very essential for successful pollination. In cross pollinated plant species it requires some transference agencies. It is affected by many of agencies like insects, birds, animals, wind, water etc. Transference of pollen by insects is also known as entomophily mode of pollination. In *Prunus*, pollen is transferred by insects, mainly of the *Apis genus*, belonging to the family Apidae (Griggs, 1953).

It mainly includes bees pollination (melittophily or hymenopterophily), butterflies pollination (psychophily), moth pollination (phalaenophily), housefly pollination (sapromyiophily), wasps etc. as principal agents of transference of pollen grains, e.g. mango, guava, ber, litchi, citrus, custard apple, apple, peach, plum, almond, walnut. Goodman, (1994) observed the efficiency of honeybees in influencing pollination in stone fruits and in pome fruits (Table 1). Sharmah *et al.*, (2015) also reported the impact of honeybee (*Apis cerana*) pollination on productivity of different fruit crops (Table 2). Pollination by is also known as ornithophily mode of pollination. It include parrots, bats (cheiropterophily) etc. as agents of transference of pollen grains. It commonly occurs in red, large and tubular flowers which secrete nectar, e.g. banana, pineapple. Pollination by mammals/animals is treated as zoophily mode of pollination. Elephant, monkey, squirrels etc. are very potent agents of pollen transference. Wind represents anemophily mode of pollination, e.g. date palm, coconut, cashewnut, papaya, jackfruit, sapota, pomegranate etc. are pollinated by wind. Wind pollinated plants produce pollen grains in abundance. These plants devoid of showy flowers and they don't produce scent or nectar. Water is potent way of transference of pollen. It is also known as hydrophily mode of pollination. Large flowers and leaves of these plants are floating on the surface of water which favours water pollination, e. g. lily, gaint water lily.

Pollinator effectiveness and efficiency

It is defined as the pollinator efficacy in relation to floral resource consumption and pollen wastage. More will be the pollinator effectiveness and efficiency more will be the fruit set. For Successful pollination pollinators effectiveness and its efficiency are utmost important. Pollinator effectiveness is the total contribution to plant reproductive success, and thus, it reflects pollinator efficacy and intensity of visitation in a simple conceptual model. It may refer to the contribution of an individual or population of a species of pollinator or a functional group of pollinators (Fishbein and Venable, 1996; Avila and Freitas, 2011). It can be estimated directly from the seed set. Pollinator efficiency is closely linked to pollinator foraging strategies, and there is a clear dichotomy between animal and plant expectations (Borrell, 2007; Fishbein and Venable, 1996).

Pollenization

Pollenization is a process of planting the variety which provides sufficient pollen for pollination. The plants which provides pollen grains for pollination are termed as pollenizer. Some plants are capable of self pollenization, but not all plants. For such plants which are incapable in self pollenization, pollenizers are required for good production of fruits. Many plants are dioecious, e.g. kiwi, papaya, date palm etc. This situation necessitates pollenization (Singh, 2017).

Pollenization depends upon various ability of pollinizer, such as regular its in its blooming habit, flowering early, overlapping flowering with the main

variety, viability of pollen, compatibility of pollen, winter hardiness in case of temperate pollenizers and pollen production at relatively low temperature etc.
Warmund obeserved different crab apple varieties as a pollenizer according to their blooming period and also found that the pollenizers often planted in between the rows or within the rows in commercial orchards had better production

Very often pollinizers are used in pollination management such plants provide abundant, compatible and viable pollen at the same flowering time as the pollinated plant. In apple, diploid varieties produce abundant viable pollen. Triploid varieties are generally fail to produce viable pollen. It is caused due to abnormal cell division in triploid plants (e.g. Baldwin, Rhode Island Greening, Tomkins King, Jonagold etc.). The pollenizer variety should have regularity in bearing in order to have continuity in fruit production. The main variety fail to receive sufficient pollen if there is off year on the pollenizing variety. Precocity in bearing is worth consideration while selecting pollenizer as it influences age at which plant is likely to come into bearing. The very non precocious variety of apple Northern Spy on non-precocious sededling root may require 12 years to produce the first bushel of fruit on a tree. Although, Northern Spy is a good source of pollen but it should not be planted as a pollinizer variety for precocious varieties such as Golden Delicious, Wayne and Yellow Newtown (Roger 1978). Early bloomer pollenizing varieties are better sources of pollen. This early type of bloomer has further advantage of the fact that the flowers that are pollinated earlier get more available time to be fertilized due to available suitable temperature (Singh, 2017) and thus fruit set hastens. The pollenizer variety may be planted in complete block or interplanted within row (Warmund,2002). With successful pollenization and pollination in plum yield has been increased to the tune of 23 per cent when Kala Amritsary has been pollinated with Titron and in Kataru Chak plum variety 13 per cent when pollinated with Kala Amritsari (Bal, 2010)

Warmund (2002) reported that some reliable pollenizer varieties (Fig. 2) planted in apple orchard for better production Pollination has been found to enhance fruit set, fruit weight and fruit size. Pollination ultimately leads to fertilization and seed development, and influences the number and distribution of seeds within the fruit, which has long been known to influence fruit quality (Brault and de Oliveira, 1995; Ward *et al.*, 2001; Dražeta, 2002) and quantity (Brain and Landsberg, 1981; Garratt *et al.*, 2014).

Table 1: Role of honeybees in the pollination of stone fruits and in pome fruits

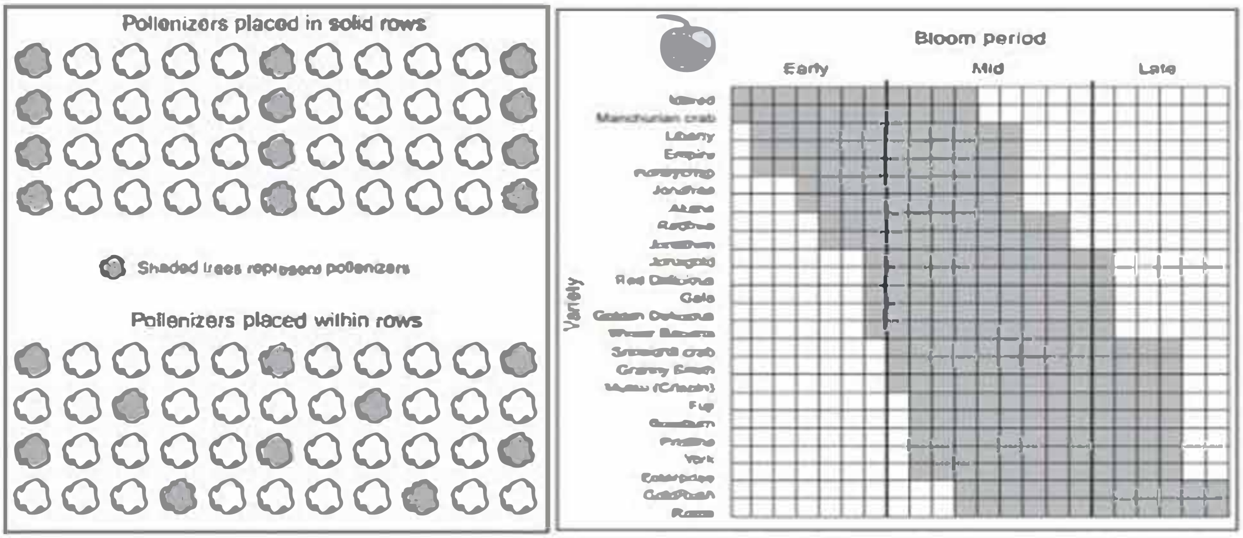
Fruit	Variety		Fruit set (per cent)	Yield/tree (kg)
Stone fruits				
Apricot	Trevatt	Open*	19	99
		Enclosed**	11	67
Cherry	Moss Early	Open	36	35
		Enclosed	2	2
Peach	Golden Queen	Open	26	216
		Enclosed	22	155++
Peach	Crawford	Open	28	47
		Enclosed	10	18
Plum	Satsuma	Open	6	38
		Enclosed	2	15
Pome fruit				
Apples	Yates	Open*	240	125
		Enclosed**	8	9
Pears	Winter Nelis	Open	53	88
		Enclosed	5	12

* Open trees: trees to which bees and other insects have access
** Enclosed trees: trees enclosed during flowering in bee-proof cages to prevent bee pollination
++ Weight of fruit harvested not significantly different

Table 2: Impact of honeybee (*Apis cerana*) pollination on fruit productivity

Crop	Increase in fruit set (per cent)	Increase in fruit weight (per cent)	Increase in fruit size (length, diameter in per cent)	References
Apple	10	33	15, 10	Verma and Dutta, (1986)
Peach	22	44	29, 23	Partap *et al.*, (2000)
Plum	13	39	11, 14	Partap *et al.*, (2000)
Citrus	24	35	9, 35	Partap, (2000a)
Strawberry	112	48	Misshapen fruits decreased by 50 percent	Partap, (2000b)

Source: Sharmah *et al.*, (2015)



(a) (b)

Fig. I a) Planting of pollenizer in compact as well as inter-row. b) Bloom period of different variety of crab apple

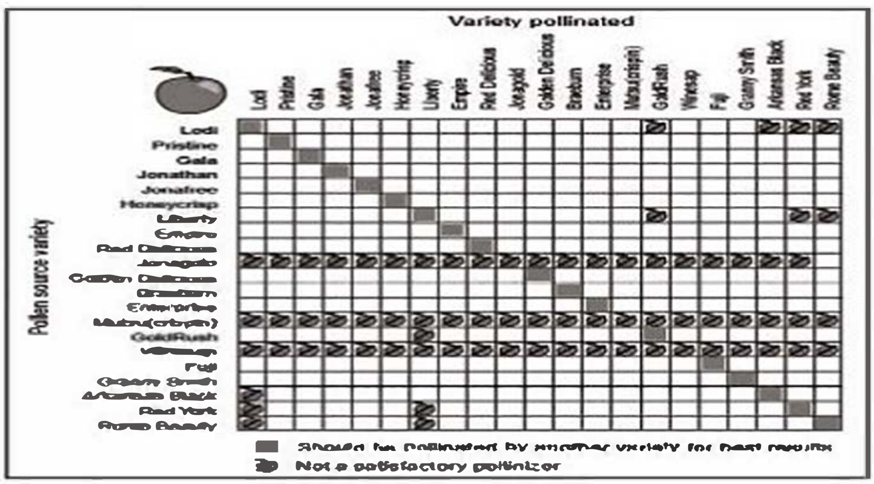


Fig. 2 Pollenizer variety for apple

Use of pollinator safe pesticides

Use of pesticides for crop protection is harmful for pollinators (bees). It is very important to understand that what type of pesticide is to spray, when to spray to assure good pollination and fruit set in the fruit trees. Generally pesticides which have warning labels on it are very harmful for bees. To protect the pollinators some safety measures like use of pesticide which have a low extended residual toxicity, the use of pesticides that come in the form of wettable powder, use of pesticide with very low concentration which have low toxicity to bees etc. can be taken.

Some systemic insecticides which have low toxicity for the mammals can be used. Neonicotinyl systemic insecticides like imidacloroprid, dinotefuran, thiamethoxam and clothianidin etc., are least toxic to bees. Its toxicity for bees also depends upon the type of application and time of application of that insecticide. It is advised to avoid the use of these neonicotinyl insecticides at the time of flowering (Vera Krischik, 2014).

Pollination in different fruit crops

Most of the fruit crops require pollination to ensure proper fruit set and consequently better production. In apple best fruit set is attained if it is largest or king blossom is pollinated. Some apple varieties may be self pollinated like Golden Delicious, Liberty, Loda, Empire, Jonathan, Jonagold, Rome and Granny Smith. Crab apple is widely used as a pollenizer when it is planted at similar distance to early to mid blooming apple variety (Warmund). The delicious apple shows cross compatibility with Winesap, while a different variety is required to pollinate it (Chadda and Pareek, 1993).

In case of japanese plum, it requires cross pollination to ensure fruit set because of self-

incompatiblity and unable to bear fruit parthenocarpically (Hartmann and Neumuller, 2009). Some pollenizer varieties are recommended for Japanese plum in different areas according to their fruit set recorded under orchard. Fortune acts as a pollenizer for Black Gold, likewise Black Diamond and Larry Ann for Black Star, Black Diamond for Black Amber, and Ambra, Black Diamond for Fortune and Angeleno, and Fortune for Golden Globe (Guerra, 2011). Cultivar Santa Rosa is a good pollenizer for Oishiwase, Soldam and White plum, while Beniryozen is most suitable pollinizer for Formosa (Chung *et al.*, 1998).

The pear cultivars grown in plains of northern India are partially self fruitful or partially fruitful but the cultivars which are grown in the temperate regions are self-incompatible or self unfruitful so they need cross-pollination. Fitzgerald (2005) reported some compatible pollenizer varieties in European and Asian pears (Table 3). High bee populations in the crop will not only ensure good fruit set, but will increase seed numbers in each fruit in pear. The majority of pollinators of pear tre eeare honey bees. Three colonies of bees per hectare may be sufficient.

Most peaches and nectarine are self fruitful. In these crops, single variety can be planted in compact block. There is no need of pollenizer variety. However, some variety like J.H. Hale is self unfruitful. It requires another variety for pollination.

Most sour cherry varieties are self fruitful. Varieties like Montmorency, English Morello, Meteor and Northstar are self fruitful.

Sweet cherry varieties like Stella, Lapins, and Sunbrust are self fruitful as well cross compatible with other varieties. Most other varieties are self unfruitful and requires pollenization. Many are cross incompatible. Incompatibility wise, grouping of sweet cherry varieties are as under:

I. Black Tartarian, Early Rivers

II. Venus, Windsor, Van, MERTON Bigarreau

III. Emperor Francis, Napolean, Bing, Lambert, Compact Lambert, Vernon

IV. Viva, Victor, Vogue

V. Gold

VI. Hedelfinger

VII. Schmidt

VIII. Rainier, Hudson, Giant, Chinook

X. Ulster, Vic

Hence, these groups should not be planted. One group of variety is pollenized by another group of variety.

In loquat many varieties are self incompatible. These require pollenization. Incompatible varieties are as under:

Self incompatible varieties: Golden Yellow, Improved Golden Yellow, Pale Yellow, Large Agra.

Partially self in compatible varieties: Large Round, Fire Bll, Thames Pride, California Paride, Tanaka.

Variety California Advance is pollenizer for Improved Golden Yellow, California Advance and Tanaka have been found pollenizers for many cultivars in loquat (Pathak, 1999).

In almond most varieties are self fruitful. It necessitates cross- pollination. The varieties like Non-pareil and I.X.L., California Paper Shell and I.X.L., Jordanalo and Harpareil are intersterile. They require pollenization with some other varieties (Bal, 2010).

Many citrus cultivars are seedless and produced parthenocarpically without pollination. Some cultivars may produce fruit either way. If pollinated, there may have seeds in the segments and no seeds if not (Vardi *et al.*, 2008). Citrus that requires pollination may be self-compatible, thus pollen must be moved only a short distance from the anther to the stigma by a pollinator. Some citrus, such as Meyer Lemons, are popular container plants. When these bloom indoors, they often suffer from blossom drop because of no access pollinators. Hand pollination is a solution. A few citrus, including some tangelos and tangerines, are self-incompatible, and require cross pollination. Pollenizers must be planned when groves are planted. Managed honeybee hives at bloom time are often used to ensure adequate pollination.

In date palm which is a dioecious fruit plant pollination depends upon the pollenizer cultivars. Pollen from different male pollenizer affect the fruit set, weight, pulp, and time of maturity of the fruit, as well as seed characteristics such as weight (Iqbal *et al.*, 2012; Shafique *et al.*, 2011). When the trees are pollinated with Madjool and Barakah pollen there is highest fruit set and yield. Whereas, when the trees are pollinated with Jarvis, pollen it gives early maturity (Muhtased and Ghnaim 2007). Pollenization with Zahidi cultivar had the highest fruit set per cent 50.30, while bunches pollinized with the Khadrawy cultivar had fruit set per cent 13.25 (Ricardo *et al.*, 2017).

Pollination is useful in mango. It produces thousands of small flowers in single panicle which may be male and harmaphrodite. The percentage of perfact flowers may be 5 to 50 per cent depending upon cultivars (Chadda and Pareek, 1993). The pollination in mango is mainly entomophilous (by house flies and hover fly), (Randhawa and Damodaran, 1961). Honey bee plays an important role in its pollination. The cultivar Dasehari was recommended as pollenizer for Langra (Ram and Sirohi, 1994). Ber is also cross pollinated fruit crop, it does not set any fruit by self pollination (Bal, 2010). In aonla the fruiting depends upon the sufficient pollenizers. Provision of 10 per cent pollenizers has been found optimum in aonla. It has been observed that NA7 is a good pollenizer for NA6. Planting of 2-3 varieties in an orchard solved the problem of pollenizer. In fig, the Smyrna type develops fruit only when receives pollen from Capri fig, also known as caprification (Radha and Mathew, 2007).

In majority of temperate and stone fruits, nuts, tropical and subtropical fruits honeybee is dominating pollination agent. In most fruit crops pollenizer varieties have been found useful (Table 4). Hence, while planning orchard both the processes of pollination and pollenization deserve to be taken into account. This is in the way of successful orcharding

Table 3: Some compatible pollenizer varieties in European and Asian pears

European Pears	**Compatible Pollenizers**
Bartlett	d'Anjou, Bosc, Comice
Bosc	Bartlett, Comice, d'Anjou, Seckel
Comice	Bartlett, Bosc, d'Anjou, Seckel
d'Anjou	Bartlett, Bosc, Comice, Seckel
Seckel	Bosc, Comice, (Bartlett is not compatible)
Asian Pears	**Compatible Pollenizers**
Chojuro	Shinseike, Bartlett
Nijisseiki (Twentieth Century)	Chojuro, Shinseike, Bartlett
Hosui	Partially self-fruitful
Shinseike	Chojuro

Table 4: Account of pollinators and pollenizers in fruit crops

Fruit crops	Pollination type	Major pollinator	No. of bee hives/ha for effective pollination	Ratio of pollenizers to main variety in the orchard
A. Temperate and stone fruits, nuts				
Apple	Largely cross-pollinated	Honeybees and bumble bees	4-5	33 per cent
Pear	Partly or entirely self-sterile, requiring cross-pollination	Honeybees and bumble bees	3-4	Inter-planting of 3-4 varieties in a block is recommended
Apricot	Cross-pollination essential	Honeybees	2-3	33 per cent
Peach	Mostly self-fruitful, some varieties require cross-pollination	Honeybees, rarely other insects and wind	2-3	1:2
Plum	Self fruitful to self-incompatible	Honeybees, bumble bees and blow flies	2-3	Every 4th tree in every 4th row
Almond	Cross-pollination essential	Honeybees	6-8	One row of pollenizer for every two rows of main cultivar
Cherry	Cross-pollination essential	Honeybees	2-3	10 per cent pollenizers
Persimmon	A very unusual sex distribution. Some varieties are self-pollinated and others require cross-pollination	Honeybees, Bumble bees and wind	2-3	A special plan is required to plant A type and B type varieties
Walnut	Cross-pollination essential	Wind	-	-
Pecan nut	Cross-pollination essential	Wind	-	-
Pistachio nut	Cross-pollination essential	Wind, Honeybees	-	1:8 (male: female)
Chestnut	Self-sterile	Wind, Honeybees, chafer beetles	-	1:1 or 1:2 (male: female)
Hazelnut	Self-sterile	Wind	-	15-20 per cent inter-planting of two cultivars is recommended
Blueberry	Self-sterile to cross-sterile	Honeybees	2-3	10 per cent
Olive	Self-sterile to self fertile	Wind, Honeybees	-	11 per cent. Sometimes inter-planting of two cultivars is recommended
Strawberry	Self-pollinated, cross-pollination beneficial	Honeybees, wild bees	10-25	No specific recommendation

B. Tropical and sub-tropical fruits				
Mango	Self to cross-pollination	Houseflies, honeybees, hover flies	5-7	Inter-planting of 3-4 varieties in a block is useful
Citrus	Self-sterile to self fertile	Honeybees	1-2	10-15 per cent in self-incompatible forms
Grapes	Self-sterile to self fertile	Honeybees and other hymenopterous insect	1	No specific recommendation
Banana	No need of pollination. However, sometimes, cross-pollination takes place	Bats and birds	-	-
Papaya	Self to cross-pollinated	Sphinx moth, sun bird, humming bird, butterflies and honeybees	-	About 10 per cent male plants should be there in an orchard in dioecious varieties, but no need for gynoedioecious varieties
Coconut	Self to cross-pollinated	Wind	-	Inter-planting of dwarf and tall cultivars is useful
Litchi	Self-fruitful, but cross-pollination is beneficial	Honeybees, hover flies, wasp and houseflies	4-5	No specific recommendation
Guava	Self to cross-pollinated	Honeybees and hover flies	-	No specific recommendation
Loquat	Self to cross-pollinated	Honeybees and hover flies	-	Inter-planting of 2-3 varieties in a block in recommended
Ber	Self-incompatible	Yellow wasp, houseflies and *Trigona sp.*	-	Inter-planting of 2-3 varieties in a block in recommended
Aonla	Both self and cross-incompatible	Wind, wasp and houseflies	-	Inter-planting of 2-3 varieties in a block in recommended
Fig	Both self to cross-pollinated	Wasp (*Blastophaga psens)*	-	In some forms, planting of Capri figs is essential
Pomegranate	Self to cross-pollinated	Honeybees, beetles and wind	-	No specific recommendation
Sapota	Self-sterile	Wind, honeybees	-	No specific recommendation

Source: Sharma, 2006.

References

Akihama, T. and Omura, M. 1986. Preservation of fruit tree pollen. In: Bajaj YPS, editor. Biotechnology in Agriculture and Forestry. Vol. 1: Trees. Springer Verlag, Berlin. pp.101–112.

Avila, R. S. Jr, Freitas, L. 2011. Frequency of visits and efficiency of pollination by diurnal and nocturnal lepidopterans for the dioecious tree Randia itatiaiae (Rubiaceae). *Aust J Bot.* 59:176–184

Bal, J. S. 2010.In: *Fruit Growing*, Kalyani Publishers, Ludhiana. p 250, 341.

Borrell, B. J. 2007. Scaling of nectar foraging in orchid bees. Am Nat 169:569–580

Brain, P. and Landsberg, J. J. 1981. Pollination, initial fruit set and fruit drop in apples: analysis using mathematical models. *Journal of Horticultural Science*, 56:41–54.

Brault, A. de Oliveira, D. 1995 Seed number and an asymmetry index of 'McIntosh' apples. *Hort Science*, 30:44–46.

Chadda, K. L. and Pareek, O. P. 1993. In: *Advances in horticulture vol. 1*,Fruit crops part I pp 464-479.

Chung-Kyeong Ho, Jun-JiHyal, Kang Sangjo. 1998. Selection of suitable pollenizers for major Japanese plums. *J. of the Korean Society for Horticultural Science* , 39 (5): 560-563.

Dražeta, L. R, 2002. Structure, function and quality development in apples. PhD Thesis. Massey University, New Zealand. pp 160

Fitzgerald, T. 2005. *Pollination of fruit trees (C105).* https//Spokane-county.wsu.edu

Fishbein, M. And Venable, D. L. 1996. Diversity and temporal change in the effective pollinators of *Asclepias tuberose*. *Ecology*, 77:1061–1073

Garratt, M. P. D., Breese, T. D., Jenner, N., Polce, C., Biesmeijer, J. C. and Potts. S. G. 2014 Avoiding a bad apple: insect pollination enhances fruit quality and economic value. *Agriculture, Ecosystem & Environment*. 184:34-40.

Goodman, R. 1994. *Honeybee pollination of fruit tree crops*. http://agriculture.vic.gov.au/agriculture/horticulture/fruit-and-nuts/orchard-management/honeybee-pollination-of-fruit-tree-crops.

Griggs, W. H. 1953. Pollination Requirements of Fruit and Nuts. College of Agriculture University of California, Berkeley, CA.

Guerra, M. E., 2011. Polinización y cuajado en ciruelo japonés. Ph. D. thesis.Extremadura, Badajoz, Spain.

Hartmann, W. and Neumuller, M. 2009. Plum breeding. In: Priyadarshan, P.M., MohanJain, S. (Eds.), Breeding Plantation Tree crops: Temperate Species. Springer,New York, pp. 161–231.

Iqbal, M., Niamatullah, M. and Munir, M. 2012. Effect of various Dactylifera males pollinizer on pomological traits and economical yield index of cv's Shakri, Zahidi and Dhakki date palm (*Phoenix dactylifera* L.). *J. Anim Plant Sci*., 22: 376-383.

Kevan, P. G. and Baker H. G. 1983. Insects as flower visitors and pollinators. *Annual Review of Entomology*, 28:407-53.

Michener, C. D. 2007. The Bees of the World. Second Edition. Johns Hopkins University Press, Baltimore, Maryland.

Muhtased and Ghnaim 2007. Effect of pollen source on productivity, maturity and fruit quality of Hayyani date palm *J. Appl. Hort*., 9 (2): 170-172.

Nath, V., Kumar, D. And Pandey, V. 2008. In: *Fruits for The Future, vol.-1*: well Versed Arid and Semi-Arid Fruit., S. S. Publishing house, Delhi, p149

Ollerton, J., Winfree, R. and Tarrant, S. 2011. How many flowering plants are pollinated by animals? *Oikos*, 120:321-326.

Omura, M. and Akihmia, T. 1980. Pollen preservation of fruit trees for gene banks in Japan. *FAO/ IBPGR Plant Genet. Resources Newsletter*. 43, 28-31.

Pathak, R.K. 2006. Loquat. In: *Tropical Horticulture*, Vol. I (Editors Bose and others), Naya Prokash, Kolkatta, p. 386-389.

Partap, U. 2000a. Foraging behaviour of *Apis cerana* on citrus (*Citrus sinensis* var. Red Junar) and its impact on fruit production. In Asian Bees and Beekeeping: Progress of Research and Development. *Proceedings of the Fourth AAA International Conference 23-28 March, 1998, Kathmandu* (p.274). New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.

Partap, U. 2000b. Pollination of strawberry by the Asian hive bee, *Apis cerana* F. In Asian Bees and Beekeeping in Asia: Progress of Research and Development. *Proceedings of the Fourth AAA International Conference 23-28 March 1998, Kathmandu* (p.274). New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.

Partap, U., Shukla, A. N., and Verma, L. R. 2000. Impact of *Apis cerana* pollination on fruit quality and yield in peach and plum in the Kathmandu valley of Nepal. In (M. Matsuka, L. R. Verma, L. R. & Partap, U. (1993). *The Asian Hive Bee, Apis cerana, as a Pollinator in Vegetable Seed Production* (p.52). Kathmandu: ICIMOD.

Radha, T. And Mathew, L. (2007) Fig. In: Fruit crops. NIPA. New Delhi, p. 319.

Ram, S. and Sirohi S. C. 1994. Selection of pollinizer for mango cultivar Langra. *Recent Horticulture* , I: 14-17.

Randhawa, O. S. and Damodaran, V. K. 1961. Studies On floral biology and Sex ratio in mango (*M. indica* L.), lit. Anthesis. Dehiscence Susceptivity of Stigma, Pollination, fruit set and fruit development. *Indian J. Hort*., 18: 51-64.

Ricardo Salomon-Torres, Noé Ortiz-Uribe, Rafael Villa-Angulo, Carlos Villa-Angulo, Susana Norzagaray-Plasencia, Cristian D. García-Verdugo 2017. Effect of pollenizers on production and fruit characteristics of date palm (*Phoenix dactylifera* L.) cultivar Medjool in Mexico. *Turk J. Agric*. 41: 338-347

Roberts, E. H. 1975. Problems of long-term storage of seed and pollen for genetic resources conservation. In: Frankel, O.H. and E. Bennett (eds) *Genetic Resources in Plants - Their Exploration and Conservation*. pp. 269-295. Blackwell Scientific Publications, Oxford.

Roger, D. Way 1978. Pollination and Fruit Set in Fruit crops. Cornell coorperative extension information bulletin 237.

Shafique, M., Khan, A. S., Malik, A. U., Shahid, M., Rajwana, I. A., Saleem, B. A., Amin, M. and Ahmad, I. 2011. Influence of pollen source and pollination frequency on fruit drop, yield and quality of date palm (*Phoenix dactylifera* L.) cv. Dhakki. *Pakistan J. Bot*, 43: 831-839.

Sharma, R. R. 2006. In: *Fruit Production Problems and Solutions*, IBDC, Lucknow, pp 94-97.

Sharmah, D., Khound, A., Rahman, S. and Rajkumari, P. 2015. Significance of Honey Bee as a Pollinator in Improving Horticultural Crop Productivity in N.E. Region, India: A Review. *Asian J. Natural Applied Sci*., 4(1): 62-69.

Simpson, Michael, G. 2006. In: *Plant Systematics*, Elsevier academic press, USA, p 471.

Singh, J. 2017 In: *Fundamentals of Horticulture*, Kalyani publishers, Ludhiana, pp.184-185.

Stanwood, P. C., Roos, E. E. and Towill, L. E. 1986. Cryopreservation of plant germplasm. A pliot research project. *FAO/IBPGR Plant Genetic Resources Newsletter*, 65,18-19.

Vardi, A., Levin, I. and Carmi, N. 2008. Induction of Seedlessness in Citrus: From Classical Techniques to Emerging Biotechnological Approaches. *Journal of the American Society for Horticultural Science*, 133 (1): 117-126.

Vera Krischik, 2014. *Protecting bees and beneficial insects from systemic insecticides applied in landscapes*. University of Minnesota Extension. http:/ www. extension.umn.edu.

Verma L. R. and Dutta, P. C. 1986. Foraging behaviour of *Apis cerana indicia* and *Apis mellifera* in pollinating apple flowers. *J. Apic. Res.*, 25:197-201.

Ward, D. L., Marini, R. P. and Byers, R. E. 2001 Relationships among day of year of drop, seed number, and weight of mature apple fruit. *Hort Science*, 36:45--48.

Warmund, M. R. *Pollinating fruit crops*.2002. University of Missouri, Columbia. http:/extension.missouri.edu/p/G6001.

INDIAN JOURNAL OF ARID HORTICULTURE 2017, Vol. 12 (1-2):10-15

Analysis of genetic diversity among the *Madhuca longifolia* genotypes from Semi-Arid Ecosystem of Gujarat

Rakesh Bhargava, Karun Gurjar, Sanjay Singh[a] and A. K. Singh[a]
Central Institute for Arid Horticulture, Beechwal, Bikaner 334003, Rajasthan
[a]Central Horticulture Experiment Station, (ICAR-CIAH, Bikaner), Vejalpur, Godhra, Gujarat
Corresponding author's e mail: rbciah@yahoo.com
(Received: 13.11.2017, Accepted: 11.01.2018)

Abstract

An attempt was made to assess the genetic diversity among the elite selections collected from the natural populations in semi-arid parts of Gujarat. A total of 10 accessions of mahua (*Madhuca longifolia*) were subjected to RAPD profiling using 10 primers (OPF). The data from all primers were pooled and subjected to analysis through Nei and Li's coefficient. The results demonstrated that a wide genetic variability exists in the natural population of mahua growing in semi arid parts of the Gujarat. This needs to be conserved and utilized for further improvement of this species.

Key words: *Mahua, RAPD, Biodiversity, genetic diversity*

Introduction

Mahua (*Madhuca longifolia*) of family sapotaceae is a multipurpose tree which is naturally growing in the semi-arid parts of Gujarat. The Indian subcontinent harbours two varieties of this species viz. *Madhuca longifolia* var. longifolia and *Madhuca longifolia* var. latifolia (Roxb.) Cheval. Of the two varieties, var. longifolia is distributed in Sri Lanka, Southern India extending northwards to Maharashtra and Gujrat; var. latifolia is found in some parts of central and north India and Burma (Ramadan *et al.*, 2006; Akshatha *et al.*, 2013). All the parts of the plants are of economic value such as bark, flowers, seeds and leaves are used for food, fodder and fuel (Jayasree *et al.*, 1998). The heartwood of the tree is used for construction of house, flowers are edible and fruits are valued for its seeds, which are the largest source of natural fat known as mahua butter (Yadav *et al.*, 2011, Sastri, 1962; Bringi, 1987; Singh and Singh, 1991). Ramadan *et al.* (2016) have highlighted the nutritional value and industrial application of this crop. The crude oil extracted from the seeds is pale yellow and remains as a semi-solid in the tropical temperatures (Marikkar and Yanty, 2012). According to Ramadan *et al.* (2006), about 46% of the fatty acids present in *M. longifolia* seed oil is saturated, 37.4% mono unsaturated, and 16.5% poly unsaturated. Despite its immense economical value it still remains to be fully utilized agriculturally since no staudard varieties and agro-techniques are available for cultivation of this species.

Being confined to the forests, it has not been subjected to any genetic improvement efforts. The natural populations are seedling populations, therefore they exhibit considerable anatomical, physiological, morphological and genetic variability to survive under varying environmental conditions. As a result of this, wide variations have been observed in sweetness, acidity, size, shape and bearing habits in mahua under Uttar Pradesh and Gujarat conditions (Singh *et al.*, 1999; Anonymous, 2002; Singh and Singh, 2005).

Assessment of genetic diversity based on phenotype has limitations, since most of the morphological characters are greatly influenced by environmental factors and the development stage of the plant. In contrast, molecular markers based on DNA sequence polymorphism, are independent of environmental conditions and show a higher level of polymorphism. Several types of molecular markers such as restriction fragment length polymorphism (RFLP) (Botstein *et al.* 1980), random amplified polymorphic DNA (RAPD) (Welsh and McClelland *et al.* 1990, Williams *et al.* 1990), amplified fragment length polymorphism (AFLP) (Vos *et al.* 1995) and simple sequence repeats (SSRs) are available to assess the genetic diversity and phylogenetic assessment of the crop species. In mahua, very limited work has been done to employ molecular markers in varietal characterization and assessment of phylogenetic kinship among germplasm lines. Accordingly, the objective of the present study was to assess the genetic diversity among the germplasm lines of mahua growing naturally in Gujarat. The results thus obtained constituted the text of the present communication.

Materials and Methods

A total of ten germplasm lines collected from semi-arid region of Gujarat and maintained at CHES, Vejalpur, Godhra constituted the material for present study.

Genomic DNA extraction, PCR amplification and diversity analysis

Young leaves from different genotypes of mahua were collected separately and immediately fixed in ethyl alcohol for 24 hrs. Total genomic DNA was extracted from 100mg of le. afrom each sample seperately by using the DNeasy® Plant Mini kit (QIAGEN, India Pvt. Ltd.) following with some modification. The lysis was achieved by the addition of 400 µl warm (65° C) lysis solution modified by the addition of 10mg/ml PVP (polyvinyl polypyrrolidone), 10mg/ml SDS (Sodium Lauryl Sulphate) and 4 µl of Proteinase K stock solution (100mg/ml) prior to grinding. After grinding the samples were collected into the 1.5 ml eppendorf tube separately. The samples were centrifuged for 30s at low speed (4000g) and 4µl RNase A stock solution (100mg/ml) was added to each tube, followed by mixing until no tissue clumps were visible. Rest of the protocol followed as per standard procedure. To remove RNA, genomic DNA was treated with RNase and stored at -20°C. The quality of DNA was checked by electrophoresis in 0.8 % agarose gel.

PCR conditions and DNA amplifications:

Kit F comprising 20 decamer random primers (Operon Technologies, Alameda, CA, USA) was screened out for the present investigation. To optimize the PCR amplification conditions, experiments were carried out with varying concentrations of DNA template, primers, Taq polymerase, as well as dNTPs. A total of 10 primers were used for PCR-RAPD analysis (Table 1). To determine the optimum amplification conditions and also to ensure the reproducibility of the results, the reaction conditions were standardized using a study and tested at least twice. This study was carried out with two primers (OPF-01 and OPF-02) using a range of DNA concentrations (1, 1.5, 2 and 2.5 µl from the diluted DNA Stock of 200ng/µl) and three different cycles (35, 40 and 45 cycles). After ascertaining the optimum quantity of DNA, annealing temperature and PCR cycles, all the PCR reactions, with 10 primers(OPF 1 to OPF 10), were carried out in 25 µl varying concentrations of template DNA, 1x TopTaq PCR buffer, 1x Q-Solution, 200 µM of each dNTP, 1.25 U TopTaq DNA polymerase, 10 pmol of primer (QIAGEN, India Pvt. Ltd.) and the reaction programmes were set at 94°C for 3 min followed by 40 cycles of 94°C for 30 Sec, 36° C for 1 min and 1 min elongation at 72°C, and a final extension at 72°C for 7 min in a thermal cycler Genemate Series (Analytica Biotech, USA). After completion of the amplification, 2.5 µl CoralLoad dye was added to the samples, and the amplified DNA was analyzed on 1.2% agarose gel pre-stained with ethidium bromide in 1X TAE buffer at 65 - 90 V for 2.5 h, along with O "GeneRuler 100 bp DNA ladder Plus (Thermo Scientific, India Pvt. Ltd.) The gels were observed on the gel documentation system (Gene Genius Bioimaging System) and photographed.

RAPD data analysis:

All the amplified bands were counted manually along with their size. Computer analysis of RAPD patterns were performed as described by Halmschlager et al. (1994) in which the band pattern obtained from agarose gel electrophoresis was digitalized by hand to a two-discrete-character-matrix (0 and 1 for absence and presence of RAPD-bands, respectively) The data of all primers were combined. The analysis data was based on the Nei and Li's coefficient (Nei & Li, 1979). Dendrograms were constructed by the unweighted paired group method of arithmetic average (UPGMA) based on Jaccard's similarity coefficient by using NTSYSpc-2.02e version 2.0.1.5 software (Applied biostatistics, Inc).

Results and Discussion

Optimization of the concentration of DNA for PCR reaction set-up:

Genomic DNA was successfully extracted from ethanol dried young leaf of mahua (*Madhuca longifolia*), using a modifications from the commercial the DNeasy® Plant Mini kit procedure. The approximate DNA concentration in the extracts was 1000 ng/µl. The original concentration of the DNA extracts was too high for reliable amplification, showing poor amplification with faint, smeared products. The optimal DNA concentration for amplification of *Madhuca longifolia* DNA was found to be 4.0 µl of 1:3 dilutions (approximately 200 ng), whilst the optimum annealing temperature was 36° C and the optimum no. of PCR cycles was 40.

Polymorphism and Marker Efficiency:

The largest fragment amplified was in the range of 250 to 3000 bp while the smallest but easily recognizable fragment was approximately of 250 bp. Most bands were concentrated between 500 to 2000 bp. An example of RAPD pattern, obtained with different primers (OPF-01 to OPF-10), is shown in Fig. 1. The number of bands scored for each primer varied from 6 to 17. The highest number of bands (17) was generated with Operon primers OPF 2, OPF 6, and OPF 10, while the lowest number (6) was obtained with Operon primers OPF 3 and OPF 8. The 10 primers yielded a total of 129 fragments, of which 79 amplicons (61.24%) were polymorphic, the number of polymorphic bands per primer ranged from 2 to 14 (Table 1). It was observed that the scored 50 RAPD-PCR fragments were monomorphic (38.75%) The primer OPF-6 is the highly polymorphic primer as 82.35% and gel image of RAPD profiling of this primer is given in Figure 1. However the five primers such as OPF-1, OPF-2, OPF-05, OPF-7, and OPF-10, were also informative primers as 60% or more of the amplicons were polymorphic. The results of the RAPD-PCR analysis indicated that some polymorphic RAPD bands are present were found to be shared among more than one genotype .

Our results are in agreement with those reported earlier on other taxa. It has been demonstrated by Dangi *et al.* (2004) that *Trigonella foenum-graecum* shows 70.12% polymorphism, Rao *et al.* (2006) reported 77.8% polymorphism in chick pea by using 10 decamer primers, Thomas *et al.* (2006) reported 78.8% in wheat by using 50

decamer primers. Patra and Chawla (2010) recorded 76.5% in rice by using 12 decamer primers and Skaria *et al.* (2011) reported 72.27% polymorphism in rice genotypes. This high level of polymorphism in mahua is indicative of fact that during the course of evolution a large number of genetic manipulations have taken place such as single nucleotide change or insertion or deletion of nucleotide or complete loss of complimentary sites. All these have generated genetic variability and got fixed in natural population since the species is a perennial tree and can be propagated by vegetative means.

Genotype identification using RAPD profiles

The data generated on 10 germplasm lines of mahua showed that the RAPD profiles developed by using primers OPF 1 to OPF 10 can be employed for cultivar identification. This is illustrated by the fact that the line MH 5 can be identified by using OPF 2 profile. The line has typical band combination being represented by 350, 2000 and 2200 bp. Similarly, line MH 6 can be identified by using profile developed by OPF 4 having band combination of 780 and 1900bp. Among other lines, MH 1 can be identified using band combination of 500 and 1700 bp in OPF 4, 1150 and 2000bp in OPF 6, combination of 550 and 1000bp with OPF 10 and sole band at 530bp with OPF 9, Line MH 2 can also be identified using combination of bands at 400, 680, 7650, 1000, 1100 and 1500bp with OPF 10.

Our results are in line with those reported in Mulberry (Bhattacharya and Ranade, 2001), *Gymnema sylvestre* (Balamurali Krishna *et al.*, 2012), *Madhuca longifolia* (Gavankar and Chemburkar, 2016 and *Trigonella* (Raja *et al.*, 2015).

Genetic relationships among accessions and cluster analysis

Cluster analysis based on similarity values (Table 2) classified genotypes into two distinct clusters (I & II, Figure 2). The first cluster (I) included only four genotypes MH-14, MH-2, MH-6 and MH-1, whereas the second cluster (II) included six genotypes (MH-10, MH-3, MH-15, MH-8, MH-5 and MH-4) and was further divided into three sub-clusters (Figure 2). Both of the cluster I and II were further divided into two sub-clusters labeled (I-A, I-B) and (II-A, II-B) respectively. The sub-cluster I-B and II A are monophyletic branches including MH-1 and MH-10 genotypes respectively. The sub cluster II-B was further grouped into two sub-sub clusters II-B_1 (MH-3, MH-8 and MH-15) and II-B_2 (MH-5 and MH-4) Similarity coefficients between Madhuca longifolia ranged from 0.619 to 0.900 (Table 2). Among the similarity coefficients of the genotypes, the similarity coefficient MH-2 and MH-6 was highest (0.900), which indicates closer relationship among these accessions, while the similarity coefficient of MH-1 and MH-4 was observed lowest (0.619) (Table 2).

Similar work has been carried out on other plant species also. A wide genetic variability has been reported by Rout and Das (2002) in *Plumbago*, Gilani *et al.* (2009) in *Wathania somnifera*, Smita and Keshvachandran (2015) in *Trigonella* cultivars. Gavankar and Chemburkar (2016) also made an attempt to assess the genetic variability in some accessions of Mahua. Our results highlight that a wide genetic variability exits in the natural population of Mahua in Panchmahal region of Gujarat. This calls for a systematic collection, evaluation and conservation of this species so that trait based breeding programme can be initiated to develop an elite forms for commercial cultivation.

Table 1: List of primers and degree description of the polymorphism obtained among 10 mahua genotypes.

S. No.	Primer code	Sequence 5' to 3'	Sizes (bp) min-max	Total band No.	Polymorphic bands	Polymorphism ratio (%)	PIC
1	OPF-1	ACGGATCCTG	330-1800	15	11	73.33	0.391
2	OPF-2	GAGGATCCCT	290-2200	17	11	64.71	0.378
3	OPF-3	CCTGATCACC	600-1300	6	3	50.00	0.406
4	OPF-4	GGTGATCAGG	450-2500	15	6	40.00	0.343
5	OPF-5	CCGAATTCCC	400-1800	15	10	66.67	0.260
6	OPF-6	GGGAATTCGG	280-2800	17	14	82.35	0.467
7	OPF-7	CCGATATCCC	600-2000	10	6	60.00	0.241
8	OPF-8	GGGATATCGG	500-1500	6	2	33.33	0.153
9	OPF-9	CCAAGCTTCC	550-3000	11	5	45.45	0.388
10	OPF-10	GGAAGCTTGG	440-2500	17	11	64.71	0.389

Table 2: Dice Jaccard's similarity co-efficient matrix of 10 different genotypes of mahua.

Genotypes	MH-14	MH-10	MH-2	MH-1	MH-3	MH-5	MH-4	MH-6	MH-8	MH-15
MH-14	****									
MH-10	0.622	****								
MH-2	0.820	0.661	****							
MH-1	0.741	0.687	0.678	****						
MH-3	0.636	0.670	0.689	0.630	****					
MH-5	0.678	0.684	0.718	0.644	0.730	****				

MH-4	0.652	0.643	0.692	0.619	0.766	0.817	****			
MH-6	0.763	0.681	0.900	0.669	0.681	0.754	0.669	****		
MH-8	0.681	0.734	0.650	0.675	0.783	0.750	0.691	0.669	****	
MH-15	0.670	0.645	0.624	0.634	0.740	0.645	0.664	0.643	0.780	****

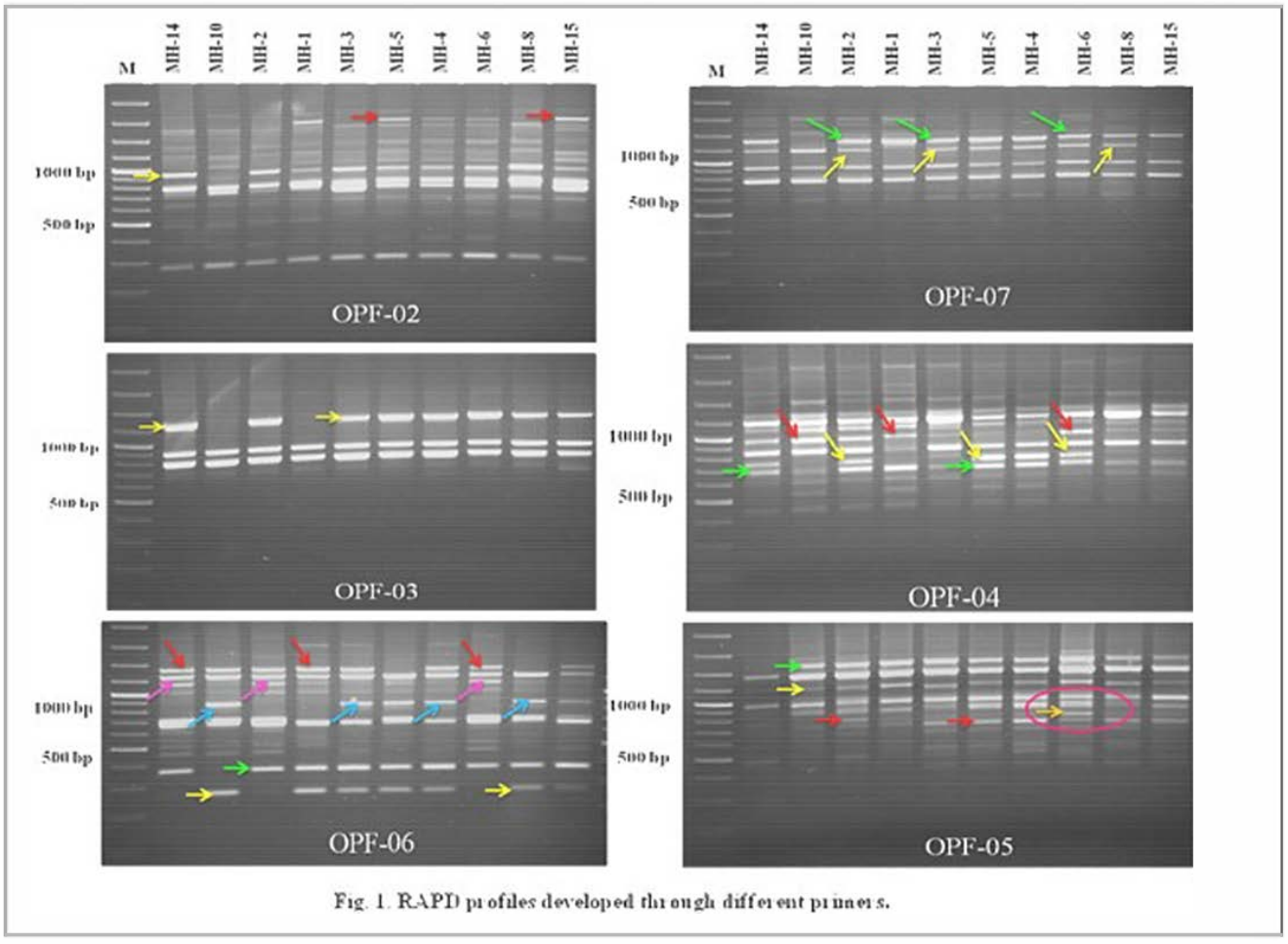


Fig. 1. RAPD profiles developed through different primers.

References

Akshatha, K. N., Mahadeva Murthy, S., and Lakshmidevi, N. 2013. Ethno medical uses of *Madhuca longifolia* - a review. *International Journal of Life Science and Pharma Research*, 3(1):44-53.

Anonymous 2002. Annual Report, Central Institute for Arid Horticlture, Bikaner, Pp 31.

Balamurali Krishna, R., Reddy, S. R., Vijayalaxmi M., Anugna, K., Divyavani, N. and Jagadeeswara Reddy, K. 2012. Molecular characterization of 17 accessions of *gymnema Sylvestre r.* Br. using rapd markers. *Int. J. Pharma and Bio Sci.*, 3(1): B126-B135.

Bhattachary, E. and Ranade, S.A. 2001. Molecular distinction amongst varieties of mulberry using RAPD and DAMD profile. *BMC Plant Biol.*, 1:3.

Botstein, D., White, R.L., Skolnick, M. and Davis, R.W. 1980. Construction of a genetic linkage map in man using restriction fragment length polymorphisms. *Am. J. Hum. Genet.* 32:314-331.

Bringi, N. V. 1987. Non-traditional oilseed and oils in India. Oxford & I.B.H. Publishing;. pp. 554109el 17.

Dangi, R. S., Lagu, M. D., Choudhary, L. B., Ranjekar, P. K. and Gupta, V. S. 2004. Assessment of genetic diversity in *Trigonella foenum-graecum* and *Trigonella caerulea* using ISSR and RAPD markers. *BMC Plant Biology*, 4:13.

Gavankar, R. and Chemburkar, M. 2016. Genetic Analysis of *Madhuca longifolia* (J. Koenig ex L.) J.F. Macbr. Using RAPD Markers. *Int. J. Curr. Microbiol. App. Sci.*, 5(8): 608-615.

Gilani, S.A., Kikuchi, A. and Watanabe, K. N. 2009. Genetic variation within and among fragmented populations of endangered medicinal plant, *Withania coagulans* (Solanaceae) from Pakistan and its implication for conservation. *Afr. Biotechnol.*, 8(23): 2948-2958.

Halmschlager, E. Messner, R. Kowalski, T. and Prillinger, H. 1994. Differentiation of *Ophiostoma piceae* and *Ophiostoma quercus* by morphology and RAPD-analysis. *System Appl. Microbiol.*, 17:554-562.

Jayasree, B. Harishankar, N. and Rukmini, C. 1998. Chemical composition and biological evaluation of mahua flowers. *J. Oil Technol. Assoc.*, 30:170-72.

Kaura, S. K., Gupta, S. K. and Chowdhury, J. B. 1998. Morphological and oil content variation in seeds of *Azadirachta indica* A. Juss. (Neem) from northern and western provenances of India. *Plant Foods for Hum. Nutr.*, 52:293e8.

Kaushik, N., Kumar, K., Kumar, S., Kaushik, N. and Roy, S. 2007. Genetic variability and divergence studies in seed traits and oil content of Jatropha (*Jatropha curcas* L.) accessions. *Biomass and Bioenergy*, 31:497e502.

Marikkar, J. M. N. and Yanty, N. A. M. 2012. Seed fat from *Madhuca longifolia* as raw material for Halal alternative fats. *Borneo Science*, 31: 84-93.

Nei, M, and Li, W. H. 1979. Mathematical model for studying genetic variation in terms of restriction endonucleases. *Proc. Natl. Acad. Sci. USA*, 76:5269-5273.

Patra, N. and Chawla, H. S. 2010. Biochemical and RAPD markers molecular for establishing distinctiveness of basmati rice verities as additional descriptors for plant variety protection. *Indian J. Biotechnol.*, 9: 371-377.

Raja, V., Wani, U. M., Kudesia, R. and John, R., 2015. Estimation of genetic variability in *Trigonella* cultivars by RAPD analysis. *Int. J. Biotechnol. Res.*, 3(2): 21-27.

Ramadan, M. F., Mohdaly, A. A. A., Assiri, A. M. A., Tadros, M. and Niemeyer, B. 2016. Functional characteristics, nutritional value and industrial applications of *Madhuca longifolia* seeds: an overview. *Journal of Food Sci. Technol.*, 53(5): 2149-2157

Ramadan, M. F., Sharanabasappa, G., Parmjyothi, S., Seshagiri, M. and Moersel Joerg-Thomas 2006. Profile and levels of fatty acids and bioactive constituents in mahua butter from fruit-seeds of buttercup tree [*Madhuca longifolia* (Koenig)]. *Eur. Food Res. Technol.*, 222: 710-718.

Rao, L. S., Rani, U. P., Deshmukh, S. P., Kumar, P. A., Panguuri, K.S. 2006. RAPD and ISSR fingerprinting in cultivated chick pea (*Cicer arietinum* L.) and (*Cicer reticulum* L.). *Gene. Resour. Crop Evol.*, 54(6): 1235-1244.

Rout, G. R. and Das, D. 2002. An Assessment of Genetic integrity of micropropagated plants of *Plumbago Zeylanica* by RAPD Markers. *Biol. Plantar.*, 45(1): 27-32.

Sastri, M.W. In: Sastri MW, editor. The wealth of India raw material, 6. New Delhi, India: CSIR; 1962. p. 207.

Singh, A. and Singh, I. S. 1991. Chemical evaluation of mahua (*Madhuca indica*) seed. *Food Chem.*, 40:221-8.

Singh, I. S., Srivastava, A. K. and Singh, B. 1999. Improvement of some under-utilized fruits through selection. *J Applied Hort.*, 1: 34-37.

Singh, S. and Singh, A.K. 2005. Genetic diversity in mahua (*Bassia latifolia*) under semiarid ecosystem of Gujarat. *Indian J. Agric. Sci.*, 75(8):519-523.

Skaria, R., Sen, S., Abdul-Muneer, P. M. A. 2011. Analysis of genetic variability in rice varieties (*Oryza sativa* L.) of Kerala using RAPD markers. *Genetic Engineering and Biotechnology Journal.* 24:1-9.

Smita, N. and Keshavachandran, R. 2006. Molecular diversity in Chakkarakolli (*Gymnema sylvestre* R. Br.) assessed through isozyme and RAPD analysis. *J. Tropic. Agric.*, 44(1-2): 31-36.

Thomas, G., Mohapatra, T., Rao, A. R., Sharma, R. P. 2006. Distinguishing Indian commercial wheat varieties using RAPD based DNA fingerprinting. *Indian J. Biotech.*, 5: 200-206.

Vos, P., Hogers, R., Bleeker, M., Reijans, M., van de Lee, T., Hornes, M., Frijters, A., Pot, J., Peleman, J., Kuiper, M. and Zabeau, M. 1995. AFLP: a new technique for DNA fingerprinting. *Nucleic Acids Research*, 23(21): 4407-4414.

Welsh, J. & M. McClelland, 1990. Fingerprinting genomes using PCR with arbitrary primers. *Nucl. Acid Res.*, 18: 7213-7218.

Williams, K. J., Kubelik A., Livak K., Rafalski J., and Tingey S. 1990. DNA polymorphism amplified by arbitrary primers are useful as genetic markers. *Nucleic Acids Research*, 18: 6531-6535.

Yadav, S., Suneja, P., Hussain, J., Abraham, Z. and Mishra. S.K. 2011. Genetic variability and divergence studies in seed and oil parameters of mahua (*Madhuca longifolia* Koenig) J.F. Macribide accessions. Biomass and Bioenergy, 35: 1773-1778.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Glossonema variens: A Threatened Food cum Medicinal Plant of Western Rajasthan

J. P. Singh, Suresh Kumar† and Kulloli R. N*
ICAR-Central Arid Zone Research Institute, Jodhpur -342 003 (Rajasthan), India
†(Now Retired- 126, Subhash Nagar, Pal Road, Jodhpur)
*(Now at Botanical Survey of India, AZRC, Jodhpur)
(Received: 12.01.2018; Accepted: 21.03.2018)

Abstract
Glossonema variens is threatened plant species in the Indian desert. Due to overgrazing and destruction of habitat, its population is depleting in its natural habitats. It is being one of the important traditional foods cum medicinal plants for desert inhabitants in Thar Desert, India. This paper describes its ethnic uses and potentials and highlights need for its *in situ* and *ex situ* conservation in arid rangelands.

Keywords: *Glossonema variens, threatened, traditional food, conservation*

Introduction

Plants of family Asclepiadaceae are both, economically as well as ecologically very important in the Thar desert. As food cum medicinal plants these species play a vital role in the life of the inhabitants of Thar Desert as compared to other parts of the country. Examples include species like *Caralluma edulis* (Edgew.) Benth. & Hook., *Ceropegia bulbosa* Roxb., *Glossonema variens* (Stocks) Benth. ex Hook.f., and *Leptadenia pyrotechnica* (Forsk.) Decne. Parts of these species used as food are nutritious and have traditional medicinal importance. As an important endangered desert plant, *Glossonema variens* received much attention recently in other regions (Phoboo *et al.*, 2015. Al Hadidi et. *al.*, 2017). Its *in situ* and *ex situ* conservation is vital to maintain its population and biodiversity in desert. In the present paper an attempt is made to highlight the ecological, economic importance and conservation of *Glossonema variens* in Thar Desert, India.

Results and Discussion

Distribution, Botanical and Ecological Characteristics

Glossonema varians (Stocks) Benth. ex Hook. f. (syn. *Mastostigma variens* Stocks) belongs to family Asclepiadaceae. The plant is locally known as *Dodha* and its follicles (fruit) are called as *Khiroli* in western Rajasthan. It is distributed in Arabia, Baharin Island, Iran, Pakistan (Sindh, Baluchistan) and India (Bhandari, 1990). In India it occurs in western Rajasthan, particularly, in Jaisalmer and Barmer districts.

This is a small, 8-20 cm high, erect perennial herb with milky latex. It regenerates from a perennial root-stock. It is much branched from near the base. Its stem is terete or more or less angular, pubescent, woody at base. It has fleshy, grayish-green and pubescent leaves with 1-2 cm long petiole. Its flowers are lemon-yellow, fragrant on sessile, umbellate 2-8 flowered cymes. Fruits are 2.5-5.0 cm long, ellipsoid, beaked, attenuated at base, covered with short, soft, scattered, spine-like processes. Seeds are 5-6 x 3-4 mm, broadly ovate, with much flattened and with very thin membranous margins. After the dehiscence of the ripe fruits, the leaves and stems dry and only the perennial-rootstock remains in the ground, which regenerates in suitable environmental conditions.

Ali and Ali (1996a) reported andromonoecy condition i.e. perfect (hermaphrodite) and male (staminate) flowers on the same plant in *G. variens*. They observed that certain flowers had usually small rudimentary ovaries without ovules. Ali and Ali (1996 b) studied the effect of sugar concentration on pollinium germination in eight members of Asclepiadaceae including *Glossonema variens*. They found that in hermaphrodite (perfect) flowers of *G. variens*, 15% sugar concentration showed maximum pollinium germination and 20% concentration in male (staminate) flowers. Generally, flowering and fruiting in *G. variens* occurs during August to November. Usually, it flowers once a year and remains in bloom for about one to two months depending on the availability of moisture. However, if there is sufficient rainfall during April and May, it may flower early. It usually produces 2-3 fruits per plant under sufficient moisture condition.

G. variens appears usually along runnels on shallow sandy gravelly soils and in depressions of rocky and gravelly areas of arid rangelands of Thar Desert. In its natural habitat, it forms association with grasses, leguminous and non-leguminous perennial herbs and also grows under the canopy of under-shrubs and shrubs. It is associated frequently with perennial grasses like *Dactyloctenium sindicum* Boiss., *Ochthochloa compressa* (Forsk.) Hilu and also with *Cymbopogon jwarancusa* (Jones) Schult. in the rocky situations and with *Lasiurus sindicus* Henr in sand deposition/sandy soils (Plate 1). Among herbaceous leguminous species, it is very much associated with *Tephrosia uniflora* Pers., which is a suffruticose leguminous perennial herb that occurs exclusively on open rocky slopes. *Indigofera cordifolia* Heyne ex Roth is one of the associated annual leguminous species. Among the non-leguminous perennial herbaceous species *Boerhavia diffusa* L., *Tribulus terrestris* L. are the main associated species. *Dipcadi erythraeum* also noticed as associate of *G. variens* in rocky-gravelly areas. The under-shrubs like *Heliotropium rariflorum* Stocks and *Seddera latifolia* Hochst. & Steud. are also associated with *G. variens* on open rocky slopes. It also grows under the canopy of the shrub species like *Leptadenia pyrotechnica* (Forsk.) Decne. and *Ziziphus nummularia* (Burm.f.) Wt. & Arn.

Plate 1: Associated plant species with Glossonema variens (Top left: Ochthochloa compressa and Dactyloctenium sindicum: Top right: Lasiurus sindicus; Below left: Tephrosia uniflora; below right: with Seddera latifolia

In the protected rangelands, *Glossonema variens* exhibits the remarkable diversity in plant types, particularly, in size and shape of leaves, flower colour and also in size of fruits. Generally plants with crisped margin leaves with light yellow flowers are common in rocky with less moisture situation. These types of plant have leaves with more length as compared to width. With little bit high moisture with sand deposition or sandy conditions plants with entire leaf margin with dark yellow flower were noticed in the rangelands. In this type, more width of leaves is observed as compared to length.

Economic importance:

Food: Its tender fruits (follicles) are known as *Khiroli* and are eaten raw by the inhabitants and supposed to have nutraceutical properties (Plate 2). The fruits collected from the rocky rangelands by the villagers are for their own consumption, however, rarely sold in the local market. Unripe tender fruits are eaten raw also used as vegetable and are very delicious. Its tender leaves are also used as vegetable. Its seeds are also edible and cooked by native Quatari people (Batanouy, 1981, Al Hadidi *et. al.*, 2017). Its fruits are reported to contain essential and non-essential amino-acids, carbohydrates, fatty acids, flavonoids having high nutritive value (Rizk et al., 1983, 1984)

Fodder: The plant is grazed by wild and domestic animals like sheep and goats, however, the plants are not generally grazed by the cattle.

Medicine: Traditionally, it is supposed one of the important medicinal plant of Thar Desert. The fruits are well known to be body tonic and energetic. The fruit juice is used in treating painful muscles, cough and sore throat. In coastal areas of Pakistan, the infusion of leaves is given for painful urination (Qasim *et al.*, 2014). Phoboo *et al.* (2015) reported moderate levels of anti-oxidant potential, soluble phenolics and ACE inhibitory activity in *Glossonema edule* from Qatar, which may be useful for potentially managing hypertension and oxidation-linked vascular complications

Plate 2: Fruits of Glossonema variens

Conservation and People Participation

Most of the threatened plant species in western Rajasthan are found in rangelands with sandy, gravelly and rocky substratum, therefore more attention is to be paid to preserve the specific niche i.e. micro and macro habitat. There is need to create the awareness among the desert inhabitants on economic and ecological importance of such type of species for their sustainable utilization and conservation. It is vital to recognize the rangeland areas with distinctive patches of *Glossonema variens* as Preservation Plot/Protected Areas particularly in its natural distribution cover particularly in Jaisalmer district.

The existence of *Glossonema variens* in the arid rangeland is threatened due to multitude of factors such as low rainfall, over-grazing by domestic animals, destruction of habitats, dilution in traditional conservation practices and changes in climatic condition. These factors have created an increased pressure on the existing natural populations of the species which finally led to decrease in the vegetation cover. Normally, it regenerates from the perennial-rootstock in the field after receiving good rainfall but it flowers in the less rainfall event, and again it requires sufficient moisture for fruiting. If soil and water conservation measures are used in its natural patches, then required moisture will be available for its regeneration and optimum growth for fruiting and availability of seeds. Therefore, conservation measures like soil and moisture conservation suitable to the habitat are to be taken up on priority to reduce soil erosion, a main cause of habitat loss. Further, actual potential of this species as food cum medicinal plant have not yet been realized. But its young shoots and fruits have attained immense importance in the recent years. The gray areas of the species where research attention required are nutritive value of its tender fruits and its medicinal aspects.

Acknowledgements:

The authors are grateful to Director, ICAR-Central Arid Zone Research Institute, Jodhpur for facilitation. We thank Department of Biotechnology, New Delhi for their financial support through All India Co-ordinated Project on "Preventing Extinction and Improving Conservation Status of Threatened Plants through Application of Biotechnological Tools". We appreciate the moral support and encouragement by Professor S.K. Barik, National Coordinator of this project.

References

Al Hadidi, Sara H., Raham Sher Khan, Asmaa al-Qaradawi, Mohammed H. Alsafran and T.A. Ahmed. 2017. Efficient plant regeneration of *Glossonema edule*, a critically endangered desert plant. *Global Journal of Agricultural Research and Reviews*, 5 : 269-277.

Ali, Tahir and Ali, S.I. 1996a. Andromonoecy in *Glossonema variens* (Stocks) Hook.f. (Asclepiadaceae). *Pak. J. Bot.*, 28: 25-29.

Ali, Tahir and Ali, S.I. 1996b. Effect of sugar concentration on pollinium germination in some members of Asclepiadaceae. *Pak. J. Bot.*, 28: 161-165.

Batanouny, K.H. 1981. *Ecology and Flora of Qatar*. Alden Press Ltd., Oxford.

Bhandari M.M. 1990. *Flora of the Indian Desert*. MPS Repros., Rajasthan.

Phoboo, S., Shetty, K. and T. ElObed. 2015. In vitro assays of anti-diabetic and anti-hypertensive potential of some traditional edible plants of Qatar. *Journal of Medicinal Active Plants*, 4: (3-4) 22-29.

Qasim, Muhammad, Abideen, Z., Yousuf Adnan, M., Ansari, R., Gul, B., and Ajmal Khan, M. 2014. *Journal of Coastal life Medicine*. 2: 22-30.

Rizk, A.M., Hammouda, F.M. and Hussein, L. 1983. Constituents of plants growing in Qatar III – Nutritive constituents of Garawah (*Glossonema edule*). *Plant Foods Human Nutr.*, 33: 71-76.

Rizk, A.M., Hammouda, F.M., Ismail, S.I., Hassan, N.M., El-missiry M.M. and Ahmad, F.A. 1990. Constituents of plants growing in Qatar Part IX. Flavonoids of *Glossonema edule* N. E. Br. *Plant Foods for Human Nutr.*, 40: 1–3.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Effect of organic manures and different levels of NPK on growth and quality of Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]

Mukesh Nagar , A.K. Soni and D.K. Sarolia
Department of Horticulture, College of Agriculture
S K Rajasthan Agricultural University, Bikaner 334006, Rajasthan, India
(Received: 12.07.2017; Accepted: 16.11.2017)

Abstract

A field experiment was conducted during *kharif,* season 2012 to study the effect of organic manures and different levels of NPK on growth and quality of Bottle gourd. The experiment consisting of 16 treatments *viz.*, four levels of NPK (control, 100:50:50, 80:40:40 and 60:30:30) and organic manures (control, vermicompost, poultry manure and FYM) factorial designed in RBD with three replications. Results indicated that application of NPK (100:50:50) + vermicompost (5.0 t/ha) was recorded minimum days taken to appearance of first female flower, maximum length of main vine (m), number of primary branches per vine, length and width of leaf (cm) 45 days after sowing, minimum node number at first female flower appeared, protein content in fruit, crude fibre content in fruit, nitrogen content in fruit, phosphorus content in fruit, potassium content in fruit, yield q/ha and return rupees investment.

Key Words: Bottle gourd, poultry manure, vermicompost.

Introduction

Among, cucurbits, bottle gourd *[Lagenaria siceraria* (Mol.) Standl.] is extensively grown in India and fruits are available throughout the year. Fruits at tender stage are used as a cooked vegetable and for preparation *of sweets, (e.g. kheer, petha, burfi,* and *halwa,*) and *pickles, rayta*. Hard shells of mature fruits are used as water jugs, domestic utensils, floats for fishing nets and making musical instruments, etc. As a vegetable it is easily digestible. It has cooling effect and has diuretic and having cardio-tonic properties. Fruit pulp is used as an antidote against certain poisons and is good for controlling constipation, night blindness and cough. A decoction made out of leaf is taken for curing jaundice (Thamburaj and Singh, 2001). The fruit contain 0.2% protein, 2.9% carbohydrate, 0.5% fat and 11 mg vitamin C of per 100 g fresh weight. In the area, cucurbits are growing extensively as kitchen garden especially during *kharif* season or as commercial scale throughout the year. The tribal's of the area are growing it and train the vines on boundary of the house and on pandal. Among cucurbits, bottle gourd is being grown by majority of the farmer than other cucurbitaceous vegetables In India, bottle gourd is grown in the area of 111 thousand hectares with annual production of 1836 thousand tonne and having 12.21 tonnes ha^{-1} productivity. It occupies 3.20 Thousand hectares area in Rajasthan producing 22.40 tonne with a productivity of 3.48 tonnes ha^{-1}(Anonymous, 2015). The effect of organic and inorganic fertilizers is complementary to each other in terms of soil fertility improvement and sustainable agriculture. Therefore, it is necessary to make their judicious use in right proportion for harvesting better yield of different crops in cropping sequence and for sustaining soil fertility. The integrated nutrient management helps in restoring and sustaining soil fertility and crop productivity. It also helps in arresting the emerging deficiencies of macro, secondary and micronutrients favorably by optimizing the physical, chemical and biological environment of soil and achieving economy and efficiency in fertilizer use. Hence, the present study was undertaken to find out the combined effect of organic manures and inorganic fertilizers on the growth and quality of bottle gourd.

Materials and Methods

The experiment was laid out at Horticulture Farm, College of Agriculture, Bikaner, during *Kharif* season 2012. The soil was loamy sandy with P^H 8.2 and contained 0.09% organic carbon, 80.19 kg ha^{-1}available N, 17.34 kg ha^{-1}available P, 185.42 kg ha^{-1}available K. The experiment was laid out Randomized Block Design (factorial) with three replications. There were sixteen treatment combinations, which included various combination of NPK (control, 100:50:50, 80:40:40 and 60:30:30) and organic manures (control, vermicompost, poultry manure and FYM). The well rotten farm yard manure (5.0 t ha^{-1}), vermicompost (5.0 t ha^{-1}) and poultry manure (7.0 t ha^{-1}) were applied and spread uniformly in the plots as per treatment. Three seeds per hill were sown manually by dibbing method on 3rd August 2012. The seeds were soaked in cold water overnight before sowing

for better germination. The sowing was done in the row keeping 2.5 m inter –row spacing and 0.80 m plant to plant spacing. At each hill and seed were sown at a depth of 1.5 to 2.0 cm. Germination took place within six days after sowing. One third dose of N, full doses of phosphorus and potassium were applied at the time of sowing. The remaining doses of nitrogen were applied 30 and 60 days after sowing into standing crop. The sources of N, P and K were used as urea, single super phosphate and muriate of potash, respectively the recommended dose of NPK was 80:40:40 kg ha^{-1} (Anonymous, 2010). Data were taken five plants were selected randomly from each plot and tagged. Minimum days taken to appearance of first female flower, length of main vine (m), number of primary branches per vine, length and width of leaf (cm) 45 days after sowing, minimum node number at first female flower appeared, protein, crude fibre, nitrogen, phosphorus, potassium content in fruit, yield q/ha and return rupees investment. Were recorded as per standard methodology. Estimated yield per hectare was calculated by number of fruit $vine^{-1}$, yield $vine^{-1}$ and total plant density and returns ha^{-1} calculated by sale price of Rs 800 q and total yield q ha^{-1}. Where returns rupees investment calculated by dividing net return to total cost of cultivation ha^{-1}.

Results and Discussion

Effect of organic manure: The data presented in (Table 1 and Table 2). Organic manures, NPK levels effect on growth and quality attributes of bottle gourd. The application of vermicompost (5.0 t ha^{-1}). Recorded length of main vine (4.09), number of primary branches per vine (11.85), protein content in fruit (0.262 %), crude fibre content in fruit (1.136 %), nitrogen content in fruit (0.042 %), phosphorus content in fruit (0.41 %), and yield q/ha (242.70 q $^{ha-1}$). However application of FYM (5.0 t ha^{-1}), recorded minimum node number at first female flower appeared (11.64), length of leaf (18.16 cm) and width of leaf (27.21 cm), 45 days after sowing, potassium content in fruit (1.52 %), and minimum days taken to appearance of first female flower (58.47), under poultry manure (7.0 t ha^{-1}).These finding clearly indicated that vermicompost played a significant role on enhancing the growth of bottle gourd. Improvement in plant growth attributes with that application of vermicompost might be due to better not only provided plant nutrient but also improve the physical condition of soil in respect of granulation, friability porosity which interm provided a balance nutritional environment favorable both soil rhizosphere and in plant system. Reddy *et al.*,(1998). These results are in close conformity with the finding of Senapati *et al.*, (1985), Pillai *et al.*, (1985), Sharhidhara *et al.*, (1998) and Tomar *et al.*, (1998) This might be due to improve nutrient environment in the rhizosphere as well as its utilization in the plant system, leading enhanced translocation of nutrient, vitamins and proteins in fruits. Another reason might be the increased activity of nitrate reductase which helped in synthesis sustains amino acid proteins as reported by Chinaswamy and Marikulandi, (1966), Lopes *et al.*, (1996), Yadav and Vijayakumari, (2004). The beneficial effect of FYM/Vermicompost in increasing the content of nitrogen in fruit might be attributed to its direct supply of nitrogen. Moreover, FYM/Vermicompost after decomposition might have released macro and micro-nutrients, which increases the availability of nutrients to the soil, plant system and thus increased the nutrient in fruit etc. The higher nutrient availability enhanced photosynthesis and their translocation to different plant parts resulting into higher concentration of nutrient particularly, nitrogen. Similar finding have been observed by Singh and Krishana (2007), Okonwu and Mensah (2012), Ouda and Mahadeen (2008).

Effect of inorganic fertilizers: Application of different levels NPK significantly influenced the growth and yield of bottle gourd. The maximum number of primary branches per vine (12.55), length of leaf (18.65 cm), width of leaf (27.54 cm) 45 days after sowing, minimum node number at first female flower appeared (11.27), protein content in fruit (0.81 %), crude fibre content in fruit (0.139 %), nitrogen content in fruit (0.045 %), phosphorus content in fruit (0.45 %), potassium content in fruit (1.74 %) and yield (249.10 q/ha) were recorded under NPK 100:50:50 fertilizer. However the NPK levels 80:40:40 fertilizers recorded maximum length of main vine (4.27 m), minimum days taken to appearance of first female flower (58.22). This may be due to the better nutrition environment in the root zone for growth and development of the plant. Nitrogen is considered as one of the major nutrient required for proper growth and development of the plants. It also play an important role in plant metabolism by virtue of being an essential constituent of diverse type of metabolically active compounds like amino acids, proteins, nucleic acids, prophytins, flavins, purine and pyrimidine, nucleotide, flavin nucleotides, enzymes, co-enzymes and alkaloid Yadav, (2000). Phosphorus is a constituent of nucleic acid, phytin and phospholipids, The beneficial influence of phosphorus in early stages of growth may be explained by early stimulation of root system through efficient translocation to the root of certain growth stimulation compounds formed on account of protoplasmic activity of tops in phosphorus feed plants, when enhanced absorption of nitrogen and other nutrient and their utilization. So an adequate supply of phosphorus in early stages of plant life is important in laying down the primodia for the reproductive part of the cauliflower Kumhar, (2004). The response of potassium fertilization in terms of overall improvement in growth characters are further supported by the fact that the leaching losses of potassium was more in light textured soil. Therefore, potassium fertilization improved overall crop growth in term of plant minimum day taken to the appearance of first female flower, minimum nodes no. at which first female flower appeared, length of main vine, number of primary branches per plant, length and width of leaf (cm) 45 day after sowing, potassium helps in the protein and chlorophyll formation ultimately the NPK are used for better vegetative growth. As far case economic is calculated the combined application of (V_1F_3) recorded maximum results revealed

that organic manure in form of vermicompost @ 5 tonnes ha^{-1} recorded higher growth and yield attributes as well as gross return over rest of treatment. Further in NPK levels higher dose *i.e* 100:50:50 kg ha^{-1} respectively showed better in growth and quality tones. The result of present study in the agreement his the earlier researches and returns per rupees investment The influence of nitrogen fertilization of N, P and K content of fruit appeared to be due to improvement nutritional environment both in the root zone in the plant system. Thus, adequate supply of NPK early in the crop season increased the availability of nutrient to the root zone coupled with increased metabolic activity and at the cellular level probably might have increased the nutrient uptake and accumulation in the vegetative plant parts, and fruit highly nutrient contents in fruit seems to be due to higher functional activity of root for longer duration under this treatment the increased NPK in bulb also observed by Hilli *et al.*, (2009).

On the basis of the results obtained in present investigation, it may be concluded that the application of NPK either alone or in combination with organic manures enhanced the growth and yield attributes in bottle gourd. Supplementation of 5.0 tonnes vermicompost combination with NPK (100:50:50 kg ha^{-1}) enhanced growth and quality as well as returns

Table1. Effect of organic manures and different levels of NPK on growth and quality of Bottle gourd.

Treatment	Days taken to appearance of first female flower	Length of main vine (m)	No. of primary branches per vine	Length of leaf (cm) 45 days after sowing	Width of leaf (cm) 45 days after sowing	Node no. at first female flower appeared	Protein content in fruit (%)	Crude fibre content in fruit (%)	Nitrogen content in fruit (%)	Phosphorus content in fruit (%)	Potassium content in fruit (%)	Yield (q/ha)
Control	60.85	3.66	11.38	17.41	26.60	12.35	0.225	1.124	0.036	0.36	1.20	188.22
Vermicompost	59.25	4.09	11.85	18.09	27.03	11.65	0.262	1.136	0.042	0.41	1.50	242.70
Poultry manure	58.47	3.85	11.61	17.87	26.98	12.03	0.256	1.127	0.041	0.34	1.45	225.17
FYM	59.62	4.05	11.58	18.16	27.21	11.64	0.256	1.131	0.041	0.38	1.52	223.26
S.Em±	0.58	0.15	0.13	0.23	0.29	0.23	0.007	0.003	0.001	0.01	0.11	0.27
C.D. (P=0.05)	1.68	NS	NS	NS	NS	NS	NS	NS	NS	0.03	NS	0.78
Control	60.86	3.33	9.92	16.76	25.99	12.78	0.218	1.113	0.035	0.33	1.08	176.08
NPK(60:30:30)	59.97	3.79	11.74	17.57	26.84	12.28	0.243	1.131	0.039	0.40	1.19	211.96
NPK(80:40:40)	58.22	4.27	12.21	18.56	27.46	11.35	0.275	1.135	0.044	0.31	1.67	242.20
NPK(100:50:50)	58.81	4.25	12.55	18.65	27.54	11.27	0.281	0.139	0.045	0.45	1.74	249.10
S.Em±	0.58	0.15	0.13	0.23	0.29	0.23	0.007	0.003	0.001	0.01	0.11	0.27
C.D. (P=0.05)	1.61	0.45	0.38	0.68	0.83	0.68	0.021	0.009	0.003	0.03	0.33	0.78

Table 2: The cultivation cost of Bottle gourd including cost of individual treatment (ha^{-1})

Treatment	Fruit Yield (qha^{-1})	Common cost of cultivation (ha^{-1})	Treatment cost (ha^{-1})	Total cost (ha^{-1})	Gross returns (ha^{-1})	Net returns (ha^{-1})	B:C ratio
V_0F_0	134.93	49245	0	49245	107944	58699	2.19
V_2F_0	182.96	49245	10500	59745	146368	86623	2.44
V_0F_1	192.56	49245	2464.53	51709.53	154048	102338.47	2.97
V_0F_2	231.56	49245	4107.58	53352.58	185248	131895.42	3.47
V_1F_2	265.98	49245	18286.02	67531.02	212784	145252.98	3.15
V_2F_1	215.77	49245	12964.53	62209.53	172616	110406.47	2.77
V_2F_2	231.36	49245	14607.58	63852.58	185080	121227.42	2.89
V_3F_2	238.44	49245	5786.02	55031.02	190752	135720.98	3.46
V_1F_0	195.11	49245	15000	64245	156088	91843	2.42
V_3F_0	191.32	49245	2500	51745	153056	101311	2.95
V_0F_2	193.83	49245	3286.02	525331.02	155064	10253.98	2.99
V_1F_1	211.33	49245	17464.53	66709.53	169064	102354.47	2.53
V_1F_3	298.39	49245	19107.58	68352.58	238712	170359.42	3.49
V_2F_2	270.57	49245	13786.02	63031.02	216456	153424.98	3.43
V_3F_1	228.19	49245	4964.53	54209.53	182552	128342.47	3.36
V_3F_3	235.09	49245	6607.58	55852.58	188072	132919.42	3.36

Sale price of Bottle gourd @ 800.0 /q

References

Anonymous, (2010). Package and Practices of Horticultural crops in Rajasthan. Directorate of Horticulture, Pant Krishi Bhavan, Government of Rajasthan, Jaipur

Anonymous, (2015). Horticulture Statistics Division, DAC and FW. 07 Ch -07.Indd 194

Chinaswamy, K.N. and Mariakulandi, A. (1966). Influence of organic and inorganic manure on the firmness and storage life of tomato. *South Indian Hort.*, 14 : 36-42

Hilli, J.S., Vyakarnahal, B.S., Birandar D.P. and Ravi Hunje. (2009). Influence of method of trailing and fertilizer levels on seed yield of ridge gourd (*Luffa acutangula* L. Roxb). *Karnataka J. Agric. Sci.*, 22 (1) : 47-52.

Kumar, S.C.P., Krishnappa, K.S., Reddy, N.S., and Anjanappa, M. (2004). Effect of varying levels of NPK on growth and yield of ridge gourd in souther dry region of Karnataka. *Mysore Journal of Agriculture Sciences*, 38 : 4, 446-453.

Lopes, A.J., Stamford, N.P., Eiguerired, M.V.B., Burity, N.A. and ferroz, E.B. (1996). Effect of vermicompost, mineral nitrogen and mineralizing agent on nitrogen fixation and yield in cowpea. *Revista Brasileria-de-ciencia-do-Solo*, 20: 55-62.

Ouda, B. A. and Mahadeen, A.Y. (2008). Effect of fertilizers on growth, yield, yield components, quality and certain nutrient contents in broccoli (Brassica oleracea.). *Int. J. Agri. Biol.*, 10 : 627-132 .

Pillai, K.G., Devi, S.I. and Setty, T.K.P. (1985). Research Achievements of *All India Coordinated Agronomical Research Project. Fertilizer News*, 30 : 26-34.

Reddy, R., Reddy, M., Reddy, T.Y.N., Reddy, N.S. and Anjnappa, M. (1998). Effect of organic and inorganic sources of NPK on growth and yield of pea (*Pisum sativum*). *Legume Res.* 21 (1) : 57-60.

Senapati, B.K., Pani, S.C. and Kabi, A. (1985). Effect of earthworm and green manuring on paddy production in pot culture. *In. National Seminar on Current trends in soil biology*, HAU, India, 71-75.

Sharhidhara, G.B., Baravaraja, P.K., Basarajapa, R., Jayadesh, R.C. and Nandagonds, V.B. (1998). Effect of organic and inorganic fertilizer on growth, yield of byadagi chilli in water and nutrient management for sustainable production and quality of spices: Proceeding of the National Seminar Medikar, Karnataka, 59-61.

Singh, K.P and Mohan, Krishan (2007). intergrated nutrient management for sustainable production of pointed gourd (*Trichosanthes dioica* Roxb.) under Ganga diara of Bihar. *Asian Journal of Horticulture*, 2 (1) : 99-101.

Thamburaj, S. and Singh, N. (2001). Textbook of vegetables, Tuber crops and Spices Published by Directorate of Information and Publication of Agriculture ICAR, New Delhi pp 29-48.

Tomar, V.K., Bhatnagar, R.K. and Patta, R.H. (1998). Effect of vermicompost on production of brinjal and carrot. *Bhartiya Krishi Anusandhan Patrika*, 13 : 153-156.

Yadav, R.L. (2000). Response of onion (*Allium cepa* L.) cultivars to nitrogen and potassium fertilizer under semi-arid conditions of Rajasthan. Ph. D. Thesis, submitted to *Raj. Agri. Univ., Bikaner*.

Yadav, R.H. and Vijayakumari, B. (2004). Impact of vermicompost on biochemical characters of chilli (*Capsicum annum*) *J. Ecotoxicology and Environmental Monitoring*, 14 : 51-56.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Effect of cocopeat, peat moss and perllite in growing bags and trays on tomato (*Lycopersicon esculentum* Mill.)

R. H. Dahiya* and Akshaya Bhati*
Department of Agriculture Science, Jayoti Vidhyapeeth Women's University, Jaipur
(Received: 20.02.2018; Accepted: 27.04.2018)

Abstract

One of the most important things in successful vegetable transplant production is to grow strong and healthy transplants. The role of plant growing media is become important in modulating physiological responses that will eventually lead to producing high quality seedlings. Aim of this study was to evaluate tomato (*Lycopersicon esculentum* Mill.) and transplant growth in various soilless growing media. Seven growing media were formulated using peat moss and cocopeat as the organic components and perlite as the inorganic components. To facilitate interpretations, seedling height, stem diameter, number of true leaves, elative leaf chlorophyll content, stem fresh weight, stem dry weight, root fresh weight, and root dry weight of 6-week old transplant grown in different growing media were compared. The results of the study have shown that the use of different growing media highly affected growth and quality of tomato transplant.

Key Words: *Tomato, cocopeat, perlite, transplant production, soilless*

Introduction

Tomato (*Solanum lycopersicum* L.) is an important vegetable crop. It is botanically a berry fruit, it is considered vegetable for culinary purposes. The fruit is rich in lycopene, which has beneficial health effects. The plants typically grow to 1–3 meters in height and have a weak stem that often sprawls over the ground.

Soilless agriculture offer a way to overcome the shortage of the normal amount of water needed to grow plants. Agriculture without soil, in fact, historically dates back to several hundred years BC since the civilization of ancient Egyptian, the Chinese and other cultures (Prasad and Maher ,2004). Soilless media is a valuable resource in your greenhouse production management systems. It supports plant life and is a source of water, nutrients and air. Growing media supports the plant from germination to the time of transplanting. The production of container-grown vegetables plants has expanded in recent years, due to the advantages of this method with respect to direct sowing techniques or the production of seedlings in traditional nurseries (Castillo *et al.*, 2004). One method of ensuring success in vegetable production is to establish healthy and vigorous seedlings that do not deteriorate in the new environment but immediately resume their growth. Growing quality transplants offers a number of benefits, such as shorter growing season and more efficient use of land, improved crop uniformity, more accurate prediction of harvest dates, facilitating the use of a wider range of herbicides, extends the growing season, more efficient use of expensive hybrid seed. By using transplants, producers can also insure a good stand of vegetable plants without the uncertainty of direct seeding or the added cost of field thinning (Hannan, 2016).The lack of appropriate cultural practices during growing season is one of the barriers to successful vegetable production. Mistakes, which made during transplant production, are multiplied through the rest of the season and will significantly affect yield and quality. Production could be much higher than the amount above if we can reduce the losses due to poor growing media and poor seedlings. The growth medium used in vegetable transplants is a determining factor given its close correlation with plant development. Growing media influences seed germination, seedling emergence, seedling growth and quality of seedlings in a nursery (Corti *et al.* 1998; Wilson *et al.* 2001; Baiyeri ,2004; Sahin *et al.* 2005; Agbo and Omaliko, 2006).

Materials and Methods

Vegetative material

Tomato seeds (*Lycopersicon esculentum* Mill., variety Pusa Ruby was used for the experiments.Pusa Ruby is a indeterminate type tomato variety. An Early maturity (60-65 days) variety suitable for autumn, winter and spring summer.

Growing Media

Three growing media were formulated using peat moss and coconut pith as the organic components and perlite as the inorganic components.

Growing Medium Composition (ratio by volume	Growing Media
1	Peat
2	Coconut peat
3	Perlite
4	Peat + Perlite (1:1)
5	Coconpeat + Perlite (1:1)
6	Coconut coir + Perlite + Peat (1:1:1)

7 Coconut coir + Perlite + Peat (2:1:1)

The experiment was carried out at an automated and heated polycarbonate-covered Greenhouse in University Campus Farm, Jasyoti Vidhyapeeth Women's University, Jaipur. The greenhouse experiment investigated the effects growing media on tomato. Tomato seeds were sown (two-seed/cell) into 45-cell plastic trays (cell volume 75 cm^3) and poly bags filled with growing media in different ratios of growing media.

Irrigation

Irrigation of seedlings was manually performed using a sprinkler nozzle connected to a hose and performed daily or twice a day according to the environmental conditions using enough water to avoid stress in the cultivated seedlings. Seedlings were fertilized with18-18-18 N-P-K soluble fertilizer at a rate of 100 $mg.L^{-1}$ N once a week. The growth period of the seedlings in the nursery was 6 weeks, until reaching commercial transplanting size.

Fig 2. Tomato seedlings in pro-trays

Fig 3 . Six-week old tomato seedlings

Observation Determined in the Seedlings

Ten plants per treatment were randomly chosen from each replicate to determine seedling growth parameters. Plant growth measurements of the 6-week-old tomato plants included seedling height, stem diameter (measured below cotyledons), number of true leaves, relative leaf chlorophyll content with a chlorophyll meter

SPAD, leaf area using LI-3100C portable area meter . The growing medium was then separated from the roots, and plant organs (shoots and roots) were separately weighted to determine fresh weights. The samples were then dried in a forced air oven (105 °C) for 24 h and recorded as dry weights.

Results and Discussion

Seedling Height (cm)

Effect of different media on seedling height of six-week old tomato seedlings are given in Table 1. The data related to seedling height shows that the growing media number 1, 6 and 7 gave the tallest tomato seedlings. Grunert *et al.* (2008) reported that tomato plants grown in the peat rooted more easily than those grown in the peat or mineral wool but the total yield was similar for all media. The growing media number 4 gave the shortest tomato seedlings. This might due to high bulk density of the media according to Grunt *et al.* (2008).

Root Length (cm)

Effect of different media on root length of six-week old tomato seedlings is given in table 1. The results showed that the media number 7higher value that the mixture media (peat moss + perlite + cocopeat) which is 12.04 cm compared other media exception for media number 1,4,5and 6 (11.23,11.89,1.18and11.83 cm respectively). The lowest root length value was obtained from media number 2 and 3which were 9.37 and 6.85 cm respectively.

Table 1. Effects of different growing media on seed ling height (cm) and root length (cm) of six week-old tomato seedlings under the greenhouse conditions

Growing Media		Seedling Height (cm)	Root Length (cm)
1	Peat moss	8.38	11.23
2	Cocopeat	5.54	9.37
3	Perlite	6.34	6.85
4	Peat moss + Perlite (1:1)	6.07	11.89
5	Cocopeat + Perlite (1:1)	5.56	11.18
6	Peat moss + Perlite + Cocopeat (1:1:1)	6.68	11.83
7	Peat moss + Perlite + Cocopeat (2:1:1)	7.22	12.04

Leaf Number

Effects of different media on leaf number of six-week old tomato seedlings are given in table 2. The results of the study showed that media number 1 peat moss and media mixture number 7 gave highest value of the leaf number (3.84 and 3.22, respectively). The lowest root leaf number value was obtained from media number 3 which is 2.93 These results were supported by the findings of Raiz *et al.* (2008) who reported that maximum number of leaves was obtained in the media mixture. The possible reason was nutritional contribution of the treatment that produced maximum number of leaves.

Leaf Area (cm^2)

Effects of different media on leaf Area of six-week old tomato seedlings are given in table 2. The results of the study showed that media number 1 peat moss and media mixture number 7 gave highest value of the leaf number (37.65 and 38.89, respectively). Leaf area value recorded in the medium number 3was the lowest which is 25.02 cm2. This might be the reason that it doesn't hold moistures well as other growing mediums (Anonymous 2017b).

Table 2. Effects of different growing media on leaf number and leaf area (cm^2) of six week-old tomato seedlings under the greenhouse conditions

Growing Media		Leaf Number	Leaf Area (cm2)
1	Peat moss	3.84	37.65
2	Cocopeat	2.95	33.44
3	Perlite	2.93	25.02
4	Peat moss + Perlite (1:1)	3.02	29.24
5	Cocopeat + Perlite (1:1)	3.15	36.91
6	Peat moss + Perlite + Cocopeat (1:1:1)	3.15	37.00
7	Peat moss + Perlite + Cocopeat (2:1:1)	3.22	38.89

Stem Diameter (mm)

Effects of different media on stem diameter of six-week old tomato seedlings are given in table 3. The table shows that the media number 1 and 7 gave highest stem diameter values (3.21and 3.28 mm, respectively).On the other hand stem diameter value recorded in the medium number 3 was the lowest which is 1.59 mm. This might be the reason that it doesn't hold moisture as well as other growing mediums (Anonymous 2017b).

Relative Leaf Chlorophyll Content (SPAD)

Effects of different media on chlorophyll content of six-week old tomato seedlings are given in table 3. It shows that the media number 3 and 4 showed highest relative leaf chlorophyll content values (36.40 and 42.79 SPAD, respectively). On the other hand, the lowest relative leaf chlorophyll content (29.69SPAD) was obtained from the growing media number 2.

Chlorophyll level gives an indirect estimate of the nutrient status, since most of the nitrogen is incorporated to the leaf chlorophyll (Filella *et al.*, 1995; Moran *et al.*, 2000).

Shoot Fresh Weight (g)

Effects of different media on shoot fresh weight of six-week old tomato seedlings are given in table 4. The data shows that the medium numbers 1and 7 were recorded in high shoot fresh weight values (3.14 and 2.68 g, respectively). The media number 3 had the lowest value which was 2.47 g. It may be because the media 3 has low nutrient and ion exchange capacity than the other growing media, therefore would cause weak growth or severe wilting in the crop (Anonymous 2016).

Shoot Dry Weight (g)

Effects of different media on shoot dry weight of six-week old tomato seedlings are given in table 4. The data shows that the medium numbers 1 and 7 were recorded in high shoot fresh weight values (0.18 and 0.16 g, respectively).On the other hand, the lowest shoot dry weight (0.12) was obtained from the growing media number 3. It may be because the media 3 has low nutrient and ion exchange capacity than the other growing media, therefore would cause weak growth or severe wilting in the crop (Anonymous 2016).

Table 3. Effects of different growing media on stem diameter (mm) and relative leaf chlorophyll content (SPAD) of six week-old tomato seedlings under the greenhouse conditions

Growing Media		Stem Diameter (mm)	Chlorophyll (SPAD)
1	Peat moss	3.21	36.40
2	Cocopeat	2.31	29.69
3	Perlite	1.59	36.82
4	Peat moss + Perlite (1:1)	2.23	34.70
5	Cocopeat + Perlite (1:1)	2.23	31.35
6	Peat moss + Perlite + Cocopeat (1:1:1)	2.46	29.75
7	Peat moss + Perlite + Cocopeat (2:1:1)	3.28	42.79

Table 4. Effects of different growing media on shoot fresh weight (g) and shoot dry weight (g) of six week-old tomato seedlings under the greenhouse conditions

Growing Media		Shoot Fresh Weight (g)	Shoot Dry Weight (g)
1	Peat moss	3.14	0.18
2	Cocopeat	2.62	0.15
3	Perlite	2.47	0.12
4	Peat moss + Perlite (1:1)	2.56	0.14
5	Cocopeat + Perlite (1:1)	2.53	0.13
6	Peat moss + Perlite + Cocopeat (1:1:1)	2.58	0.14
7	Peat moss + Perlite + Cocopeat (2:1:1)	2.68	0.16

Root Fresh Weight (g)

Effects of different media on root fresh weight of six-week old are given in table 5which shows in media number 7 had the highest value of root fresh weight which is 1.50 g. On the other hand, the lowest the root fresh weight value was recorded for medium number 3 which is 0.81 g. This might be due to physically impact of the media on the roots (Neelam and Ishtiaq, 2001).

Root Dry Weight (g)

Effects of different media on root dry weight of six-week old tomato seedlings are given in table 5which shows in media number 7 had the highest value of root fresh weight which is 0.11 g. On the other hand, the lowest the root fresh weight value was recorded for medium number 3 which is 0.05 g. This might be due to physically impact of the media on the roots (Neelam and Ishtiaq, 2001).

It can be clear that using different growing media for cultivation of vegetable transplants is important, in particular for the first of growing stage which in this stage the plant depends on the types of media to obtain nutrients. If soil based media used vegetable transplants usually face many problems such as diseases and pests affecting their growth. In addition, utilizing variety of growing media for different plant growing will give different result as in the research illustrated that combination of peat moss + perlite + cocopeat (2:1:1) media has may be the greatest value than other media. However, Only peat moss media also has the positive impact as well. The reason is refer to many aspects one of them is water holding capacity, pH, EC and other factors such as easily be controlling with easy service.

Table 5. Effects of different growing media on root fresh weight (g) and root dry weight (g) of six week old Tomato seedlings under the greenhouse conditions

Growing Media		Root Fresh Weight (g)	Root Dry Weight (g)
1	Peat moss	1.00	0.07
2	Cocopeat	0.98	0.07
3	Perlite	0.81	0.05
4	Peat moss + Perlite (1:1)	1.15	0.08
5	Cocopeat + Perlite (1:1)	0.91	0.06
6	Peat moss + Perlite + Cocopeat (1:1:1)	0.90	0.06
7	Peat moss + Perlite + Cocopeat (2:1:1)	1.50	0.11

References

Agbo, C.U. and Omaliko, C.M. 2006. Initiation and growth of shoots of *Gongronema latifolia* Benth stem cuttings in different rooting media. *African Journal of Biotechnology*, 5(5): 425- 428

Aniel, J., Cantliffe, J. Z., Astellanos, C. and Paranjpe, A. 2007. Yield and Quality of Green house-grown Strawberries as Affected by N Level in Coco Coir and Pine Bark Media. *Proceeding of the Florida State Horticulture Society*, 120: 157-161

Anonymous. 2014. Commercial Production of Vegetable Transplants. The University of Georgia, Fort Valley State University, the U.S. *Department of Agriculture Bulletin*, 1144

Baiyeri, K.P. 2004. Evaluation of nursery media for seedling emergence and early seedling growth of two tropical tree species. Moor *Journal of Agricultural Research*. 4(1): 60- 65.

Castillo, J.E., Herrera, F., López-Bellido, R.J. and Fernández, E.J. 2004. Municipal solid waste (msw) compost as a tomato transplantmedium. *Compost Science & Utilization*, 12(1): 86-92.

Corti, C., Crippa, L., Genevini, P.L. and Centemero, M. 1998. Compost use in plant nurseries: hydrological and physicochemical characteristics. *Compost Science and Utilization*, 6(1): 35- 45

Fitella, I., Serrano, L., Serra, J. and Peñuelas, J. 1995. Evaluating wheat nitrogen status with canopy reflectance indices and discriminant analysis. *Crop Sci.*, 35(5): 1400 – 1405.

Grunert, ●., Perneel, M. and Vandaele, S. 2008. Peat-based organic grow bags as a solution to the mineral wool waste problem. *Mires and Peat*, 3: 1–5.

Hannan, J. 2016. Seasonal Notes. Iowa Produce.org e-Newsletter. February 2016, p.8

Neelam, A. and Ishtiaq, M. 2001. Response of *Eucalyptus camaldulensis* seedlings to different soil media. *Sarhad Journal of Agriculture*, 17(1): 75-79.

Prasad, M. 1997. Physical chemical and microbiological properties of coir cocopeat. *Acta Horticulture*, 40: 21–27.

Raiz, A., Arshad, M., Younis, A., Raza, A., and Hameed, M. 2008. Effect of different growing media on the growth and flowering of *Zinnia elegans* cv. Blue point. *Pakistan Journal Botany*. 40: 1579-1585.

Sahin, U., Ercisli, S., Anapali, O. and Esitken, A. 2005. Effect of pumice amendment on physical soil properties and strawberry plant growth. *Journal of Central European Agriculture*, 6(3): 361- 366.

Wilson, S.B., Stoffella, P.J. and Graetz, D.A. 2001. Use of compost as a media amendment for containerized production of two subtropical perennials. *Journal of Environmental Horticulture*, 19(1): 37-42.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Effect of different pruning date and severity on growth, yield and quality parameters of *Ber* (*Zizyphus mauritiana* Lamk) in arid condition

R. L. Bhardwaj[1], M. M. Sundria[2] and B. R. Choudhaty[3]
Agricultural Research Station, Mandor, Agriculture University, Jodhpur-342304, Rajasthan, India
1 Asstt. Professor (Horticulture), Agricultural Research Station, Mandor
2. Asstt. Professor (Entomology), Agricultural Research Station, Mandor
3. Director Research, Agriculture University, Jodhpur
E-mail: rajubhardwaj3@gmail.com

(Received: 8.8.2017, Accepted: 22.01.2018)

Abstract

The research was carried out at experimental field of Agricultural Research Station, Mandor, Jodhpur during April, 2016 to February, 2017 to evaluate the response of pruning time and severity on fruit production, quality and profitability of *Ber* cv. Gola. Six year old grafted trees of *ber* were pruned at intervals, i.e. on 30 April, 15 May, 30 May, 15 June with two pruning severity levels i.e. 30 per cent and 50 per cent removal of previous season growth. The yield improving growth parameters *viz*., comparatively less number of main shoots (21.43 plant^{-1}), maximum number of branches (240.25 plant^{-1}), minimum shoot length (117.60 cm) and girth of shoots (13.26 cm) have been markedly promoted by the 15th June pruning with 30 per cent severity than rest of the treatments. Early pruning (30 April) with highest severity (50%) has been found to increase the vegetative growth like shoot length and girth but yield has been formed inversely proportional supra-optimal level of pruning. Flowering and fruit setting was delay by 15 days in tree pruned on 15th June, which was significantly reduce flower and fruit drop. All the yield parameter and fruit yield *viz*., fruit set per cent (29.40%), fruit retention per cent (29.95%), fruit harvest per cent (8.80%), number of fruits in sq. meter^{-1} canopy of plant (165), fruit yield plant^{-1} (72.09 kg) and fruit yield ha^{-1} (200.41 q) was significantly higher in T_5 treatment. Highest economic performance *viz*., Gross return (Rs. 180368.85), net return (Rs. 134368.51) and B : C ratio (2.92) was recorded maximum in trees pruned on 15th June with 30 per cent severity whereas quality characters of fruits like highest Total Soluble Solids (15.40°Brix), lowest acidity (0.13%), high ascorbic acid (61.41 mg 100g^{-1}), highest fruit surface colour score (8.43), fruit taste score (8.20) and overall quality score of fruits (8.76) was reported in T_2 treatment. Minimum fruit fly infestation (3.93%) was reported in T_9 treatment.

Keywords: *Ber, Day After Pruning, fruit set, fruit retention, growth, shoots, taste score*

Introduction

Ber or Indian jujube (*Ziziphus mauritiana* Lamk) is indigenous to India it belongs to the family Rhamnaceae. Among the sub tropical fruits, it is one of the most common and ancient fruits of India. In last two decades area under *ber* crop is increased and farmers have adopted its commercial cultivation. It is grown extensively in the Madhy Pradesh, Rajasthan, Gujarat, Uttar Pradesh, Haryana, Bihar, Maharashtra, Punjab, Tamil Nadu and Andhra Pradesh under rainfed and irrigated conditions, in almost all the states covering an area of 0.49 million hectares with an annual production of 4.81 million tonnes and productivity of 10.0 tonnes per hectare (Anonymous, 2016). Rajasthan alone covering an area of 714.2 hectares with an annual production of 6732 tonnes and productivity of 9.42 tonnes per hectare (Anonymous, 2015). The fruits are rich in carbohydrate, vitamin C, A, B complex and minerals. Its leaves contain 5.6 per cent digestible crude protein and 49.7 per cent total digestible nutrients, making it a nutritive fodder for animals. Ripe fruits are eaten fresh and utilized in the preparation of jam, jelly, preserve and candy. Ripe fruits can be dried to prepare a product, similar to Chhuhara. *Ber* juice can be prepared from the fresh fruit and can be used for making squash. Annual pruning in *ber* is essential to induce maximum number of new healthy shoots which would bear good quality fruits. The *ber* trees being summer deciduous and are in deep dormancy during May and June and level of reserve metabolites such as carbohydrates starch and sugars is higher during this phase of dormancy. Pruning during this period led to more

growth, higher fruit set, and greater yield. However pruning done during the induction phase (April) and breaking phase (July) resulted in lower yield. Pruning is done during the hot and dry season when the tree sheds leaves and enters into dormancy.

The *ber* flowers have borne in the axil of leaves on the young growing shoots of the current year. Hence, a regular annual pruning is necessary to induce a good healthy growth which will provide maximum fruit bearing area on the tree. Pruning is an essential operation to maintain vigour of trees, fruit productivity and yield of *ber* (Singh *et al.*, 2004). It is also essential to remove the undesirable, weak, intercrossing, diseased and broken branches to avoid crowding and to encourage healthy growth for maximum fruit bearing. Moreover, annual pruning required to replace old and unproductive wood by new one, in unpruned trees, the old wood goes on accumulating every year and leads to barren centre, reduced productivity and poor fruit yield owing to shading and related problems. Therefore, in *ber* tree, it is essential practice to maintain their vigour and productivity as well as to improve the fruit size and fruit yield. The objective of pruning is to produce more number of fruits with high quality marketable fruits at a low cost. Apart from these, pruning also lead to rejuvenation, better ventilation, and higher penetration of sun light and also become feasible in application of plant protection chemicals and also reduce insect pest infestation. In last six to seven year's *ber* producer of western Rajasthan face a severe problem of flower and fruit drop due to high temperature in the month of September which coincides with the time of flowering and fruit setting. Due to high temperature acceptability duration of stigma was reduce and pollination and fertilization of flower is fail and maximum flower and fruits are dry. It is necessary to standardized date of pruning to minimize the effect of high temperature which was coinciding with the time of flowering and fruit setting. In case of unpruned tree canopy area continue to enlarge year after year, branch lets become very weak, fruit size reduced and tree ultimately become unproductive whereas in case of judiciously pruned tree vigor and shape is maintained and fruit size and quality is improved (Singh and Bal, 2008). Therefore, it is very much essential to ascertain the timing and extent of pruning in particular cultivars. Hence, keeping in the view the above, the present investigation was undertaken.

Materials and Methods

A field experiment was carried out on the six year old *ber* orchard at Agricultural Research Station, Mandor, Jodhpur (Rajasthan), India during April, 2016 to February, 2017. The soil of experimental fields were uniform in fertility, sandy loam in texture, low in organic carbon (0.75%), medium in available P (25.5 kg ha^{-1}) and high in K (270.0 kg ha^{-1}) with saturated extraction electrical conductance of 2.0 $ds.m^{-1}$ and slightly alkaline reaction (pH 8.5) during experimentation. The abiotic factors *viz.*, average minimum and maximum temperatures were 25.0°C ± 5.0°C and 40.0°C ± 5.0°C, average relative humidity of 55.0 ± 15.0 per cent and 350 mm rainfall per annum were recorded. The experiment was conducted in a completely randomized design having nine treatments comprising by different pruning time and severity *viz.*, T_1 (No pruning), T_2 (Pruning on 30th April + 30% removal of previous season growth), T_3 (Pruning on 15th May + 30% removal of previous season growth), T_4 (Pruning on 30th May + 30% removal of previous season growth), T_5 (Pruning on 15th June + 30% removal of previous season growth), T_6 (Pruning on 30th April + 50% removal of previous season growth), T_7 (Pruning on 15th May + 50% removal of previous season growth), T_8 (Pruning on 30th May + 50% removal of previous season growth), T_9 (Pruning on 15th June + 50% removal of previous season growth). All the observations were taken from 5 selected plant of each treatment throughout the investigation period at appropriate time by adopting standard method for growth, development, fruiting behaviour, yield and quality. Days taken for sprouting is calculated by couming the number of days taken for the pruned shoots to sprout, number of shoots emerged was recorded by counting the number of sprouts produced on each pruned tree, shoot burning per cent and number of branches $plant^{-1}$ calculate by simple counting method, shoot length is measured by the help of scale from base of shoot to highest tip of the shoot at the time of flower initiation, girth of primary shoots at base is recorded by counting of five randomly selected primary shoots at a marked point from base which was measured at 120 days after pruning with the help of a vernier callipers and average was calculated. Days taken to first flower initiation, flower density, number of fruits per square meter area of plant, days taken from pruning to first picking of fruit, last picking of fruits and duration of harvesting was calculated by simple counting method. Fruit set per cent, fruit retention per cent and fruit harvest per cent were recorded by following formulas:

$$\text{Fruit set per cent} = \frac{\text{Total number of fruits set plant}^{-1}}{\text{Total number of flowers plant}^{-1}} \times 100$$

$$\text{Fruit retention per cent} = \frac{\text{Total number of fruits gets maturity plant}^{-1}}{\text{Total number of fruits set plant}^{-1}\text{ (at initially stage)}} \times 100$$

$$\text{Fruit harvest per cent} = \frac{\text{Total number of harvested fruits plant}^{-1}}{\text{Total number of normal flowers plant}^{-1}} \times 100$$

The total fruit yield plant^{-1} and hectare^{-1} was calculated by weighing total marketable fruits on digital balance and average fruit yield of each plant was calculated and has been expressed in kilogram and quintal respectively. Market rate of fruits was taken from fruit market (Phal Sabji Mandi, Jodhpur) during the period harvesting (December, 2016 to February, 2017). The gross return was calculated from yield multiplied by average market rate during the period of investigation. Further, the net return was calculated by subtracting cost of each treatment from gross return. The benefit cost ratio was calculated by dividing net return to total cost of cultivation. Total soluble solids (TSS) of the fruit pulp was determined by Zeiss Hand Juice Brix Refractometer, values corrected to 20^{0}C and expressed as ^{0}Brix. Acidity (as citric acid) was determined by using standard N/10 NaOH solution in the presence of phenolphthalein as an indicator, AOAC (1984). The ascorbic acid (vitamin C) content of the juice was estimated by visual titration method with 2, 6-dichlorophenol-indonenol dye solution (AOAC, 1984). The overall quality (pulp colour, pulp: seed ratio, skin colour, size and shape of fruits), colour score and fruit taste or consumer preference of fruits was done by a panel of five semi-trained judges using 10 point hedonic scale (Amerine *et al.*, 1965). Per cent incidence of fruit fly was measured by visual inspection of five member team of crop experts at fruit harvesting. All data were subjected to analysis of variance (ANOVA) to determine significant differences followed by critical difference (CD) with in the treatment was calculated in order to compare the treatment at $P \leq 0.05$ level of significance only.

Results and Discussion

Plant growth parameters

Observations regarding number of days taken for sprouting after pruning were recorded and data thus obtained were analysed statistically it is clear from the table-1 that 50 per cent pruning of previous year shoot growth on 15th June (T_9) showed significantly earlier sprouting (21.60 days) which was *at par* with T_5 (25.4 days) and T_8 (24.7 days) treatments, whereas in control (no pruning) took relatively more number of days for sprouting (40.17 days). Number of main shoots emerged after pruning were counted and data obtained the mean values are summarized in table-1 which indicated clearly that maximum number of main shoots emerged under T_6 treatments (32.83). It was however noted that all the treatments other than control remained *at par* when compared among themselves. The number of shoots ranged from 10.63 to 32.83 under different treatments. The lowest number of main shoots was emerged under control (10.63). Shoot burning also effect significantly by time and intensity of pruning. Highest shoot burning (10.47%) was reported in T_1 treatment whereas minimum shoot burning was observed in T_5 treatment (1.23) which was significantly lower than all other treatments. It may be dne to early sprouting concurring with high temperature and hot dry wind with high velocity (10-30km h^{-1}) in the month of May and June. Length of *ber* shoots were recorded at time of flower initiation and data obtained with the mean values displayed in table-1. Treatments T_5 include significantly smaller shoots (117.6 cm) as compared to all other treatments whereas treatment T_4, T_3 and T_1 are *at par* with T_5 treatment. The highest length of shoot was reported in T_9 treatment. The mean values of *ber* shoots girth presented in table 1 that all the treatments produced significantly greater diameter of shoots when compared with control (8.33 cm) the maximum values (16.63 cm) in this regards were noted under T_2 treatment. Shoot length and diameter also appreciably increased in early pruning (30th April) with moderate severity (30%) because it cause lower inter branch competition and have sufficient time for growth before on set of reproductive phase. The days taken for sprouting, number of shoots emerged, shoot length, girth of shoots and fruit yield have been markedly promoted by the 30 per cent pruning intensity (Harit Kumar *et al.*, 2014).

Fruit yield and yield parameters

The yield and yield parameters was strongly influenced by pruning dates and severity. Pruning on 15th June and 30 per cent removal of previous season growth was more productive over the other dates of pruning and severity (Table 2). Minimum days required in flower initiation after pruning (115.4 days) was reported in T_5 treatment which was statically *at par* with T_1 treatment (121.46 days), T_4 treatment (120.30 days), T_8 treatment (117.40 days) and T_9 treatment (115.70 days) whereas maximum days required for flower initiation (137.13 days) in T_2 treatment. The flower initiation started earlier in treatments where early pruning was done. The initiation of flowering took place by 6th September where pruning was done on 1st May and flower initiation was delayed by 30th September when pruning was done on 28th July (Singh and Bal, 2008). Pruning was significantly effective for increasing the number of flower clusters/primary, secondary and tertiary branches. The maximum flower density (3123.12 sq. meter^{-1} canopy) on each type of branches were observed under pruning on 15th May with 30 per cent intensity (T_3 treatment) whereas lowest number of flowers density (1662.26 sq. meter^{-1} canopy) was reported in T_2 treatment. It was due to that flower production in *ber* mainly takes place on the secondary and tertiary shoots of optimum vigour. As 30 per cent pruning on 15th May could induce more number of both types of branches, it could thereby increase the number of flower clusters on all type of shoots. Similar types of results were reported by Singh and Bal, (2008), Harit Kumar *et al.*, (2014) in *ber*.

Maximum fruit set (29.40%), highest fruit retention (29.95%), uppermost fruit harvest (8.8%) was observed in T_5 treatment which was significantly superior from all other treatments, whereas least fruit set (15.17%), minimum fruit retention (7.46%) and lowest fruit harvest per cent (1.13) was recorded in T_1 treatment. Least

number of fruits square meter^{-1} area of plant^{-1} (20.24) was reported in T_1 treatment, whereas mean highest number of fruits square meter^{-1} area of plant^{-1} (165.0) was reported in T_5 treatment, which was significantly superior to all other treatment. Fruit set and retention increased in light pruning treatment than in severely pruned shoots and obtained higher yield by light pruning since fruit set and retention decreased with severity of the pruning. However the early pruned trees retained less fruit as compared to late pruned tree. The highest initial fruit set exhausted the trees due to coincide with high temperature thus reducing the final retention in early pruned trees. It might be due to delay pruning (15th June) of *ber* helps in delay emerging new sprouts and flower initiation which assist in avoiding coincide with high temperature of late summer months which major cause of flower and fruit drop. Similar results were also reported by Singh and Bal (2008) and Bhardwaj *et al.* (2015) in *ber*.

Minimum days required in start fruit picking after pruning (200.17 days) was reported in T_5 treatment which was statically *at par* with T_9 treatment (202.0 days), whereas maximum days required for start fruit picking after pruning (235.33 days) in T_1 treatment. Minimum days required for last fruit picking after pruning (237.0 days) was reported in T_6 treatment which was statically *at par* with all other treatments other than T_1 treatment (267.0 days). Maximum duration of fruit harvesting (39.83 days) was reported in T_5 treatment, which was *at par* with T_2 treatment (37.83 days). Minimum duration of fruit harvesting (29.83 days) was reported in T_6 treatment. The possible cause of early fruit harvesting and longer duration of fruit harvesting due to pruning of tree at proper time (15th June) with moderate severity pruning help in all over development of plant and fruits, which helps in maximise fruit retention capacity and final yield of the tree comparatively higher those required longer duration for harvesting than the lower yield produces trees. These results were also supported by Dhaliwal and Rajwant (2003) in guava, Gill and Bal (2006) in *ber*, Shaban and Haseeb (2009) in guava.

The maximum fruit yield tree^{-1} (72.09kg) and ha^{-1} (200.41q) has been achieved by employing moderate pruning (30%) intensity on 15th June which proved significantly superior over all other treatments and control. Minimum fruit yield tree^{-1} (25.35kg) and ha^{-1} (70.46q) was reported in T_1 treatment. Significantly higher fruit yield tree^{-1} and yield ha^{-1} might be attributed to increased percentage of both setting and retention of fruit, and also increase fruit harvest per cent, number of fruits square meter^{-1} area of plant, duration of harvesting with the help of 30 per cent pruning intensity on 15th June *i.e.*, all these yields attributing characters paved the way for significant improvement in fruit yield tree^{-1} of *ber*. This increment in number of fruit, size, yield and fruit quality at medium pruning level (30%) on later date (15th June) might be due to the stimulation of optimum vegetative and floral growth, which might have brought about balance between the fruiting wood and leaf area. Total yield was decreased by severe pruning. It is admitted fact that reduction in the fruit yield is due to reduction in number of the shoots which lead to the less number of fruit per tree as bearing area get reduced. Gill and Ball (2006) reported, increase in fruit size and weight might be attributed to better source-sink relationship and lesser competition for assimilates among the fruits in pruned trees. Similar observations were also obtained by Shaban and Haseeb (2009) during the study of effect pruning severity and chemical sprays on guava. Lower yield in dense pruning (50%) on 30th April, the flowering and fruit setting coincide with high temperature which cause lower pollen acceptability and higher flower and fruit drop at initial stage. Another scientific explanation for significantly increasing yield with moderate pruning (30% severity) may be because of more open tree canopy with wider leaf area resulted allowing more light penetration that led assimilation more photosynthetic materials and also less competition for the growth of individual fruit as compared to unpruned tree under optimum time of pruning (15th June) condition. The present findings are in closed agreement with earlier scientist *viz.*, (Singh *et al.*, 2004 and Khan and Syamal, 2004) who reported that medium pruning of 30 per cent produced higher yield in *ber* fruit. As pruning intensity advanced that is severe pruning (50% severity) yield was reduced. The reduction in yield which severe pruning (60%) might be due to admitted fact that reduction in number of bearing shoot results. It is in accordance with Gill and Bal (2006) who observed decreased yield by severe pruning. It is from the data that all the treatments induced significantly varying size of length of shoots when compared among themselves the lowest length of shoots were recorded under control. In case of unpruned tree canopy area continue to enlarge year after year, branch let's become very weak, fruit size reduced and tree ultimately become unproductive.

Economics

The economics of *ber* production was strongly influenced by pruning time and severity. Plant prune on 15th June with 30 per cent severity was more profitable over the other treatments (Table 3). Highest gross return (Rs. 180368.85), net return (Rs 134368.51) and benefit: cost ratio (2.92) was observed in T_5 treatment which was significantly different from all other treatments, whereas market rate of fruits was highest in T_1 treatment those ripe earlier than all other treatments. Lowest gross return (Rs. 105695.6), net return (Rs 65695.6) and benefit: cost ratio (1.64) was reported in T_1 treatment. It is fact that in case of judiciously timely pruned tree produces maximum fruit yield than other treatment which was helpful in fetch maximum gross and net return with highest benefit: cost. Possible explanation of this fact that the annual operation and judiciously pruned tree at proper time improved vigour and fruiting area, which increasing productivity, quality of fruits and ultimately increase profitability of *ber* cultivation. Similar results of *ber* tree pruning on 2nd week of June with moderate severity (25 to 35%) helps in earn more profit in *ber* production under arid condition of western Rajasthan (Bhardwaj *et al.*, 2015). The present study gets ample support from the work Gill and Ball

(2006), Singh *et al.*, (2012) and Harit Kumar *et al.*, (2014) in *ber*.

Quality parameters

Data presented in Table 4 be evidence for the pruning of *ber* tree on 15th May with 30 per cent removal of previous season growth exhibited a significant effect on the fruit quality parameter *viz.*, TSS, acidity, fruit colour, taste and overall quality score of fruits but ascorbic acid content of fruits are non significantly effect by pruning date and intensity. In the present investigation, the pruning of *ber* tree on 15th May with 30 per cent removal of previous season growth exhibited superior fruit quality and had a tendency to decrease with delay in pruning dates and increase intensity. The sweetness of *ber*, mainly assessed by TSS (total soluble solids) content and maximum TSS (15.4°Brix) was reported in T_3 treatment which was statistically *at par* with T_2 (15.29°Brix), T_4 (14.39°Brix), T_6 (14.78°Brix), T_7 (14.90°Brix), and T_8 (14.18°Brix), and rest of the treatments was significantly different and lowest TSS (11.34°Brix) was in T_1 treatment. The minimum acidity (0.13%) was observed in T_3 treatment, which was *at par* with T_2 (0.14%) and T_7 (0.14%) treatments, and rest of the treatments was significantly different and highest acidity (0.21%) was in T_1 treatment. Maximum ascorbic acid (61.41%), highest colour score of fruit (8.43), fruit taste score (8.60) and maximum overall fruit quality score (8.76) was also observed in T_3 treatment. The unpruned tree produced more fruit this is because of the reduction of shoots in pruned trees whereas fruit quality in terms of the TSS acidity and vitamin C content improved in moderately pruned tree (30%) hence the quality of the fruit improved due to pruning effects.

This might be due to the fact that *ber* tree pruning on 15th May with 30 per cent removal of previous season growth, which is positive for increased rate of photosynthesis and accumulate more dry matter in fruits which ultimately resulted in higher quality of the fruits. Moreover, lower total soluble solid in late pruned plants may be due to low temperature in favour of less conversion of sugars from starch during fruit ripening. Higher acidity (0.21) in not pruned tree (control) may be due to shade effect where sugar conversion from organic acid is hampered due to lack of sufficient light at internal part of tree. Gill and Ball (2006) reported that low intensity of pruning in *ber* improved the fruit yield and quality. They further reported that early pruning advanced bud sprouting and early harvest and improved fruit quality. The deviation in time of pruning from this phase of dormancy results in the lower yield and poor quality fruits. Similarly maximum TSS and ascorbic acid and minimum acidity were recorded in the fruit of those trees that were pruned on 30th May. (Singh and Bal, 2008). Delayed pruning is suitable for bud burst manipulation, but it may have a negative effect on grape maturation and quality due to the shorter period for ripening (Ratsep *et al.*, 2014).The present study gets ample support from the work of Harit Kumar *et al.*, (2014) in *ber* and Singh *et al.*, (2012) in peach. It is a well established fact that pruning at the right time and to the adequate extent improves the size, colour and quality of fruits by making more sun shine fall on the leaves, fruits and on a larger portion of the plant (Singh 2005). Higher and early yield of quality *ber* fruit with higher total soluble solids, lower acidity and more intense coloured fruit from early pruning might be due to increased nutrient uptake, it also encourages more flow of nutrients and water by the tree and consequently more synthesis of carbohydrates and other metabolites and their translocation to the fruit. Secondly the fruit load is also reduced with medium severity pruning at early stage. These findings are in agreement with those of Dhaliwal and Rajwant (2003) in guava, Gill and Ball (2006) in *ber*.

Occurrence of fruit fly infestation

Occurrence of fruit fly was detected in the month of September and first week of October the investigation period. The minimum infestation of fruit fly (3.93%) was observed in T_9 treatment (Pruning on 15th June + 50% removal of previous season growth), whereas maximum infestation of fruit fly (11.43%) was reported in T_1 treatment (control). Late and heave pruning delay in fruit setting and provide more open area which was significantly reduces fruit fly infestation as well as population at initial stage of fruit setting that is most prone stage of infestation. However, June month pruning with 50 per cent was found to be safer in respect to fruit fly infestation because at that time the fruit fly population and activity was very low due to low temperature and lower density of foliage. Occurrence of fruit fly infestation influenced by different pruning time and intensity was also reported by Singh and Bal (2008) in *ber*. Similarly Bhardwaj *et al.*, (2015) was also observed that, minimum infestation of fruit fly in *ber*, when tree was pruned in the month of June with high intensity (50%).

The time and severity of the pruning determines the vegetative growth, tree canopy and advances the bud sprouting, induces flowering, fruiting and quality of fruits. Low intensity of pruning improves the fruit yield and quality. The *ber* pruning on 15th June with moderate intensity (30%) gave better growth rates and development in concern to increase fruiting area and reduce shoot burning as compared to other treatment combinations. However, first flower initiation, maximum per cent fruit set, fruit retention, fruit harvest, number of fruits per plants, fruit picking duration have been markedly promoted by the tree pruning on 15th June with 30 per cent pruning intensity than rest of the treatments. The early pruning with moderate severity (15th May pruning with 30 per cent intensity) favour in advances bud sprouting and early harvest and improves fruit quality parameters such as TSS, acidity, ascorbic acid, fruit colour score, taste score and overall quality score. Maximum fruit yield plant^{-1} and ha^{-1} with highest gross return, net return and benefit: cost ratio also reported in the *ber* tree pruning on 15th June with 30 per cent pruning intensity than rest of the treatments combination. This treatment combination is much suitable for arid agro-

climatic condition of western Rajasthan but fruit fly infestation per cent was fewer in pruning on 15th June with 50 per cent pruning intensity. From over all experimental results, it is concluded that moderate severity of pruning (30% pruning on previous season growth) on 15th June has been adjudged as optimum level of pruning and time in improving yield of *ber* fruits cv. Gola. Highest severity of pruning (50%) on 15th May has been found to increase the vegetative growth but yield has been found inversely proportional supra-optimal level of pruning.

Table 1. Effect of pruning time and severity on vegetative parameter of *ber*

Treatments	Days taken for sprouting	Number of main shoot	Shoot burning %	Number of branches plant^{-1}	Shoot length (cm)	Girth of shoot (cm)	Flowers density (sq. meter^{-1} canopy of plant)
T_1	32.17	10.63	10.47	71.59	121.97	8.33	1791.15
T_2	34.97	30.73	7.37	181.97	129.27	16.63	1662.26
T_3	30.57	28.93	5.65	197.97	124.07	15.13	3123.12
T_4	27.80	25.03	2.48	225.90	120.80	14.60	2163.46
T_5	25.40	21.43	1.23	240.25	117.60	13.26	1875.00
T_6	32.50	32.83	9.53	165.50	132.60	14.90	1925.47
T_7	27.50	31.80	6.37	160.20	128.40	12.50	3021.39
T_8	24.70	28.90	4.07	195.20	137.30	12.10	2407.05
T_9	21.60	26.40	2.07	205.70	147.70	11.60	2346.28
S. Em. ±	1.646	1.53	0.222	4.342	2.947	0.289	13.78
CD at 5%	4.871	4.556	0.658	12.850	8.724	0.858	40.800

Table 2. Effect of pruning time and severity on yield and yield attributes of *ber*

Treatments	First flower initiation (DAP)	Fruit set (%)	Fruit retention (%)	Fruit harvest (%)	No of fruits sq. meter^{-1} canopy of plant	Picking of fruits		Duration of harvesting (days)
						First (DAP)	Last (DAP)	
T_1	121.46	15.17	7.46	1.13	20.24	235.33	267.00	31.67
T_2	137.13	18.27	11.60	2.12	35.24	225.33	260.00	34.67
T_3	130.83	22.07	17.43	3.85	120.24	215.33	252.00	36.67
T_4	120.30	26.80	23.30	6.24	135.00	205.17	243.00	37.83
T_5	115.40	29.40	29.95	8.80	165.00	200.17	240.00	39.83
T_6	132.50	16.40	9.85	1.61	31.00	215.17	245.00	29.83
T_7	126.50	20.59	18.14	3.74	113.00	210.00	243.00	33.00
T_8	117.40	25.10	20.37	5.11	123.00	207.00	241.00	34.00
T_9	115.70	26.60	23.24	6.18	145.00	202.00	237.00	35.00
S.Em. ±	2.541	0.845	0.541	0.251	2.912	1.302	9.913	0.976
CD at 5%	7.520	2.501	1.602	0.744	8.618	3.854	29.337	2.889

DAP- Days after pruning

Table 3. Effect of pruning time and severity on yield and yield attributes and economics of *ber*

Treatments	Yield plant^{-1} (kg)	Yield ha^{-1} (q)	Market Rate of fruits (Rs kg^{-1})	Gross Return (Rs.ha^{-1})	Net Return (Rs.ha^{-1})	B C ratio
T_1	25.35	70.46	15.00	105695.60	65695.60	1.64
T_2	33.45	92.98	14.00	130174.43	84174.43	1.80
T_3	46.55	129.40	12.00	155279.68	109279.68	2.38
T_4	63.39	176.22	10.00	176223.87	130223.53	2.83
T_5	72.09	200.41	9.00	180368.85	134368.51	2.92
T_6	35.19	97.83	14.00	136959.15	90958.81	1.98
T_7	42.90	119.25	12.00	143098.61	97097.95	2.11
T_8	52.70	146.49	10.00	146492.73	100492.07	2.18
T_9	60.10	167.07	9.00	150358.19	104357.53	2.27
S.Em. ±	**1.736**	**3.869**	**0.133**	**6117.63**	**6117.63**	**0.112**
CD at 5%	**5.140**	**11.452**	**0.395**	**18105.16**	**18105.16**	**0.332**

Table 4. Effect of pruning time and severity on quality attributes and fruit fly infestation of *ber*

Treatments	TSS of fruit °Brix	Acidity of fruits (%)	Ascorbic acid (mg 100g^{-1} plup)	Colour score of fruit (10 marks)	Fruit taste score (10 marks)	Overall score of fruits	Fruit fly infestation (%)
T_1	11.34	0.21	57.65	7.43	7.90	7.91	11.43
T_2	15.29	0.14	60.31	8.23	8.20	8.46	7.83
T_3	15.40	0.13	61.41	8.43	8.60	8.76	9.06
T_4	14.39	0.16	58.14	8.00	8.00	8.00	6.05
T_5	13.89	0.17	57.30	7.80	7.80	7.80	4.39
T_6	14.78	0.17	55.28	8.23	8.00	8.12	6.14
T_7	14.90	0.14	60.00	8.30	8.40	8.35	8.50
T_8	14.18	0.18	54.89	7.53	7.70	7.62	4.53
T_9	13.28	0.19	53.99	7.03	7.30	7.17	3.93
S.Em. ±	**0.428**	**0.006**	**1.247**	**0.088**	**0.800**	**0.162**	**0.346**
CD at 5%	**1.269**	**0.018**	**NS**	**0.263**	**0.237**	**0.480**	**1.026**

References

AOAC. 1984. Official Methods of Analysis, 12th (ed), Association of Official Agricultural Chemist. Washington, DC, USA.

Amerine, M. A., Pangbron, R. M. and Rossler, E. A. 1965. Principles of sensory evaluation of food. Academic Press, New York and London.

Anonymous, 2016. Indian Horticulture Database-2015-16, 2nd Advance estimate of area and production of horticulture crop (2016-17). Ministry of Agriculture, Government of India, Gurgaon, p5-6.

Anonymous, 2015. Agricultural Vital. Ministry of Agriculture, Government of Rajasthan, Jaipur, p29-35.

Bhardwaj, R. L., Choudhary, D. and Solanki, V. R. 2015. Bench mark survey of *ber* unfruitfulness in district Pali, Jodhpur and Sirohi. KVK, Sirohi, Agriculture University, Jodhpur, p3-6.

Dhaliwal, G. S. and Rajwant, K. 2003. Effect of time and pruning intensity on age of bearing shoot and fruit quality of 'Sardar' guava. *Haryana Journal of Horticultural Science*, 32: 21–24.

Gill, K.S. and Bal, J.S. 2006. Influence of pruning severity and time on yield and fruit quality of *ber* (*Zizyphus mauritiana* L.) cv. Umran. *Indian Journal of Horticulture*, 63(2): 162-165.

Harit Kumar, Katiyar P.N., Singh A.K., and Rajkumar, B.V. 2014. Effect of different pruning severity on growth and yield of *Ber* (*Zizyphus mauritiana* Lamk), cv. Banarsi Karaka. Int. J. Curr. Microbiol. *App. Science*, 3(5): 935-940.

Khan, M. and Syamal, M.M. 2004. Effect of pruning intensity on flowering and fruiting of Kagzi lime (*Citrus aurantifolia* Swingle). *Indian Journal Horticulture*, 61(2): 171-172.

Ratsep, R., Karp, K., Vool, E. and Tonutare, T. 2014. Effect of pruning time and method on hybrid grapevine (*vitis* sp.) 'hasanski sladki' berry maturity in a cool climate conditions. *Acta Sci. Pol. Hortorum Cultus*, 13(6): 99-112.

Shaban, A. E. A. and Haseeb, G. M. M. 2009. Effect of pruning severity and spraying some chemical substances on growth and fruiting of guava trees. American-Eurasian. *Journal of Agricultural and Environment Science*, 5: 825–31.

Singh, A., Deka, B. C., Patel, R. K., Nath, A. and Mulieh, S. R. 2012. Effect of pruning time, severity and tree aspects on harvesting period and fruit quality of low chilling peach (*Prunus persica*). *Indian Journal of Agricultural Sciences*, 82(10): 34-38.

Singh, S., Singh, B. and Singh, M. 2010. Influence of time and severity of pruning on vegetative growth, fruit quality and yield of *ber* cv. Umran. National Seminar on recent trends and development, CCS. HAU, Hissar : 57-58.

Singh, H., Bal, J.S. and Singh, G. 2004. Standardization of pruning technique in *ber*. A Review. *Indian Journal Horticulture*, 61(3): 259-260.

Singh, R. and Bal, J.S. 2008. Pruning in *ber* (*Zizyphus mauritana* Lamk.): A Review. *Agriculture Review*, 29 (1) 61-67.

Singh, S.K. (2005). Studies on pruning behavior in *Aonla* (*Embilca officinalis* Garten.) cv. NA-7 NDUAT thesis Kumarganj, Faizabad, (U.P).

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Determinants and restraints in production of snapmelon (Cucumis melo var. momordica) at large scale in hot arid regions : A study

S. R. Meena*
ICAR- Central Institute for Arid Horticulture, Bikaner-334 006 (Raj.)
*Corresponding author's E-mail: srm. extn@gmail.com
(Received: 17.04.2018, Accepted: 8.05.2018)

Abstract

The present study was conducted in Bikaner, Nagaur and Churu districts of western Rajasthan during 2013 - 15. Random method of sampling was used to make total sample size of 108 respondents (snap melon growers) for the study. Further, the selected respondents were personally contacted and interviewed one by one to assess the determinants which encourage (compel the farmers to adopt and grow snapmelon crop at large scale on their fields. Simultaneously, the factors which restrain adoption and production of snap melon crop at large scale were also collected to analyse and drawing inferences of the study. There found deteteminats which lead to encourage farmers for adoption and production of snap melon (*Cucumis melo var. momordica*) at large scale in hot arid regions of the western Rajasthan. Among such determinants major were:" low water requirement of the crop, accessibility of drought escaping local varieties, very short duration crop and easy in cultivation and harvesting, acute shortage of vegetables and substitution for dwellers, likeness of the dwellers as a food stuff and daily dietary item, useable throughout the year in the form of dehydrated products (dry slice) and easiness in preparation vegetable and other dishes, high demand in localities/ local markets/*mandies*, cheapest source of vegetables for all, long shelf life of the fresh fruits at room temperature, the snapmelon is most suitable crop in existing climatic conditions, it can grow with low soil moisture/very low rainfall, has high drought tolerant & escaping capacity, it is a important component existing cropping system, etc. On the other hand, the major restraints (constraints) which hindered the adoption and production of snap melon in hot arid regions were at large scale scarcity of water, very low and erratic rainfall, occurrence of drought very frequently, very deep and poor quality of ground water, unfamiliarity with improved production technologies, lack of viable schemes and support system, poor marketing and market intelligence system and poor extension and information system, etc.

Key words: *Snap melon, adoption of technology, Socio-psychological determinants*

Introduction

Hot arid region of the western Rajasthan covers 12 district including Bikaner, Jaisalmer, Barmer, Jodhpur, Pali, Nagur, Sikar, Jhunjhunu, Churu, Sri Ganganar, Humunangarh and Jalor. It spreads over 61 % area of Rajasthan state and characterized by an annual rainfall between 100 – 500 mm with a coefficient of variation (CV) varying from 40 – 70 %, low and erratic rainfall combined with extremes of temperature (450-500 cal/cm^2/day), low relative humidity, high sunshine and abundant solar energy leading to high rate of evapo-transpiration value ranging from 1600 to 1800 mm in eastern and western part of the region respectively. Other important characteristics of the hot arid region are hot winds with high velocity, poor soil condition, poor ground water with brackish and saline in reaction, poor vegetation, frequent occurrence of drought and frost, difficult to execute agro-techniques, difficulty in post harvest handling and marketing owning to limited and inefficient transportation and marketing facilities (Yadav and Soni, 2008) . Even in such hard and harsh climatic condition, the farmers/dwellers of the hot arid region of western Rajasthan grow several traditional cucurbitaceous vegetables for their own use and sale the surplus for earning money and livelihood security. Among such vegetables, snap melon (*Cucumis melo var. momordica*) is most favourite, most suitable and drought hardy vegetable of study areas of the hot arid region which grown at large scale, particularly during the rainy season. It belongs to family- *Cucurbitaceae*, genus- *cucmis*, species-*melo* and *var. - momordica*. It is locally known as '*phoot or photo kakadi, kakadia*. Snapmelon is a monoecious, an annual climber, its stem are generally covered with rough hairs and vines grow up to 1.5 m which spreads on the ground. The flowers of the same are small, yellow, solitary or rarely in pairs or threes. Initially, the immature fruits of the snap melon are green in colour with hairy surface and have bitterness. As soon as the fruits reach at maturity, their hairs and bitterness disappear and become smooth with relish acidic taste. There is wide variability among the shape, size, appearance and colour of the snapmelon fruits. Most of the fruits of snapmelon are cylindrical, 10-22 cm length with 18-32 cm central girth, green-yellow/reddish-

yellow/creamy-yellow or green with yellow/greens strips/pots at maturity stage. After maturity, fruits reach to over maturity stage and at this stage the fruits start to crake automatically which are locally known as *phoot*. These *phoots* are of sweet-sour in taste and eaten directly as fresh fruit very eagerly by the local peoples of the region. It is one of most liked vegetable of the hot region of the western Rajasthan where it was consumed by > 90 % dwellers/farmers of the region as fresh vegetable, *salad* as well as in different value added forms. It has high nutritional value and work as a mean of food seasoning or relish/palatability of the diet of the dwellers of the study areas. The farmers of the hot arid region of western Rajasthan adopt and produce snapmelon 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 the mixed cropping system. However, the actual detriments which leads to grow to produce snapmelon at large scale in hot arid ecosystem of western Rajasthan are not yet crystal-clear, Keeping these facts in mind, this study was under taken with the following objectives:

1. To assess the determinants (factors) which encourage the farmers for adoption and production of snapmelon at large scale in hot arid region.
2. To analyze the restraints (constraints), if any which lead to restrain the adoption and production of snap melon at large scale in hot arid regions.

Methodology

The present study was conducted in Bikaner, Nagaur and Churu districts of western Rajasthan during 2013 - 2015. Bikaner district consist of 08 block/ Tehsils (*viz.*, Bikaner, Nokha, Loonkaransar, Khajuwala, Shri Dungargarh, Kolayat, Chhattargarh, Pugal) and 1498 villages. The Nagaur district consist 12 block/Tehsils (*viz.*, Nagaur, Kheenvsar, Jayal, Merta City, Degana, Didwana, Ladnun, Parbatsar, Makrana, Kuchaman City, Nawa,Mundwa) and 1607 villages. The Churu district consist of major 06 block/Tehsils (viz., Churu, Ratangarh, Taranagar, Rajgarh, Sardarshahar, Sujangarh) and 899 villages. Two blocks from Bikaner distract (i.e. Bikaner and Sri Dungargarh), two blocks from Nagaur distract (i.e. Nagaur and Jayal), and two Block from Churu dostrict (i.e. Ratangarg and Sardarshahar) were selected purposively keeping the facts in mind like majority of the farmers of these block grow snapmelon, have good transportation facilities, approachability, etc. Thus, a total of six blocks, among all three districts of the study areas were selected for the study. With the help of secondary data available at each selected blocks' headquarters, a list of the total number of villages falling under these blocks were prepared separately before during the study. On the basis of population size, all villages fall under these blocks were categorised in three groups i.e. small, medium and big villages. Further, three villages (1 small, 1 medium and 1 big village) selected randomly from each block under study (6). Thus, a total of 18 villages were selected for the study. All snapmelon growing farmers of these selected villages were listed one by one during the study and divided in three groups i.e. small, medium and big farmers (snapmelon growers). Amongst the so selected of 18 villages, two small farmers, two medium small farmers and two big farmers were selected randomly. In this way, 6 respondents (snapmelon growers) were chosen from each category of so selected villages by using random method of sampling to make total sample size of 108 respondents (snap melon growers) for the study. Further, the selected respondents were personally contacted and interviewed one by one to assess the determinants which encourage (compel the farmers to adopt and grow snapmelon crop at large scale on their fields. Simultaneously, the factors which restrain adoption and production of snapmelon crop at large scale were also collected. To find out the rank order of different determinant of growing snapmelon, were assigned with specific score as per response of the individual respondent (farmer) as was interviewed. The first determinant was assigned with highest score and last one assigned with lowest score under different groups of the factors. To measure the factors which restrain the adoption and production of snapmelon 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 study, several determinants /factors were observed which encourage the farmers of the hot arid regions of the western Rajasthan to adopt and produce the snap melon at large scale regularly. These were grouped as economic, production and technological, socio-religious determinants and the determinants related to storage and marketing, agro-ecological aspects, etc. The major determinants responsible for large adoption and production of snapmelon in hot arid region as reported by respondents (farmers) of the study were as follows.

1. Economical determinants.

During the study, the respondents (farmers) reported several economic determinants which lead to adoption and production of snapmelon at large scale in hot arid regions western Rajasthan. The results of the study revealed that "life sustaining earning from fresh fruits of snapmelon, substantial income from dried (khelre) slice of snapmelon, plenty of land resource and family labour/manpower and low cost of cultivation with easy picking (harvesting) were major economical

determinants which encourage the farmers to grow snapmelon for large on their fields in hot arid climatic conditions which were ranked as 1st, 2nd, 3rd, and 4th by the respondents with scores 584, 504, 456 and 444, respectively as shown in Table 1.

Table 1. Economical determinants

S.No	Inspirational factors	Score (PMS* = 648)	Rank
1	Life sustaining earning from fresh fruits of snapmelon	584	1
2	Substantial income from dried (khelre) slice of snapmelon	504	2
3	Low cost of cultivation with easy picking (harvesting)	444	4
4	Low or no loss due to the attack of insects and diseases	332	5
5	Substantial income from selling of seeds	288	6
6	Plenty of land resource and family labour / manpower	456	3

*PMS = Possible Maximum Scores.

The other economical determinants found and leads to large production of snapmelon in hot arid environment of western Rajasthan were "low or no loss due to the attack of insects and diseases and substantial income from selling of seeds, etc. These results are similar to the finding of Meena, *et.al.* 2016.

2. Production and technological determinants

The other determinants which were found encouraging to e cultivate the snapmelon at large scale in hot arid regions were " low water requirement of the crop, accessibility of drought escaping local varieties, very short duration crop and easy in cultivation and harvesting" which were ranked as 1st, 2nd, 3rd, and 4th by the respondents with scores 696, 544, 506 and 468, respectively as shown in Table 2.

The other economical determinants found and leads to large production of snapmelon in hot arid environment of western Rajasthan were "high productivity of the crop, minimal land preparation requirement, high seed germination capacity, etc. Similar kin of findings were reported by Meena, *et.al.* 2009.

Table 2. Production and technological determinants

S. No.	Determinants	Score (PMS* = 756)	Rank
1	High productivity of the crop	447	5
2	Easy in cultivation & harvesting	468	4
3	Minimal land preparation requirement	412	6
4	Minimal requirement of intercultural operation	234	8
6	Accessibility of drought escaping local varieties	544	2
7	Very short duration crop	506	3
7	Low water requirement	696	1
8	High seed germination capacity	314	7

*PMS = Possible Maximum Scores.

3. Socio-psychological determinants

There were found several socio-psychological determinants during the study which inspired the farmers (respondents) to grow the snapmelon crop at large scale on their fields in different seasons. Among such determinants major were "acute shortage of vegetables and substitution for dwellers, likeness of the dwellers as a food stuff and daily dietary item, useable throughout the year in the form of dehydrated products (dry slice) and Easiness in preparation vegetable and other dishes which were ranked as 1st, 2nd, 3rd, and 4th by the respondents with scores 666, 595, 513 and 484, respectively as shown in Table 3. 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.

The other socio-psychological determinants which compelled the farmers to grow snapmelon on their fields at large scale in harsh climatic conditions of western Rajasthan as revealed during the study were "consumers were fond of its special test and flavour, has high digestive and health value, higher production viewed as high social status, etc. The similar type of the findings also reported by Singh, et.al. 2004.

Table 3. Socio-psychological determinants

S.No.	Inspirational factors	Score (PMS* = 756)	Rank
1	The likeness of the dwellers as a food stuff and daily dietary item	595	2
	Acute shortage of vegetables and substitution for dwellers	666	1
2	Consumers were fond of its special test and flavour	422	5
3	Easiness in preparation vegetable and other dishes	484	4
4	Has high digestive and health value	332	6
5	Higher production is viewed as high social status	246	7
6	Useable throughout the year in the form of dehydrated products (dry slice)	513	3

*PMS = Possible Maximum Scores.

4. Determinants related to storage and marketing aspects.

The group of determinants was related to storage and marketing aspects as revealed in table 4. The Table 4 revealed that " high demand in localities/ local markets/*mandies* (ranked 1st with score 558, the cheapest source of vegetables for all (ranked 2nd with scores 532), long shelf life of the fresh fruits at room temperature (ranked 3rd with scores 478) and easy in packing, loading-transportation-unloading (ranked 4th with scores 333) were major determinants among this group which lead to higher production of snapmelon at large scale in hot arid climatic conditions of the western Rajasthan.

Moreover, the demand of dehydrated slice (locally called *khelre*) was observed high and they have very long storage life at room temperature which also considered as determinants for large adoption and production of snapmelon in hot arid climatic conditions of western Rajasthan. The findings are in conformity of the study of Zelleke *et.al (1991) who* revealed in their study that horticultural crop production can be promoted/ increased by developing effective storage and transportation facilities, processing, marketing system, etc.

Table 4. Determinants related to storage and marketing aspects.

S.No.	Determinants	Score (PMS* = 648)	Rank
1	High demand in localities/ local markets/*mandies*	588	1
2	Easy in packing, loading-transportation-unloading	333	4
3	Cheapest source of vegetables for all	532	2
4	Long shelf life of the fresh fruits at room temperature	478	3
5	High demand of dehydrated slice (khelre) of snapmelon	292	5
6	Very long storage life of dehydrated slice (khelre) of snapmelon at room temperature	277	6

*PMS = Possible Maximum Scores .

5. Agro - ecological determinants

During the study, the respondents farmers disclosed several agro- ecological determinants wich play very important role in high adoption and growing of snapmelon at large scale in hot arid regions of the western Rajasthan. Among them major determinant factors as observed during the study were " the snapmelon is most suitable crop in existing climatic conditions, it can grow with low soil moisture/very low rainfall, has high drought tolerant & escaping capacity, it is a important component existing cropping system which were ranked as1st, 2nd , 3rd, and 4th by the respondents with scores 705, 686, 667 and 502, respectively as shown in Table 5.

Table 5. Agro - ecological determinants

S.No.	Inspirational factors	Score (PMS* = 756	Rank
1	Most suitable crop in existing climatic conditions	705	1
2	Has high drought tolerant & escaping capacity	667	3
3	Helps in soil and moisture conservation	433	5
4	Important component of existing cropping system	502	4
5	Can grow with low soil moisture/very low rainfall	686	2
6	Creates suitable micro-climate in crop fields	334	7
7	Add organic matter and increase soil fertility	298	6

*PMS = Possible Maximum scores.

The other agro-ecological determinants recorded during the study were "snapmelon crop helps in soil and moisture conservation and it cerate suitable micro-climate in crop fields Add organic matter and increase soil

fertility as were viewed by the respondents. The restraints in adoption and production of snapmelon at large scale in hot arid regions.

It is a well-known fact that the snapmelon is a tremendous crop grown in hot arid region of western Rajasthan at large scale and famers earn their livelihood by this crop. The crop is highly suitable in harsh and hard climatic condition of the region and the farmers of the region grow it easily with low investment. However, the farmers face some restraints (constraints) in successful quality production of snapmelon at large and commercial scale in the region. During the present study, the respondent farmers reported various restraints (constraints) which hinder the high adoption and production of snapmelon at large scale on their fields. The major such restraints as reported by the respondents during the study were; Scarcity of water, very low and erratic rainfall, occurrence of drought very frequently, very deep and poor quality of ground water, unfamiliarity with improved production technologies, lack of viable schemes and support system, poor marketing and market intelligence system and poor extension and information system which were ranked as 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, and 8th by the respondents with scores 988, 967, 912, 888, 756, 746, 634 and 600, respectively as reveals Table 6.

Table 6: Major restraints in adoption and production of snapmelon at large scale

S.No.	Restraining factors	Score (PMS*= 1296)	Rank
1	Scarcity of water	988	1
2	Occurrence of drought very frequenly	912	3
3	Very deep and poor quality of ground water	888	4
4	Very low and erratic rainfall	967	2
5	Lack of standardized technique of value addition	374	11
6	Comparative net income is low	488	10
7	Unfamiliarity with improved production technologies	756	5
8	Poor extension and information system	600	8
9	Lack of viable schemes and support system	746	6
10	Poor transportation and linkage system	523	9
11	Inadequate supply of electricity	311	12
12	Poor marketing and market intelligence system	634	7

*PMS= Possible maximum score.

The other restraints, observed during the study were, poor transportation and linkage system, comparative net income is low, lack of standardized technique of value addition, inadequate supply of electricity, etc which were considered responsible for low adoption and production of snapmelon in hot arid climatic conditions of the western Rajasthan. These findings are in conformity of the findings of Magray et. al., 2014.

The present study revealed that there were several economical, production and technological, socio-psychological, storage and marketing and agro-ecological determinants factors which encourages the farmers for adoption and production of snapmelon at large scale in hot arid agro-ecosystem of Western Rajasthan. During the study it was also found that the farmers face some restraints in successful quality production of snapmelon at large and commercial scale in the region. During the present study, the respondent farmers reported various restraints which hinder the high adoption and production of snapmelon at large scale. These restraint factors should be kept in mind while preparing ant research and developmental programme for large scale production of snapmelon in hot arid climatic conditions of the country. Therefore, suitable strategies and action plan should be prepared to combat the harmful restraints so that farmers can able to produce snapmelon at large scale.

References:

Magray, M. M., Jabbe, N., Chattoo, M. A., Parray, F. A., Shabir, A. and and Kirmani., S.N. (2014) Various problems of dryland agriculture and suggested agro-techniques suitable for dryland vegetable production. *Int. Jour. of App. Sc. and Eng.*, 2(2): 45-57.

Maini, S. B. (1997). Valueaddition to horticultural wastes. *Indian Horticulture*, 42 (2): 73-78

Meena, S. R. Singh, R. S., Sharma, B. D. and Singh, D. (2016). Most favourite traditional cucurbitaceous vegetables and their utilization pattern in Thar desert of the western Rajasthan, India. *Indian Journal of Traditional Knowledge*, 15(3) : 385-394

Meena, S. R., More, T. A., Singh, D. and and Sinfg, I. S. (2009) . Arid Vegetable Production Potential and Income Generation. *Indian Res. J Ext. Edu.*, 9 (2): 72-75

Singh, J.P., Beniwal, R.K. and Yadava, N.D. (2004). Ethnobotanical importance of cucurbits in India. In Advances in Arid Horticulture: Present Status (Eds. P.L. Saroj, B.B. Vashishtha and D.G. Dhandhar). Vol. I, pp. 203-219. International Book Distributing Co., Lucknow.

Yadav N.D. & Soni M.L. (2008). Integration of horticulturul crops into farming system in hot arid zone of western Rajasthan. In: Hi-tech Production of Arid Horticulture, edited by More TA *et al.*, PP 367-371.

Zelleke,A., Mamiam, B. G., Jager, A., de (ed.) ; Verhaegh, A. P. (ed.) (1991).Role of research for agricultural development in Ethiopia. *Acta Horticulture*, 270: 189-196.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Biology and morphomatrics of lemon butterfly *Papilio demoleus* (Lepidoptera: Papilionidae) on bael, *Aegle marmelos* in Arid Region of Rajasthan

S. M. Haldhar *
Central Institute for Arid Horticulture, Bikaner, Rajasthan-334006
*Corresponding author's e-mail: haldhar80@gmail.com

Abstract

Biology and morphomatrics studies of lemon butterfly, *Papilio demoleus* L. were carried out on bael. Adult female laid eggs singly on the under surface of tender leaves and also on tender twigs. The pooled mean duration of the different stages of lemon butterfly *viz*., the incubation period of 2.80 days, larval period of 9.23 days, pre-pupal period of 0.99 days, pupal period of 8.11 days, female adult longevity period of 6.95 days and male longevity period of 3.85 days respectively. The average length, width and wing expanse of male butterfly were found to be 27.961 mm, 5.997 mm and 88.518 mm while female butterfly was found to be 29.015 mm, 6.327 mm and 91.072 mm, respectively. The morphometric variations of different life stages of the citrus butterfly have been recorded.

Key words: *Papilio demoleus*, *Aegle marmelos*, biology, morphomatrics.

Introduction

Bael (*Aegle marmelos* Correa) belongs to family Rutaceae is an important indigenous fruit crop to dry forest in hills, plains of central and southern parts as well as arid and semi arid regions of India. It also called as Bengal quince or Indian quince. Fruits are famous for its medicinal values as well as edible fruit quality. The different parts of bael are used for various therapeutic purposes, such as for treatment of asthma, anaemia, fractures, healing of wounds, swollen joints and diarrhoea. The unripe dried fruit of bael is astringent, digestive, stomachic and dysentery. Sweet drink prepared from the pulp of fruits produce a soothing effect on the patients who have just recovered from bacillary dysentery. The *bael* is gaining popularity among the farmers of arid and semi arid areas for economic cultivation. However, the quality of fruits and productivity is not obtained up to the standard (Samadia and Haldhar, 2017).

One of the reasons for it is infestation of insect-pests on the vegetative as well as developing fruits which ultimately leads to significant yield loss and quality attributes of the fruits. About 30 species of insect and mites have been reported feeding on *bael* in India (Lakra, 2004). Various types of insect-pests are found to be infesting bael in which *P. demoleus* is major one which defoliate the plant. Pathak and Rizvi (2002) reported that the *P. demoleus* is a serious citrus pest in India. Among various insects of bael lemon butterfly commonly known as the lime or citrus swallowtail, has a successful dispersal and becoming a major pest of citrus plants throughout Asia. The infestation of *P. demoleus* appeared from August to February. The highest egg, larval population and plant infestation were observed 12.75, 6.15/ 10 branches and 65.0 %, respectively. The relationship between lemon butterfly egg, larval population and maximum temperature was negatively correlated whereas the maximum relative humidity was positively in arid region (Haldhar *et al.*, 2010). *P. demoleus* feeds on the foliage of citrus trees and is regarded as a major citrus pest especially in nurseries the larval forms cause serious damage to citrus family by devouring large quantity of foliage during the later stages of their development. The biology and developmental period is mainly dependant on the climate, location and plant species on it feeding. The defoliation was observed 83 per cent in sweet oranges grown in the Southern zone of Andhra Pradesh (Narayanamma *et al.*, 2001). Severe infestation results in defoliation of the tree and leads to retarding of plant growth and decreases fruit yield. Keeping in view its economic importance, the study has been carried out for biology and morphomatics of lemon butterfly, *P. demoleus* on bael to develop a tool for eco-friendly management.

Materials and methods

The larval populations of lemon butterfly were collected on bael plants from entomological experimental field of ICAR-Central Institute for Arid Horticulture, Bikaner (N 28° 06' E 73° 21') situated in western parts of Rajasthan and brought to entomology laboratory to study the biology and morphomatric of lemon butterfly. The biology of lemon butterfly on bael was studied during September to November of 2015-16 and 2016-17 in the entomology laboratory by collecting fifth instar larvae regularly from the bael plants from entomological experimental field. The larvae were reared in glass jars by providing fresh bael leaves daily. The male and female adults obtained were released in cages for egg laying. The adult moths were provided with 10 per cent honey solution in cotton swabs that were left suspended in the

cages throughout the period of egg laying in which tender bael twigs were placed in conical flasks containing water. The twigs were changed after one day. The eggs were transferred to petridishes containing fresh tender leaves in petridishes at room temperature (28±2°C). A moistened filter paper was kept in each petriplate to prevent the drying of leaves. The caterpillars were maintained in petridishes upto third instar. Later on they were transferred and reared in separate glass troughs and allowed to complete first generation.

Ten samples (egg, larval stages, pupa and adult) were used for observation and measurements. The larvae were reared under laboratory condition for measurement of different stages. The average linear measurements of various body parts of male and female butterfly were obtained under a stereo binoculars microscope (Radical Instruments, Ambala, Haryana, India) using Jenoptic Pro 2.8.0 software. The terminology used to denote different parts of the body of the butterfly (Haldhar, 2012; Haldhar and Singh, 2014; Haldhar *et al.*, 2015, Haldhar *et al.*, 2016). Transformations were used as necessary to achieve normality in the data before analysis. The data on biology and morphomatrics of lemon butterfly were analyzed through one-way ANOVA using SPSS software. The standard error of the mean was calculated by this formula $\frac{s}{\sqrt{n}}$ where, 's' is the sample standard deviation and 'n' is the size (number of observations) of the sample.

Results and discussion

The field experiments were conducted during 2015-16 and 2016-17 with bael (*Aegle marmelos*) to determine the biology and morphomatrics studies of lemon butterfly, *Papilio demoleus* L. On the basis of pooled data of 2015-16 and 2016-17, adult female laid eggs singly on the under surface of tender leaves and also on tender twigs by curling its abdomen. The freshly laid eggs measured 0.91 mm to 1.04 mm with an average of 0.98 mm and smooth, spherical creamy yellow in colour and they turned to grayish with brown streaks all over the chorion before hatching. Incubation period ranged from 2.38 to 3.25 days. There were only five larval instars which the average duration of first to fifth instars were 2.21, 1.03, 1.55, 1.93 and 2.51 days respectively. Newly hatched caterpillars were less spiny, cylindrical in shape, light brown to brownish black in colour with thorax thicker than rest of the body having dirty white mark on dorsal side showing resemblance to birds excreta (Table 1, 2, 3 & 4). Resham *et al.* (1986), Singh and Gangwar (1989), Radke and Kandalkar (1989) and Ramakrishna Rao (2015) reported that the incubation periods varying from 3-7 days, 4-7 days, 5days and 2.90 days, respectively. The difference in the incubation period was due to variations in the weather factors of different regions.

`The first instar larva recorded an average length and width of 5.56 mm and 1.55 mm respectively. The average duration of first instar larva was 2.21 days with range of 1. 63 to 3.13 days. The second instar larvae were less spiny and dark brown in colour with a dirty white line present obliquely along lateral sides of the abdomen and with a break on the dorsal side. The average size of the second instar larvae in length and width was found to be 9.05 mm and 2.71 mm, respectively. The average second instar larval period was found to be 1.03 days with a range of 0.75 to 1.38 days. Third instar larvae were resembled the second instar larvae except in size. Third instar larvae was recorded an average length and width of 13.25 mm and 3.659 mm, respectively. The average third instar larval period was 1.55 days with rage of 1.25 to 1.88 days. The fourth instar larvae were black in colour with a little greenish tinge and whitish bands could be seen on meso and meta thoracic segments laterally, anterior part of abdomen and on last anal segments. The average fourth instar larval period was found to be 26.56 mm in length and 5.74 mm in width. The average fourth instar larval period was found to be 1.93 days with a range of 1.63 to 2.25 days. Fifth instar larva were yellowish green or green in colour. The average length and width of the fifth instar larva was found to be 42.86 mm and 5.74 mm respectively. The average duration of fifth instar larva was 2.51 days (Table 1, 2, 3 & 4). The results of the present investigation are also comparable with Madansuri *et al.* (1979) who recorded the mean head capsule width of first, second, third, fourth and fifth instars of *P. demoleus* as 0.61, 0.95, 1.49, 2.33 and 3.64 mm respectively. Sharif et al. (1989) recorded the durations for egg, larva and pupal stages as 3.24, 18.24 and 11.7 days respectively and the butterfly had four generations in a year with a life cycle of 33.19 days and similarly Jahnavi *et al.* (2018) recorded duration of total larval period varied from 17.16 to 17.66 days with an average of 17.53 days on acid lime.

Before changing to pre-pupa the caterpillar shrunk in side and it hangs from the twig with the help of a silken girdle. The pre-pupal period was observed to be 0.75 to 1.25 days with an average of 0.99 days. Pupae were naked and varied in colour from green, straw to brown majority being green in colour with several black markings on the body. The average length and width of the pupal period was found to be 30.48 mm and 8.88 mm, respectively. The duration of the pupal period was observed to be 7.38 days and 8.50 days with an average of 8.11 days. Adult butterflies were large and beautiful with wide wing spread. Head, thorax and legs were black with creamy yellow streaks on either side, whole abdomen. The average length, width and wing expanse of male butterfly were found to be 27.96 mm, 6.00 mm and 88.52 mm while female butterfly was found to be 29.02 mm, 6.33 mm and 91.07 mm, respectively. The female adults were lived longer than the male adult. The longevity of male and female was 3.38 to 4.25 and 6.38 to 7.38 days with an average of 3.85 and 6.95 days when provided with dilute honey as a food (Table 1, 2, 3, 4 & Plate 1). The variation in adult longevity was in agreement with the findings of Ramakrishna Rao (2015) and Jahnavi *et al.* (2018). Singh and Gangwar (1989) reported the longevity female and male was 5.80 and 5.10 days. Smith *et al.* (2008) studied the taxonomy and morphological characters of 5 species of *P. demoleus*, *P. demodocus*, *P. erithonioides*, *P. grosesmithi*, and *P. morondavana* based

on features of the wings, male and female genitalia. The results revealed that the tail on hind wing vein M3 is rudimentary or very short, less than twice as long as those of neighbouring veins in *P. demoleus*.

References

Haldhar, S.M. 2012. Report of *Homoeocerus variabilis* (Hemiptera: Coreidae) on khejri (*Prosopis cineraria*) in Rajasthan, India: incidence and morphometric analysis. *Florida Entomologist*, 95: 848-853.

Haldhar, S.M., and Singh, R.S. 2014. Report of *Dictyla cheriani* Drake (Hemiptera: Tingidae) on Indian Cherry (*Cordia myxa L.*) in Rajasthan, India: incidence and morphometric analysis. *Indian Journal of Agriculture Sciences*, 84: 128–130.

Haldhar, S.M., Bhargava, R., Singh, R.S., Krishna, H. and Sharma, S.K. 2015. First Report of *Colotis amata* (Lepidoptera: Pieridae) on *Salvadora persica* (Capparales: Salvadoraceae) in Rajasthan, India: Incidence and Morphometric Analysis. *Florida Entomologist*, 98(2):442-445.

Haldhar, S.M., Karuppaiah, V., Sharma, S.K. and Singh, R. S. 2010. Population dynamics of lemon butterfly (*Papilio demoleus*) in bael (*Aegle marmelos*) as influenced by abiotic factors in arid region of Rajasthan. *Indian Journal of Arid Horticulture*, 5 (1-2): 50-52.

Haldhar, S.M., Behere, G.T., Bhargava, R., Singh, R.S., Krishna, H., Jat, G.L. and Singh, D. 2016. Observations on the pioneer white butterfly, *Belenois aurota* (Lepidoptera: Pieridae) in ker (*Capparis decidua*) plant in arid region of India. *Indian Journal of Arid Horticulture*, 11:108-112.

Jahnavi, M., Ramakrishna Rao, A. and Sarada, G. 2018. Biology and morphology of citrus butterfly *Papilio demoleus* Linnaeus (Lepidoptera: Papilionidae) on acid lime. *Journal of Entomology and Zoology Studies*, 6(1): 1556-1561.

Lakra, R.A. 2004. Insect pests of fruits of arid and semi arid regions of India. In *pest management in horticultural crops* (ed. Verma, L. R., Verma, A.K. and Gaudam, D. C.). Vedams Books Pvt. Ltd., Delhi. Pp 544.

Madansuri, A.N., Pawar, V.M. and Suryawanshi, D.S. 1979. Width of head capsule of *P. demoleus* L. *Research Bulletin Marathawada Agricultural University*, 3(10):130.

Narayanamma, V.L., Savithri, P. and Rao R. 2001. Influence of citrus butterfly Papilio demoleus L. Damage on growth parameters of the sweet orange host plant. *Indian Journal of Plant Protection*, 29:140-141.

Pathak, K.N. and Rizvi, P.Q. 2002. Age specific life table of *Papilio demoleus* on different hosts. *Annals of Plant Protection Sciences*, 10: 375-376.

Radke, S.G. and Kandalkar, H.G. 1989. Observations on the lemon butterfly, *Papilio demoleus* Linnaeous (Lepidoptera: Papilionidae) *PKV Research Journal*, 13(2):176-177.

Ramakrishna Rao, A. 2015. Studies on biology and morphometrics of citrus butterfly *Papilio demoleus* (Linnaeus) (Lepidoptera: Papilionidae) on sathgudi wweet orange *Citrus sinensis* Swingle. *International Journal of Current Research in Life Sciences*, 4 (3): 168-171.

Resham, B., Fanindra, P.N. and Butani, D.K. 1986. Insect pests of citrus in Nepal and their control. *Pestology*, 10(4): 24-27.

Samadia, D.K. and Haldhar, S.M. 2017. Breeding strategies and scope of improvement in arid zone fruit crop-plants under abiotic stressed agro-climate: an analysis. *Journal of Agriculture and Ecology*, 4: 1-13.

Sharifi, S. and Zarea, N. 1989. Biology of the citrus Butterfly, *P. demoleus* (Lepidoptera: Papilionidae). *Annals of the Entomological Society of America*, 63(5):1211-1213.

Singh, Y.P. and Gangwar, S.K. 1989. Biology of the lemon butterfly (*Papilio demoleus* Linn.) on Khasi mandarin and its development on citrus cultivars. *Journal of Andaman Science Association*, 5(2):151-153.

Smith, C.R., Wright, R.I. 2008. Classification, nomenclature and identification of lime swallowtail butterflies: a post-cladistic analysis (Lepidoptera: Papilionidae). *Systematics and Biodiversity*, 6(2):175-203.

Table 1 Biology of different life stages of the lemon butter fly, *Papilio demoleus* in 2015-16

S. No.	Life stages	Duration in days				
		Minimum	Maximum	Mean	SD	SEm
1	Incubation period	2.250	3.250	2.750	0.312	0.099
2	1st instar larva	1.500	3.000	2.150	0.444	0.141
3	2nd instar larva	0.750	1.250	0.975	0.219	0.069
4	3rd instar larva	1.250	1.750	1.500	0.204	0.065
5	4th instar larva	1.750	2.250	1.900	0.175	0.055
6	5th instar larva	2.250	2.750	2.475	0.219	0.069
7	Pre-pupal period	0.750	1.250	0.950	0.197	0.062
8	Pupal period	7.500	8.500	8.050	0.329	0.104
9	Male adult longevity	3.250	4.250	3.800	0.307	0.097
10	Female adult longevity	6.250	7.250	6.900	0.337	0.107

Mean of ten samples

Table 2 Biology of different life stages of the lemon butter fly, *Papilio demoleus* in 2015-16

S. No.	Life stages	Duration in days				
		Minimum	Maximum	Mean	SD	SEm
1	Incubation period	2.50	3.50	2.85	0.34	0.11
2	1st instar larva	1.75	3.25	2.28	0.46	0.15
3	2nd instar larva	0.75	1.50	1.08	0.29	0.09
4	3rd instar larva	1.25	2.00	1.60	0.27	0.09
5	4th instar larva	1.50	2.50	1.95	0.28	0.09
6	5th instar larva	2.25	3.00	2.55	0.28	0.09
7	Pre-pupal period	0.75	1.50	1.03	0.25	0.08
8	Pupal period	7.25	8.25	8.18	0.41	0.13
9	Male adult longevity	3.50	4.50	3.90	0.32	0.10
10	Female adult longevity	6.50	7.50	7.00	0.33	0.11

Mean of ten samples

Table 3 Pooled data of biology of different life stages of the lemon butter fly, *Papilio demoleus* in 2015-16 and 2016-17

S. No.	Life stages	Duration in days				
		Minimum	Maximum	Mean	SD	SEm
1	Incubation period	2.38	3.25	2.80	0.31	0.10
2	1st instar larva	1.63	3.13	2.21	0.45	0.14
3	2nd instar larva	0.75	1.38	1.03	0.25	0.08
4	3rd instar larva	1.25	1.88	1.55	0.23	0.07
5	4th instar larva	1.63	2.25	1.93	0.21	0.07
6	5th instar larva	2.25	2.75	2.51	0.23	0.07
7	Pre-pupal period	0.75	1.25	0.99	0.21	0.07
8	Pupal period	7.38	8.50	8.11	0.35	0.11
9	Male adult longevity	3.38	4.25	3.85	0.30	0.10
10	Female adult longevity	6.38	7.38	6.95	0.33	0.10

Mean of ten samples

Table 4 Linear morphometric measurements of different life stages of the lemon butter fly, *Papilio demoleus*

S. No.	Life stages	Measurement in 'mm'				
		Minimum	Maximum	Mean	SD	SEm
	Egg diameter	0.91	1.04	0.98	0.04	0.013
	Length of 1st instar larva	4.78	6.91	5.56	0.63	0.199
	Width of 1st instar larva	1.47	1.65	1.55	0.07	0.021
	Length of 2nd instar larva	8.45	9.78	9.05	0.51	0.161
	Width of 2nd instar larva	2.44	3.01	2.71	0.20	0.063
	Length of 3rd instar larva	12.05	14.89	13.25	0.84	0.266
	Width of 3rd instar larva	3.12	4.01	3.65	0.27	0.085
	Length of 4th instar larva	24.59	27.89	26.56	1.06	0.334
	Width of 4th instar larva	5.45	6.02	5.74	0.15	0.049
	Lengthof 5th instar larva	40.15	45.78	42.86	1.95	0.616
	Width of 5th instar larva	6.52	7.14	6.78	0.22	0.068
	Length of pupa	29.58	31.25	30.47	0.55	0.175
	Width of pupa	8.45	9.25	8.88	0.21	0.066
	Length of adult male	25.36	29.68	27.96	1.24	0.392
	Width of adult male	5.88	6.12	5.10	0.09	0.028
	Width of adult male with wing expanse	86.99	90.25	88.52	1.17	0.369
	Length of adult female	27.28	30.89	29.02	1.08	0.342
	Width of adult female	6.01	6.55	6.33	0.19	0.060
	Width of adult female with wing expanse	88.97	93.58	91.07	1.62	0.511

Mean of ten samples

Plate 1 Different life stages of the lemon butter fly, *Papilio demoleus* on bael

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Impact of Front Line Demonstrations on productivity of Chilli (*Capsicum annum* L.) cv. GVC 121 in Panchmahals district of central Gujarat

Raj Kumar [1], A. K. Rai, [1] S. Khajuria[1] and K. Lata[2]
ICAR-Krishi Vigyan Kendra-Panchmahals, (ICAR-CIAH)
Godhra-Vadodara High way Vejalpur, Gujarat 389 340
[1]SMS, KVK-Panchmahal
[2] Head, KVK-Panchmahal
E-mail: rajhortches@gmail.com
(Received: 15.11.2017, Accepted: 19.03.2018)

Abstract

Chilli (*Capsicum annum* L.) is one of the most important vegetable crops of the country and used as a spice. The development of the agriculture primarily depends on the application of the science and technology by making the best use of available resources. One of the major constraints of traditional chilli farming is low productivity due to non-adoption of recommended improved production technologies. To overcome these constraints, KVK-Panchmahals was conducted Front Line Demonstrations at various farmers fields to show the difference between improved production technology and existing technology. During the study period, it was observed that in front line demonstrations, the improved Chilli variety Gujarat Vegetable Chilli-121 recorded the higher average yield (95.60 q/ ha) as compared to local check cv. G-4 (70.30 q/ ha). The per cent (35.98) increase in the yield over local check was recorded. The technology gap (25.30 q/ha) and the technology index values (26.46%) were recorded. It is concluded that wide gap existed in potential and demonstration yield in high yielding chilli varieties due to technology and extension gap in Panchmahals district of Gujarat. By conducting front line demonstrations of proven technologies, yield potential of chilli can be increased to a great extent. It is not only increasing the income but also livelihood of the farming community.

Key words: *FLD (front line demonstrations), local check (G-4), chilli, technology, yield*

Introduction

Chilli (*Capsicum annum* L.) also known as hot pepper was introduced in India from Brazil in 16th century by Portuguese and it is one of the most important vegetable crop of the country and used in culinary adding flavor, colour, vitamins and pungency (Thamburaj and Singh, 2001). It is widely used in preparation of curry powder, curry paste and all kinds of pickles and preparing sauces, soups, salad etc. The total area, production and productivity of chilli in India is 8.45 lakh ha, 21.26 MT and 2.51 MT/ha, respectively. In Gujarat, area, production and productivity of chilli is 43.40 (000 ha), 68.53 MT and 1.57 MT, respectively (Anonymous, 2016).

In Panchmahals district of Gujarat Chilli is one of the most important vegetable crops. The area and production of chilli of the district are 2211 ha and 2260.65 M.T (Anonymous, 2016).

The Gujarat Vegetable Chilli -121 is one of the most important variety of the area. A field trial was carried out at ten farmer's field at Panchmahals district of Gujarat under front line demonstration during 2009-2010. It can be grown throughout the year with ensure irrigation facility, havever, the large numbers of farmers grow chilli during season. The climatic conditions of the Panchmahals district of Gujarat is characterized as hot semi-arid ecosystem.

The main objective of Front Line Demonstrations (FLD) are popularizing the good Agriculture practices (GAP) like as high yielding varieties, seed treatment, spacing, integrated nutrient management (INM), integrated pest and disease management etc among the farmers. It is also involve in organizing extension programmes (field day) for horizontal disseminating the technologies. FLD is playing a very important role in proper transfer of technologies and changing scientific temperament of the farmers.

Generally, the agricultural technology is not accepted by the farmers completely in all respects. As such there always appears to be a gap between the recommended technology by the scientist and its modified form at the farmer's level. The technological gap is thus the major problem in the efforts of increasing agricultural prodnction in the country. A need of the day is to rednce the technological gap between the agricultural technology recommended by the scientist or researcher and its acceptance by the farmers on their field. In view of the above factors, frontline demonstrations were undertaken in a systematic manner on farmers' field to show the

worth of a new technology and convince the farmers to adopt the same.

Materials and Methods

The present study was conducted in Panchmahals district of Gujarat during 2009-10. The genuine or truthfully labeled seeds of chilli cv. Gujarat Vegetable Chilli -121 (GVC 121) was procured from Anand Agricultural University, Anand (Gujarat). The healthy seedlings were raised under keen supervision of KVK experts at farm and distributed to ten selected farmers of various villages *viz.* Ghoda, Manipur, Bhalania, Richhiya and Sureli under FLD programme. All the participating farmers were trained on various aspects of chilli production technologies. The field was prepared by one deep ploughing during May and two harrowing before transplanting. A one fifth area was also devoted to grow local check (cv. G-4). All the recommended practices *i.e.* seed treatment, spacing, recommended dose of manure and fertilizers, weed management, insect pest management have been adopted by the farmers in both treatments G-4 as local check and Gujarat Vegetable Chilli -121). The data related to cost of cultivation, production, productivity, gross return and net return were collected in both treatments time to time from all participating farmers. An average of cost of cultivation yield, net returns of different farmers was analyzed by the formula.

$$\text{Average} = \frac{(F1 + F2 \ldots \ldots \ldots \ldots Fn)}{N}$$

Fl = Farmer

N=No. of farmers (10)

In the present study, technology index was operationally defined as the technical feasibility obtained due to implementation of Front Line Demonstrations in Chilli. To estimate the technology gap, extension gap and technology index following formula used by Samui *et al.* (2000) have been used:

Technology gap = Pi (Potential yield) - Di (Demonstration yield)

Extension gap = Di (Demonstration Yield) - Fi (Farmers yield)

$$\text{Technology index} = \frac{\text{Potential yield} - \text{Demonstration yield}}{\text{Potential yield}} \times 100$$

Result and Discussion

Performance of FLD

A compression of productivity levels between demonstrated variety and local check (G-4) is shown in table-1. During the period of study, it was recorded that in front line demonstrations, the improved chilli cv. GVC 121 recorded the higher average yield (95.60 q/ ha) as compared to local check (70.30 q/ ha). The per cent increase in the yield over G-4 was 35.98. It is clear from the study that the performance of improved variety was found better than the local check under same management and environment conditions. Similar yield enhancement in different crops in front line demonstration has been documented by Kumar *et al.* (2014) in okra, Hiremath *et al.* (2007) in onion and Mishra *et al.* (2009) in potato. The farmers were motivated by results of agro technologies applied in the FLDs trials and it is expected that they would adopt these technologies in the coming years.

Technology gap

The technology gap shows the demonstration yield over potential yield and it was 25.30 q/ ha. The Front Line Demonstration was laid down under the keen supervision of KVK Specialist at the farmer's field. There exist a gap between the potential yield and demonstration yield. This may be due to the soil fertility and weather conditions. Hence location specific recommendations are necessary to bridge the gap. These findings are in line as reported by Samui *et al.* (2000) in ground nut and Sharma and Sharma (2004) in oilseeds.

Technology index

Technology index shows the feasibility of the production technology at the farmer's field. The lower the value of technology index more is the feasibility. Result of study depiction in Table- 1, revealed that the technology index values were 26.46 The results of the present study are in consonance with the findings of Kumar *et al.* (2014) in okra, reported 9.10 q/ha. The similar findings are also reported by Singh *et al.* (2007), Hiremath and Nagaraju (2009) in onion .

Table 1. Yield, technology gap and technology index of demonstration

Variables	Yield (q/ ha)	Increase (%) over Local check (G-4)	Technology gap- (q/ ha)	Technology index (%)
Local check (G-4)	70.30	-	-	-
Demonstration (GVC-121)	95.60	35.98	25.30	26.46

Economics of frontline demonstrations

The economics of chilli cultivation under front line demonstration was caculated and the results of the study have been presented in Table- 2. The front line demonstration recorded higher gross returns (Rs. 53200 / ha) and net return (Rs. 27700 /ha) with higher cost benefit ratio (2.08) as compared to local check (gross return 42500, net return 18500 and cost benefit ratio 1.77).

These results are in accordance with the findings of Kumar *et al.* (2014) in okra, Hiremath *et al.* (2007) in onion and Hiremath and Nagaraju (2009) in onion. Further, additional cost of Rs.1500 per hectare in demonstration has increased additional net returns Rs. 10700 per hectare with incremental benefit cost ratio 6.13 suggesting its higher profitability and economic viability of the demonstration. More and less similar results were also reported by Hiremath and Nagaraju (2009) in onion.

Table 2. Economics of frontline demonstrations

Variables	Cost of cultivation (Rs/ ha)	Gross return (Rs/ ha)	Net return (Rs ha)	Benefit: cost ratio
Local check	24000	42500	18500	1.77
Demonstration	25500	53200	27700	2.08
Additional in demonstration	1500	10700	9200	6.13*

* Incremental benefit cost ratio

The findings of the study revealed that wide gap existed in potential and demonstration yield in high yielding chilli variety due to technology and extension gap in Panchmahals district of Gujarat. By conducting front line demonstrations of proven technologies, yield potential of chilli can be increased to a great extent. This will substantially increase the income as well as the livelihood of the farming community.

References

Anonymous, (2016). Gujarat, State Government Report pp.27.

Anonymous, (2016). Indian Horticulture Database-2012. NHB, Ministry of Agriculture, Government of India.

Hiremath S M and Nagaraju M V. (2009). Evaluation of front line demonstration trials on onion in Haveri district of Karnataka. *Karnataka J Agric. Sci.*, 22(5): 1092-1093.

Hiremath, S. M., Nagaraju, M. V. and Shashidhar, K. K. (2007). Impact of front line demonstrations on onion productivity in farmers field. Paper presented In: *Nation Sem Appropriate Extn Strat Manag Rural Resources*. Univ. Agric. Sci., Dharwad, December 18-20, p. 100.

Mishra, D. K., Paliwal, D. K., Tailor, R. S. and Deshwal, A. K. (2009). Impact of Frontline Demonstrations on Yield Enhancement of Potato. *Indian Res J Ext Edu*, 9(3): 26-28.

Kumar, R., Khadda, B.S., Jadav, J. K, Rai, A. K and Lata, K. (2014) "Impact of front line demonstrations on productivity of Okra cv. Gujarat Okra-2 in Panchmahals district of middle Gujarat" *Int. J Arid Hort.*, 8 (1-2) 68-70

Samui, S. K., Maitra, S., Roy, D. K. Mondal, A. K. and Saha, D., (2000). Evaluation on front line demonstration on groundnut (*Arachis hypogaea* L.) *J. Indian Soc. Coastal Agric. Res.*, 18: 180-183.

Sharma, R.N. and Sharma, K.C. (2004). Evaluation of Front Line Demonstration trials on oilseeds in Baran district of Rajasthan. *Madhya Pradesh J. Ext. Edu.*, 7: 72-75.

Singh, D. K., Gautam, U. S. and Singh, R. K., (2007). Study on Yield Gap and Level of Demonstrated Crop Production Technology in Sagar District. *Indian Res J Ext Edu*, 7 (2&3): 94-95.

Thamburaj, S. and Singh, N. (2001) Textbook of Vegetables, Tuber crops and Spices Published by Directorate of Information and Publications of Agriculture ICAR, New Delhi pp 51.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Status of micronutrient cataions in arid irrigated acid lime orchard soil profiles in Sikar District of Rajasthan

Balbir Singh* and Atul Chandra
S.K. Rajasthan Agricultural University, Bikaner
* Present Address: Assistant Professor (Hort.), BKVK, Fatehpur Shekhawati, Distt. – Sikar (Rajasthan)
*Corresponding author's e mail: balbirdr@gmail.com
(Received: 18.01.2017; Accepted: 16.06.2017)

Abstract

The present study on distribution of micronutrient cataions in arid irrigated acid lime orchard soil profiles in Sikar district of Rajasthan was conducted during March 2007-2008. The study included analysis of soil profiles with respect to micronutrients. The available iron ranged between 3.54 to 6.38 mg kg^{-1}, available zinc between 0.247 to 1.017 mg kg^{-1}, available copper between 0.103 to 0.420 mg kg^{-1} and available manganese between 1.37 to 5.15 mg kg^{-1}. All the micronutrients were found to be low to medium in range.

Key words: *Acid Lime, Orchards, Micronutrients*

Introduction

India has large arid zone covering an area of 317090 sq. km scattered mainly in the North-West parts of country and Rajasthan alone covers 62.00 per cent of area under arid zone. In Rajasthan, fruit cultivation is practised over an area 19795 ha and total production is 238475 tonnes (Anonymous 2005).The area of Sikar district forms a part of Thar desert which covers an area of 774244 square kilometres situated in the North Eastern Rajasthan. The district has moderate climate with seasonal temperature variation with scanty rainfall to the magnitude of 450-500 mm per annum during normal rainfall years. The high temperature (up to 48°C) along with high wind velocity, low soil fertility status, low water retention capacity of soil, high soil pH, salinity, calcium carbonate concretion in sub soil etc. are hard impediment in successful cultivation of many fruit crops in arid region. Increasing the production of fruits thus has sufficient scope in arid region of Rajasthan. In Sikar district, the area under fruit crops is 0.002 lac ha with production of 0.02 lac metric tonnes (Anonymous 2005). There is a vast potential of increasing area under fruit cultivation in arid region of Rajasthan provided irrigation facilities are available. These areas are suitable for cultivation of fruit crops such as aonla, ber, beal citrus, pomegranate etc. Presently Sikar district has nearly 2,12,096 lac hectares irrigated area through tube wells/wells. Irrigation facilities has opened great avenues for cultivation of fruit crops likes ber, aonla, bael, lime, pomegranate, datepalm, guava, jamun, karonda, phalsa etc. besides traditionally grown fruits such as Ker (*Capparis decidua*), Gonda (*Cordia myxa*), Pilu (*Salvadora oleiodes*), Khejri (*Prosopis cineraria*) etc.

Inspite of all vagaries, the farmers of Sikar district has shown tremendous response towards fruit cultivation particularly of ber, bael, lime and aonla fruits.

In Indian fruit industry, poor nutrition is the major cause of low orchard efficiency resulting poor productivity and poor fruit quality. Sufficient information on nutrient management in fruit crops has been generated, but response and requirement of nutrients of perennial fruit crops vary markedly in a particular area depending on soil and climatic conditions and also depend on growth, bearing habit, age, root stock and management practices. Balanced nutrition of fruit crops is paramount importance particularly in arid areas having largely sandy soils of poor fertility status. For knowing the exact status of mineral nutrition in the fruit trees, survey of the orchards for their fertility status is done. Studies on nutritional survey of arid fruits in Rajasthan are meagre inspite of their great importance and relevance. With this aim, the present study was undertaken to evaluate the micronutrient fertility status of different orchards in Sikar district.

Materials and Methods

A detailed soil survey during the year 2007-2008 was conducted in Sikar district of Rajasthan. Orchards were selected in such a way that these can represent general conditions of area under study. Eight orchards were selected covering different tehsils viz. Danta Ramgarh, Piparali, Laxmangarh and Srimadhopur.The details of locations and name of the fruit growers are given in table below.

S.No.	Name of fruit grower	Village	location
1.	Shri Prahalad	Raghunathgarh	Raghunathgarh
2.	Shri Panna Ram	Pachar	Pachar-IV
3.	Shri Ram Dev Singh	Purohit Ka Bas	Purohit Ka Bas-II
4.	Shri Roopchand Pipliwal	Pachar	Pachar-V
5.	Shri Hanumana Ram	Sanwalod	Sanwalod
6.	Shri Pokhar Mal	Purohit Ka Bas	Purohit Ka Bas-III
7.	Shri Guljari Kumawat	Jorawar Nagar	Jorawar Nagar
8.	Shri Harlal Singh	Palsana	Palsana-III

Soil samples were collected from eight fruit orchards, on the basis of variability and orchard performance at different locations of Sikar district. Thereafter, from each selected orchards, three soil profiles, based on soil fertility variation and plant performance were taken up. One hundred ninety two representative composite soil samples at different soil depths viz., 0-15, 15-30, 30-45, 45-60, 60-75, 75-90, 90-105 and 105-120 cm. were collected. After processing, the soil samples were analyzed for micronutrients. The available Fe, Cu, Zn, and Mn were extracted with DTPA solution as per procedure of Lindsay and Norvell (1978) and were determined by atomic absorption spectrophotometry.

RESULTS AND DISCUSSION

The distribution of DTPA extractable micronutrients as depth wise in 8 acid lime fruit orchards in Sikar district of Rajasthan was studied.

DTPA extractable Iron:

Distribution of DTPA extractable iron content showed a regular decreasing trend with increasing depths. The DTPA extractable iron content of soil depths viz. 0-15, 15-30, 30-45, 45-60, 60-75, 75-90, 90-105 and 105-120 cm varied from 3.81 to 6.38, 3.79 to 6.36, 3.76 to 6.33, 3.71 to 6.31, 3.69 to 6.25, 3.64 to 6.20, 3.58 to 6.15 and 3.54 to 6.10 mg kg^{-1} with their mean value 4.71, 4.69, 4.65, 4.61, 4.57, 4. 53, 4.48, and 4.43 mg kg^{-1}, respectively. On overall mean basis according to soil depths, the maximum DTPA extractable iron (4.71 mg kg^{-1}) was recorded at 0-15 cm soil depth and it decreased progressively at increasing soil depths and was recorded minimum (4.43 mg kg^{-1}) at 105-120 cm soil depth. The mean DTPA extractable iron on the basis of location wise was found maximum (6.26 mg kg^{-1}) at Jorawar Nagar and it was recorded minimum (3.69 mg kg^{-1}) at Pachar-IV. Data in table 1 revealed that 50 per cent soil samples drawn from surface soil depth of acid lime orchards were deficient and remaining were sufficient in DTPA extractable iron in the present study.

As per the ratings given by Tandon (1992a), the soils having <4.5 mg kg^{-1} falls under deficient category and those having >4.5 mg kg^{-1} falls under sufficient category. The deficient to sufficient status of iron found in the soil might be due to calcareousness, low organic carbon content, light textured coarse sandy soils. Similar observations were reported by Bhatnagar and Chandra (2003) and Kumawat (2005). These finding are in conformity to the results of present investigation.

DTPA extractable zinc:

Data related to DTPA extractable zinc content in acid lime orchards is presented in the table 2. From the data presented in the table, it is evident that the DTPA extractable zinc content of soil depths viz. 0-15, 15-30, 30-45, 45-60, 60-75, 75-90, 90-105 and 105-120 cm varied from 0.393 to 1.017, 0.367 to 0.997, 0.347 to 0.970, 0.317 to 0.947, 0.300 to 0.917, 0.273 to 0.897, 0.253 to 0.867 and 0.247 to 0.780 mg kg^{-1} with their mean value 0.796, 0.775, 0.753, 0.728, 0.705, 0.682, 0.656 and 0.609 mg kg^{-1}, respectively. On overall mean basis according to soil depths, the maximum DTPA extractable zinc (0.796 mg kg^{-1}) was recorded at 0-15 cm soil depth and it decreased progressively at increasing soil depths and was recorded minimum (0.609 mg kg^{-1}) at 105-120 cm soil depth. The mean DTPA extractable zinc on the basis of location wise was found maximum (0.909 mg kg^{-1}) at Pachar-V and it was recorded minimum (0.312 mg kg^{-1}) at Raghunathgarh. Data in table 2 revealed that 25 per cent soil samples drawn from surface soil depth of acid lime orchards were deficient and 75 per cent were sufficient in DTPA extractable iron in the present study. Distribution of DTPA extractable zinc content exhibited a regular decreasing trend with increasing depths.

As per the ratings given by Tandon (1992a), the soils having less than 0.6 mg kg^{-1} falls under deficient category, those having 0.6 to 1.2 mg kg^{-1} falls under sufficient category. This range of zinc in soils might be due to the presence of quartz, feldspar or the exchange complex being such as to have sites saturated with Ca/Mg under alkaline soil reaction. Calcareous nature and low organic matter are some of the other properties where low levels of zinc are anticipated. These results are in accordance with the findings of Bhatnagar and Chandra (2003) and Kumawat (2005).

DTPA extractable copper:

Data related to DTPA extractable copper content in acid lime orchards are presented in the table 3. From the data presented in the table, it is evident that the DTPA extractable copper content of soil depths viz. 0-15, 15-30, 30-45, 45-60, 60-75, 75-90, 90-105 and 105-120 cm varied from 0.157 to 0.420, 0.140 to 0.397, 0.137 to 0.370, 0.130 to 0.340, 0.120 to 0.317, 0.117 to 0.310, 0.113 to 0.290 and 0.103 to 0.270 mg kg^{-1} with their mean value 0.285, 0.269, 0.250, 0.229, 0.218, 0.204, 0.194 and 0.173 mg kg^{-1}, respectively. On overall mean basis according to soil depths, the maximum DTPA extractable copper (0.285 mg kg^{-1}) was recorded at 0-15 cm soil depth and it decreased progressively at increasing soil depths

and was recorded minimum (0.173 mg kg^{-1}) at 105-120 cm soil depth. The mean DTPA extractable copper on the basis of location wise was found maximum (0.339 mg kg^{-1}) at Palsana-III and it was recorded minimum (0.127 mg kg^{-1}) at Jorawar Nagar. Data in table 3 revealed that 25 per cent soil samples drawn from surface soil depth of acid lime orchards were deficient and 75 per cent were sufficient in DTPA extractable iron in the present study.Distribution of DTPA extractable copper content showed a regular decreasing trend with increasing depths. As per the ratings given by Tandon (1992a), the soils having <0.2 mg kg^{-1} falls under deficient category, those having >0.2 mg kg^{-1} falls under sufficient category. The deficient to sufficient available copper status of orchard soil might be due to high pH, calcareousness, lower organic carbon and light textured coarse sandy soils.The present results are in accordance with those reported by Baser and Lodha (1971) who reported that available copper status in sandy soils of Rajasthan varied from 0.05 to 2.38 ppm. Similar types of results have also been reported by Bhatnagar and Chandra (2003) who reported available copper status in sandy soils of Rajasthan varied from 0.0.08 to 0.51 ppm.

DTPA extractable manganese:

Distribution of DTPA extractable manganese content showed a regular decreasing trend with increasing depths. The data presented on DTPA extractable manganese content of orchard soils showed a regular decreasing trend with increase in depths. Data related to DTPA extractable manganese content in acid lime orchards is presented in the table 4. From the data presented in the table, it is evident that the DTPA extractable manganese content of soil depths viz. 0-15, 15-30, 30-45, 45-60, 60-75, 75-90, 90-105 and 105-120 cm varied from 1.88 to 5.15, 1.74 to 5.07, 1.68 to 5.00, 1.62 to 4.95, 1.57 to 4.90, 1.51 to 4.83, 1.43 to 4.79 and 1.37 to 4.74 mg kg^{-1} with their mean value 3.25, 3.15, 3.09, 3.03, 2.98, 2.92, 2.87 and 2.81 mg kg^{-1}, respectively. On overall mean basis according to soil depths, the maximum DTPA extractable manganese (3.25 mg kg^{-1}) was recorded at 0-15 cm soil depth and it decreased progressively at increasing soil depths and was recorded minimum (2.81 mg kg^{-1}) at 105-120 cm soil depth. The mean DTPA extractable manganese on the basis of location wise was found maximum (4.93 mg kg^{-1}) at Sanwalod and it was recorded minimum (1.60 mg kg^{-1}) at Raghunathgarh. Data in table 4 revealed that 25 per cent soil samples drawn from surface soil depth of acid lime orchards were deficient and 75 per cent were sufficient in DTPA extractable iron in the present study. Results of DTPA extractable manganese in all the orchards clearly indicate that deficiency of manganese in the acid lime orchards is now coming. The deficiency of DTPA extractable manganese might be due to the presence of high $CaCO_3$ content and low organic carbon content. These results are in accordance with those reported by Bhatnagar and Chandra (2003) and Kumawat (2005).

Table 1: DTPA Extractable Iron (mg kg^{-1}) in Acid lime Orchards at Different Soil Depths in Sikar District

Location of orchards	Soil depths (cm)								
	0-15	15-30	30-45	45-60	60-75	75-90	90-105	105-120	Mean
Raghunathgarh	4.55 ±0.90	4.52 ±0.09	4.49 ±0.10	4.44 ±0.09	4.42 ±0.72	4.37 ±1.55	4.32 ±1.62	4.26 ±0.51	4.42 ±0.92
Pachar – IV	3.81 ±0.09	3.79 ±0.09	3.76 ±0.09	3.71 ±0.08	3.69 ±0.08	3.64 ±0.08	3.58 ±0.06	3.54 ±0.48	3.69 ±0.21
Purohit Ka Bas-II	3.92 ±0.04	3.89 ±0.04	3.83 ±0.01	3.79 ±0.01	3.77 ±0.04	3.73 ±0.05	3.68 ±0.06	3.64 ±0.43	3.78 ±0.18
Pachar – V	4.91 ±0.05	4.88 ±0.05	4.84 ±0.04	4.80 ±0.84	4.78 ±1.60	4.75 ±0.04	4.69 ±0.04	4.66 ±1.11	4.79 ±0.75
Sanwalod	4.44 ±0.34	4.41 ±0.10	4.39 ±0.09	4.36 ±0.09	4.30 ±0.08	4.25 ±0.09	4.20 ±0.09	4.16 ±0.31	4.31 ±0.20
Purohit Ka Bas-III	5.82 ±0.82	5.79 ±0.75	5.69 ±0.08	5.67 ±0.08	5.61 ±0.08	5.57 ±0.08	5.50 ±0.09	5.46 ±0.36	5.64 ±0.43
Jorawar Nagar	6.38 ±0.04	6.36 ±0.04	6.33 ±0.03	6.31 ±0.02	6.25 ±0.02	6.20 ±0.02	6.15 ±0.02	6.10 ±0.41	6.26 ±0.18
Palsana – III	3.88 ±0.52	3.85 ±0.03	3.85 ±0.01	3.82 ±0.01	3.78 ±0.02	3.73 ±0.03	3.68 ±0.02	3.64 ±0.38	3.78 ±0.24
Mean	4.71	4.69	4.65	4.61	4.57	4.53	4.48	4.43	

± indicates standard deviation
Deficient – 50%
Sufficient – 50%

Table 2: DTPA Extractable Zinc (mg kg^{-1}) in Acid lime Orchards at Different Soil Depths in Sikar District

Location of orchards	Soil depths (cm)								
	0-15	15-30	30-45	45-60	60-75	75-90	90-105	105-120	Mean
Raghunathgarh	0.393 ±0.029	0.367 ±0.025	0.347 ±0.025	0.317 ±0.033	0.300 ±0.022	0.273 ±0.026	0.253 ±0.026	0.247 ±0.045	0.312 ±0.063
Pachar – IV	0.867 ±0.058	0.843 ±0.062	0.827 ±0.058	0.800 ±0.062	0.783 ±0.057	0.767 ±0.061	0.740 ±0.057	0.670 ±0.028	0.787 ±0.081
Purohit Ka Bas-II	0.837 ±0.025	0.817 ±0.025	0.797 ±0.025	0.777 ±0.024	0.750 ±0.028	0.727 ±0.091	0.700 ±0.022	0.647 ±0.074	0.756 ±0.076
Pachar – V	1.017 ±0.025	0.997 ±0.025	0.970 ±0.016	0.947 ±0.012	0.917 ±0.009	0.897 ±0.012	0.867 ±0.019	0.663 ±0.037	0.909 ±0.106
Sanwalod	0.950 ±0.029	0.930 ±0.029	0.907 ±0.026	0.883 ±0.024	0.863 ±0.024	0.837 ±0.019	0.813 ±0.017	0.777 ±0.033	0.870 ±0.061
Purohit Ka Bas-III	0.937 ±0.041	0.917 ±0.041	0.897 ±0.041	0.870 ±0.037	0.847 ±0.039	0.823 ±0.042	0.787 ±0.037	0.780 ±0.036	0.857 ±0.067
Jorawar Nagar	0.507 ±0.039	0.490 ±0.036	0.460 ±0.128	0.430 ±0.120	0.410 ±0.042	0.390 ±0.042	0.370 ±0.042	0.370 ±0.042	0.428 ±0.087
Palsana – III	0.863 ±0.025	0.843 ±0.025	0.817 ±0.026	0.800 ±0.014	0.767 ±0.026	0.743 ±0.184	0.720 ±0.022	0.717 ±0.009	0.784 ±0.086
Mean	0.796	0.775	0.753	0.728	0.705	0.682	0.656	0.609	

± indicates standard deviation
Deficient – 25%
Sufficient – 75%

Table 3: DTPA Extractable Copper (mg kg^{-1}) in Acid lime Orchards at Different Soil Depths in Sikar District

Location of orchards	Soil depths (cm)								
	0-15	15-30	30-45	45-60	60-75	75-90	90-105	105-120	Mean
Raghunathgarh	0.190 ±0.016	0.177 ±0.017	0.167 ±0.009	0.147 ±0.005	0.157 ±0.012	0.147 ±0.012	0.140 ±0.008	0.123 ±0.005	0.156 ±0.023
Pachar – IV	0.320 ±0.008	0.300 ±0.008	0.277 ±0.012	0.250 ±0.014	0.230 ±0.014	0.210 ±0.014	0.193 ±0.009	0.160 ±0.014	0.243 ±0.053
Purohit Ka Bas-II	0.390 ±0.014	0.367 ±0.009	0.343 ±0.012	0.317 ±0.009	0.300 ±0.008	0.273 ±0.012	0.257 ±0.009	0.223 ±0.012	0.309 ±0.054
Pachar – V	0.193 ±0.012	0.173 ±0.021	0.157 ±0.012	0.143 ±0.017	0.137 ±0.012	0.127 ±0.012	0.130 ±0.014	0.120 ±0.014	0.148 ±0.028
Sanwalod	0.210 ±0.041	0.210 ±0.028	0.183 ±0.021	0.173 ±0.021	0.163 ±0.012	0.157 ±0.017	0.153 ±0.012	0.140 ±0.008	0.174 ±0.033
Purohit Ka Bas-III	0.400 ±0.016	0.387 ±0.012	0.363 ±0.009	0.333 ±0.017	0.317 ±0.012	0.293 ±0.017	0.273 ±0.012	0.240 ±0.014	0.326 ±0.054
Jorawar Nagar	0.157 ±0.012	0.140 ±0.014	0.137 ±0.012	0.130 ±0.008	0.120 ±0.008	0.117 ±0.005	0.113 ±0.005	0.103 ±0.005	0.127 ±0.019
Palsana – III	0.420 ±0.024	0.397 ±0.025	0.370 ±0.016	0.340 ±0.016	0.317 ±0.005	0.310 ±0.008	0.290 ±0.008	0.270 ±0.008	0.339 ±0.052
Mean	0.285	0.269	0.250	0.229	0.218	0.204	0.194	0.173	

± indicates standard deviation
Deficient – 25%
Sufficient – 75%

Table 4: DTPA Extractable Manganese (mg kg^{-1}) in Acid lime Orchards at Different Soil Depths in Sikar District

Location of orchards	Soil depths (cm)								
	0-15	15-30	30-45	45-60	60-75	75-90	90-105	105-120	Mean
Raghunathgarh	1.88 ±0.02	1.74 ±0.05	1.68 ±0.07	1.62 ±0.08	1.57 ±0.09	1.51 ±0.09	1.43 ±0.10	1.37 ±0.11	1.60 ±0.18
Pachar – IV	1.95 ±0.03	1.79 ±0.06	1.75 ±0.03	1.69 ±0.04	1.64 ±0.04	1.57 ±0.04	1.52 ±0.05	1.48 ±0.05	1.67 ±0.15
Purohit Ka Bas-II	2.31 ±0.23	2.23 ±0.03	2.16 ±0.05	2.09 ±0.05	2.05 ±0.05	1.99 ±0.05	1.94 ±0.06	1.89 ±0.07	2.08 ±0.17
Pachar – V	4.68 ±0.02	4.57 ±0.85	4.53 ±0.04	4.46 ±0.05	4.42 ±0.05	4.34 ±0.03	4.39 ±0.14	4.24 ±0.03	4.45 ±0.33
Sanwalod	5.15 ±0.01	5.07 ±0.82	5.00 ±0.01	4.95 ±0.02	4.90 ±0.01	4.83 ±0.02	4.79 ±0.02	4.74 ±0.02	4.93 ±0.32
Purohit Ka Bas-III	3.45 ±0.03	3.35 ±0.01	3.29 ±0.81	3.21 ±0.01	3.18 ±0.00	3.11 ±0.01	3.02 ±0.03	2.97 ±0.04	3.20 ±0.33
Jorawar Nagar	2.82 ±0.02	2.74 ±0.03	2.68 ±0.03	2.62 ±0.02	2.57 ±0.03	2.51 ±0.01	2.44 ±0.02	2.39 ±0.01	2.60 ±0.14
Palsana – III	3.79 ±0.03	3.71 ±0.02	3.63 ±0.03	3.59 ±0.02	3.54 ±0.03	3.48 ±0.03	3.41 ±0.04	3.38 ±0.05	3.57 ±0.14
Mean	3.25	3.15	3.09	3.03	2.98	2.92	2.87	2.81	

± indicates standard deviation
Deficient – 25%
Sufficient – 75%

References

Anonymous. 2005. Horticultural Data Base. National Horticultural Board, Ministry of Agriculture, Govt. of India.

Baser, B.L. and Lodha, P.S. 1971. Available micronutrients in sandy soils of Rajasthan. *Annals Arid Zone.*, 10 : 93-94.

Bhatnagar, P. and Chandra, A., 2003. Distribution of micronutrient cations in arid irrigated orchard soil profiles of western Rajasthan. *Journal of Eco-physiology*, 6(3-4): 93-100.

Kumawat, R. 2005. Nutrient status of soils of ber (*Zizphus mauratina* L.) orchard in Jaipur district of Rajasthan. M.Sc. Thesis, RAU, Bikaner.

Lindsay, W.L. and Norvell, W.A. 1978. Development of DTPA soil test for zinc, manganese and copper. *Soil Sci. Soc. Am. J.*, 42 : 421-428.

Tandon, H.L.S. 1992a. Fertilizer Development and Consultation Organization, 202-204, A Bhanot Corner, 1-2 Pompers Enclave, New Delhi.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Efficacy of GA_3 on seed germination and seedling vigour of wood apple

Vikas Yadav, A. K. Singh, V.V. Appa Rao, D.S. Mishra and Sanjay Singh
Central Horticultural Experiment Station (ICAR-CIAH), Vejalpur- 389340, Panchmahals, Gujarat
Corresponding author's e mail: vikasyadav.hot@gmail.com
(Received: 16.04.2018; Accepted: 8.05.2018)

Abstract

Wood apple is an underutilised indigenous fruit tree and belongs to Rutaceae family. It is slow growing tree. Owing to its slow growth in nursery, seedlings attain graftable stage in longer duration. Therefore, an attempt was made to find out the effect of GA_3 on germination and seedling vigour at nursery of Central Horticultural Experiment Station (ICAR-CIAH), Vejalpur during June to November, 2016-17. Seeds were treated with various concentrations of GA_3 (0, 25, 50, 75, 100, 125, 150,175, 200, 225, 250 and 275mgL^{-1}) which were soaked for 48 hours under laboratory condition. Experiment was laid out in Complete Randomized Design (C.R.D) and which was replicated thrice. A total of 50 seeds were treated with GA_3 in each concentration. Results of study revealed that the different levels of GA_3 enhanced the germination and quick growth of seedling than control. Among the different concentrations of GA_3, 150 mgL^{-1} GA_3 exhibited better response in seed germination *i.e.*, 11.86, 28.54, 34.75, 10.34, 6.52 and 0.00 % at 5th, 7th, 9th, 11th 13th and 15th days after sowing, respectively. The seeds treated with 150mgL^{-1} GA_3 showed the highest germination (91.98%) among different treatments. The maximum seedling shoot length (23.94 cm), root length (24.53 cm), seedling diameter (5.21 mm), number of leaves/seedling (21.23), primary branches/seedling (4.52) and vigour index (4458.27) were recorded with $GA_3$150 mgL^{-1} after six month of sowing. Based on the observations, it may be inferred from the study that the $GA_3$150mgL^{-1} is found more effective to improve the seed germination and vegetative growth of seedling in nursery, whereas GA_3 concentration more than 150mgL^{-1} declined the seed germination but the vigour of seedling is not affected by higher concentration of GA_3 after germination.

Key words: *GA_3, Germination, Seedling Vigour Index, Wood Apple*

Introduction

The wood apple (*Feronia limonia* L.) is belongs to family Rutaceae. Wood apple has the common names like as elephant apple, monky fruit, curd fruit and kaith bel (Singh *et al.*, 2016). The original home of wood apple is south India and Srilanka (Lande *et al.*, 2010). It is subtropical fruit species which prefers dry climatic condition during flowering and fruit setting. It has very deep and penetrating root system, which makes it highly drought tolerant (Vaidayaratnam *et al.*, 1995). Generally wood apple requires 8-17 days for seed germination in normal condition (Hiwale, 2015). So far, little work has been carried out on this aspect in wood apple particularly under dry land condition. Therefore, seed treatment of wood apple with GA_3 is required to improve germination and seedling vigour and such seedlings could be attained graftable stage in short duration. Therefore, this study was conducted to find out the effect of GA_3 on seed germination and seedling growth of custard apple under hot semi arid condition.

Material and Methods

The present study was carried out at nursery unit of Central Horticultural Experiment Station (ICAR-CIAH), Vejalpur, Panchmahals during 2016-2017. The experiment was laid out in Complete Randomized Design (C.R.D) with three replications. There were twelve treatments like T_1: seed soaking in tap water for 48 hours (control), T_2: seed soaking in GA3 25 ppm for 48 hr, T_3: seed soaking in GA3 50 ppm 72 hr, T_4: seed soaking in 75 ppm GA_3 for 48 hr, T_5: seed soaking in 100 ppm GA_3 for 48 hr, T_6: seed soaking in 125 ppm GA_3 for 48 hr, T_7: seed soaking in 150 ppm GA_3 for 48 hr, T_8: seed soaking in 175 ppm GA_3 for 48 hr, T_9: seed soaking in 200 ppm GA_3 for 48 hr, T_{10}: seed soaking in 225 ppm GA_3 for 48 hr, T_{11}: seed soaking in 250 ppm GA_3 for 48 hr and T_{12}: seed soaking in 275 ppm GA_3 for 48 hr. The seeds of wood apple were collected from fully mature fruits of wood apple. Fully soaked seeds were selected and sown in 15th June 2017 at uniform distance in polythene bags. The size of polythene bag is 45 x 15cm and each polythene bag consists of 10 seed. Every polythene bag was filled with a composite media, which consists of soil, FYM and sand in ratio of 1:1:1. The percentages of germination of seeds were calculated according to the rules for seed testing (ISTA, 1996). The seedlings were allowed to grow for six months (June to November, 2017). After six months, 10 seedlings for each treatment were selected for measuring growth parameters: shoot and root length, seedling diameter and number of leaf. The data on germination and seedling growth under various treatments were statistically analyzed. Vigour index was calculated

according to Abdul-baki and Anderson (1973) as germination per cent × seedling total length (total shoot + root length). The data was analyzed by statistical significant at $p<0.05$ level. S.E. and C.D. at 5 per cent level by the procedure given by Gomez and Gomez (1984).

Result and discussion

The germination percentage of Wood apple seed treated with GA_3 are summarized in Table & fig (1), the differences between treatments and control were significant 5, 7, 9, 11, 13 and 15th day after sowing. Results showed that treatment of seeds with GA_3 had markedly improved germination from 51.20 to 91.98% when compare out with control 61.24%. It is clear from the Table1 that seeds treated with 150ppm GA_3, the germination percentage at 5, 7, 9, 11, 13 and 15th day after sowing was recorded as 11.86, 28.54, 34.75, 10.34, 6.52 and 0.0% respectfully, while in control it was 10.42, 18.42, 16.40, 6.52, 5.00 and 4.48 (Fig.1). The maximum and early germination percentage for wood apple seed was found in GA_3 treated seed, It may be due to GA_3 hormone increase cell size of embryo by stimulating the cell wall to release and transmit its calcium in the cytoplasm which makes favourable condition for absorption of water and cell growth and activation of hydrolytic enzyme (Taiz & Zeieger, 2002). The highest germination per cent was noted in T_7 (91.98%) followed by T_2 (72.72%), T_3 (66.10%) and T_{10} (62.42%) while lowest (61.24%) was observed in T_1 (control) at 15 days after sowing (DAS) of seeds. In Table (1) results are shown the positive effects of GA_3 150ppm treatment on shoot and root length, seedling diameter, no. of leaf/ young seedling, primary branches/seedling and vigour index of seedling, it was 23.94cm, 24.53cm, 5.21mm, 21.23, 4.52 and 4458.27, respectively. Wood apple seeds treated with 150 ppm GA_3, enhance early and quickly germination which accelerate the difference in seedling growth, it may be due to growth promotional effect of GA_3; it stimulates and accelerates cell division, increased cell elongation and enlargement or both (Hartmann *et al.*, 1990). Early germination caused by gibberellic acid which provided enough time to the plant for proper growth and development. These finding more or less similar with finding of Vanangamudi and Vanangamudi (2003) in tamarind and Swamy *et al.* (1999) noticed highest germination per cent, shoot length and root length when jamun seeds. In this study, we increase period of soaking seed because long time soaked seed gave higher germination due to maximum removal of germination inhibitor (Dzayi, 2010).

From the foregoing discussion it can be concluded that among the different treatment, T_7 (seed soaking in 150 ppm GA_3 for 48 hours) is found superior and most effective for seed germination as well as better growth of wood apple seedlings over the rest of the treatment combinations.

Table 1. Efficacy of GA_3 on seed germination and seedling vigour of wood apple (*Feronia limonia* L.)

Treatments	Total germination (%)	Seedling Shoot length (cm)	Seedling Root length (cm)	Seedling diameter (mm)	Number of leaf/seedling	Primary branches/seedling	Vigour index
T_1: Control	61.24	10.52	11.23	3.41	10.26	3.21	1331.97
T_2: GA_3 25 ppm	72.72	15.23	14.26	4.10	16.18	3.54	2144.51
T_3: GA_3 50 ppm	66.10	16.58	15.23	4.23	17.23	3.48	2102.64
T_4: GA_3 75 ppm	54.38	16.43	17.20	4.42	15.23	3.75	1828.8
T_5: GA_3 100 ppm	57.80	19.63	17.36	4.47	18.10	3.82	2138.02
T_6: GA_3 125 ppm	51.20	19.78	18.23	4.40	17.75	3.92	1946.11
T_7: GA_3 150 ppm	91.98	23.94	24.53	5.21	21.23	4.52	4458.27
T_8: GA_3 175 ppm	60.74	18.34	20.63	5.10	20.24	3.96	2367.04
T_9: GA_3 200 ppm	52.72	17.24	18.65	4.83	19.46	3.37	1892.12
T_{10}: GA_3 225 ppm	62.42	18.23	18.10	5.12	20.23	3.27	2267.72
T_{11}: GA_3 250 ppm	55.92	17.83	17.67	4.73	18.23	2.87	1985.16
T_{12}: GA_3 275 ppm	41.50	16.85	17.21	4.63	17.56	2.92	1413.49
C.D. (P=0.05)	4.32	1.52	1.21	0.35	1.87	0.27	202.65

Fig.1: Effect of GA_3 on seed germination (%) of wood apple (*Feronia limonia* L.)

Fig. 2: Annual weather data of CHES in 2016-17

References

Abdul - Baki, A. and Anderson, J.D. 1973. Vigour determination in Soybean seed by multiple criteria. *Crop Science*, 13: 630-633.

Black, M. 1980. Role of indogenous harmones in germination and dormancy of fruit crops. *Israel Journal of Botany*, 29: 181-192.

Dzayi, F. H. Rahman. 2010. Effect of GA3 and Soaking time on Seed Germination and Seedling Growth Lemon (*Citrus limon* L.) High Diploma. Thesis college of Agriculture, university of Salahaddin – Erbil.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for Agricultural Research. 2nd Edition Awiley Inter Science. Publication, New York (USA).

Hartmann, H. T., Kester, D. E. and Davies F. T. 1990. Plant Propagation Principles and Practices. Englewood Cliffs, NJ: Prentice- Hall.

Hiwale, S. S. (2015). Wood apple (*Feronia limonia* Correa). *In*: Saroj P L Advances in Arid Horticulture: production technology of arid and semiarid fruits, Vol. II, pp 435-442.

International Seed Testing Association (ISTA) (1996). International Rules for Seed Testing, Rules 1996.

Lande, S.B., Nirmal, V.S. and Kotecha, P.M. 2010. Studies on preparation of ready-to-serve beverages from wood apple pulp. *Beverages and Food World*, 37(4): 69-70.

Singh, A.K., Singh, S., Yadav V. and Sharma, B.D. 2016. Genetic variability in wood apple (*Feronia limonia*) from Gujarat. *Indian Journal of Agricultural Sciences*. 86(11): 1504-1508.

Swamy, G.S.K., Patil, P.B., Athani, S.I. and Prabhushankar, D.S. 1999. Effect of organic and inorganic substances on germination of jamun (*Syzygium cumini*) seeds. *Advances in Agricultural Research in India*. 11: 89-91.

Taiz, L. and Zeieger, E. 2002. Plant Physiology. 3rd Ed. USA, Sinauer Associates, Inc.: 544–546.

Vaidayaratnam, V.P.S., Arya, V.S. and Kottakkal 1995. Indian medicinal plants, Vol III Orient Longman Ltd., Madras, 1995, 327-332.

Vanangamudi K. and Vanangamudi M. 2003. Response of tamarind (*Tamarindus indica L.*) to presowing seed treatment with growth stimulants. *Journal of Tropical Forest Science*, 15(1): 6-11.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Effect of size of polythene bags on seedling growth and budding success in jamun

Sanjay Singh, A.K. Singh, D.S. Mishra and V. V. Appa Rao
Central Horticultural Experiment Station (ICAR-CIAH), Vejalpur-389340, Godhra, Gujarat
(Received: 31.01.2018, Accepted: 5.05.2018)

Abstract

Studies were conducted to determine the effects of poly container size on the seedling and root growth and their effect on budding success in jamun at experimental farm of CHES, Vejalpur, Godhra, Gujarat. Four size of polythene bags (25x15 cm, 25x10 cm, 30x8 cm and 20x8 cm) were used with a potting medium that consisted of sand soil and FYM in the ratio of 1:1:1. Overall growth of jamun seedlings after 8 months of seed sowing in terms of seedling height, collar diameter, number of leaves/plant, buddable root stock percentage, root length, root diameter, number of secondary and tertiary roots were best in 25x15 cm size of polythene bags which was followed by 25x10 cm polythene bags. Good quality seedling root stocks for budding purpose with seedling height above 80 cm and collar diameter above 2.0 cm along with higher number of secondary and tertiary and secondary roots in 8 months in 25x15 cm polythene bags. Most of the parameters of quality seedling root stocks were also produced by 25x10 cm polythene bags. Highest budding success percentage was recorded in 25x15 cm size followed by 25x10 cm polythene bags. These findings suggest use of 25x15 cm polythene bags for speedy seedling root stock growth and high budding success in jamun.

Key words: *Budding success, polythene bags, seedling growth, Syzygium cuminii*

Introduction

The Jamun (*Syzygium cuminii* Skeels) is one of the important minor fruit crops belonging to the family Myrtaceae which is widely distributed throughout the tropic and sub-tropics. Its ripened fruits are eaten fresh and can be processed into beverages like jelly, jam, squash and vinegar. Fruits are useful against various lifestyle ailments as diabetes, heart and liver troubles (Singh, 2001). A wide range of variability occurs with regard to fruit size and quality owing to its seed propagation, which needs to be conserved and exploited (Devi *et al.* 2002). For the conservation and exploitation, standardization of faster multiplication protocols is required in jamun. Traditionally seedlings of jamun are raised by direct sowing seed in the nursery beds which produce seedlings with poor root and shoot growth. As a consequence, it takes more time to produce a seedling plant for budding purpose and also poor survival under field condition. Owing to this containerized seedling production is now widely used for production of nursery stock (Saroj et al., 2000 and Lal et al., 2004). Polythene bags are conventionally used for large-scale production seedling root stocks of fruit plants as they are easy to handle and transport. Optimum container size depends on factors such as species, plant stocking in the nursery, size of the seedling desired type of growing medium and length of the growing season (Jinks, 1994). It is therefore important to select the best size of polythene bags which can contain sufficient quantity of growing medium to support optimum root and shoot growth of seedlings in lesser time so that buddable size root stocks are ready for grafting in minimum time with high success percentage. The systematic study is lacking with regard to size of polythene bags for raising seedling root stocks in jamun; therefore, present investigation was undertaken with an objective to determine the optimum container size for the rapid large-scale production of quality seedling root stocks of jamun.

Material and Methods

Seeds of jamun cv. Goma Priyanka were collected from freshly harvested fruits during the first week of June from experimental farm of CHES, Vejalpur, Godhra, Gujarat. Extracted seeds were collected in bucket filled with fresh water and after grading, healthy seeds were directly used for sowing in the different size of polythene bags. The sand, silt and FYM were used an potting medium in the ratio of 1:1:1. (The potting medium used was sand, soil and FYM in the ratio 1:1:1.) The different size of polythene bags *viz.*, 25x15 cm, 25x10 cm, 30x8 cm and 20x8 cm were used for testing. A total of 100 seedlings used in each treatment, arranged in four replicate each of 25 seedlings in a randomized block design (RBD). The experiment was conducted in an open condition and during the experimental period, normal management practices were adopted, but no fertilizer was applied. Various growth characters were taken after 8 months of seed sowing, however, for recording the data on root characters, three randomly-selected seedlings from each replicate were carefully uprooted without disturbing the root system and washed in running tap water and then data on root length, diameter and number of secondary and tertiary roots were recorded. After this, 8 months old seedling from each treatment were used for budding with scion shoots of Goma priyanka for recording the data on

budding success (%). The data were statistically analyzed as per method of Gomez and Gomez (1984).

Results and discussion

Effect of different size of polythene bags on seedling growth and percentage of buddable rootstocks were presented in table1. In general, seedling height, collar diameter, number of leaves per plant and percentage buddable rootstocks significantly increased with increase in polythene bag size. The maximum seedling height (85.50 cm), collar diameter (2.50 cm), number of leaves per plant (25.10) and buddable rootstocks (98.0 %) were recorded with 25x15 cm polythene bag followed by 25x10 cm polythene bag. The seedling height variation in different containers can probably be attributed to the size of containers. Similar relationships have been reported between container volume and seedling height and biomass in *Grevillea robusta* (Misra and Jaiswal, 1993) and in aonla (Saroj et al., 2000). The minimum seedling height (52.0 cm), collar diameter (1.50 cm), number of leaves (12.50) and buddable root stock percentage (10.50 %) were noted with 20x8 cm polythene bag. The poor growth in 20x8 cm polythene bag, compared to that in the 25x15 cm and 25x15 cm sizes, can be attributed to the poor root system development due to small volume area available for root development which ultimately affected the aerial growth of plant and photosynthetic activity too as growth rate of shoots and roots are interdependent (Tonutti and Giulivo, 1990).

Among various sizes of polythene bags, 25x15 cm size recorded the maximum root diameter (1.10 cm), number of secondary (34.10) and tertiary roots (83.10) followed by 25x10 cm polythene bag. However, the maximum root length was recorded with 30x8 cm polythene bag (60.10 cm) followed by 25x15 cm size (40.50 cm). Whereas the minimum root length (30.50 cm), root diameter (0.58 cm), number of secondary (19.50) and tertiary roots (41.10) were observed in 20x8 cm polythene bag. Seedlings with relatively large root system generally suffer less post plant shock after planting than the plants with small root system. Our results confirm the findings of Misra and Jaiswal (1993) who observed better root architecture in *Grevillea robusta* seedlings when raised in different size of polythene bags. Highest budding success was obtained with 25x15 cm polythene bag (80.50%) followed by 25x10 cm size (75.10 %) while 20x10 cm polythene bag recorded only 56.0% budding success which was having seedling girth of 1.50 cm. It is important to note that the girth of rootstock should be more than 2.0 cm during budding for better success. Similar kind of observations were made by Saroj *et al.* (2000) in aonla.

Table 1. Effect of size of polythene bags on seedling growth and budding success in jamun after 8 months of seed sowing

Size of polythene bags (cm)	Seedling height (cm)	Seedling girth (cm)	No. of leaves plant^{-1}	Buddable rootstocks (%)	Root length (cm)	Root diameter (cm)	No. of secondary roots	No. of tertiary roots	Budding success (%)
25x15	85.50	2.50	25.10	98.00	40.50	1.10	34.10	83.10	80.50
25x10	75.00	2.00	20.00	94.50	38.00	0.70	32.00	79.50	75.10
30x8	60.10	1.70	16.00	40.00	60.10	0.60	22.00	68.00	68.00
20x8	52.00	1.50	12.50	10.50	30.50	0.58	19.50	41.10	56.00
CD (P=0.05)	3.55	0.15	1.20	8.50	3.80	0.11	1.13	2.52	3.50

References

Devi, S. P., Thangam, M., Desai, A. R. and Adsule, P. G. 2002. Studies on variability in physico-chemical characters of different jamun (*Syzygium Cuminii* Skeels) accessions from Goa. *Indian Journal of Horticulture*, 59 (2): 153-156.

Gomez, K. A. and Gomez, A. A. 1984. Statistical Procedure for Agricultural Research, 2nd edn., John Wiley and Sons Inc., New York.

Jinks, R.L. 1994. Container production of tree seedlings. In: Aldhous, J.R. and Mason, W.L. (eds) Forest Nursery Practice. Forestry Commission, London, Bulletin 111, pp. 122–134.

Lal, G., Jat, R. G., Dhaka, R. S., Sen, N. L. and Pareek, C. S. 2004. Standardization of propagation techniques in ber (*Ziziphus mauritiana* Lamk.). *Haryana Journal of Horticultural Science*, 33(1 & 2) : 20-22.

Misra, K. K. and Jaiswal, H. R. 1993. Effect of size of polythene bags and potting mixtures on the survival and growth of silver oak (*Grevillia robusta* Parker) seedlings. *Indian Forester*, 119: 941–943.

Singh I.S. 2001. Minor fruits and their uses. *Indian Journal of Horticulture*, 58 (1-2): 178-82.

Saroj, P. L., Nath, Vishal and Vashishtha, B. B. 2000. Effect of polycontainers on germination, seedling vigour, root characters and budding success in aonla. *Indian Journal of Horticulture*, 57(4) : 300-304.

Tonutti, P. and Giulivo, C. 1990. Effect of available soil volume on growth of young kiwi plants. *Acta Horticulturae*, 282:283-294.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Epidemiological studies on powdery mildew (*Oidium erysiphoides f.sp. ziziphi)* of *ber* in scarce rainfall zone of A.P

B. Srinivasulu*, K. Subramanyam, P. Deepthi, N. Janaki ratnam and G. Rajeshwari
Dr. Y.S.R. Horticultural University
Horticultural Research Station, Rekulakunta, Anantapuramu, A.P
E mail: headhrs_anantapur@drysrhu.edu.in
(Received: 2.10.2017, Accepted: 01.05.2018)

Abstract

Ber, the king of arid fruits is an ancient fruit crop grown in arid and semi arid regions of India. The powdery mildew caused by *Oidium erysiphoides f. sp. ziziphi* Yen and Wang, is an important limiting factor in the successful cultivation of *ber*. To know the effect of different abiotic environmental factors on the development of disease, a field experiment was conducted from 1998 to 2015 on her cultivar Gola. Based on the epidemiological studies on ber powdery mildew, it is concluded that the disease initiation took place during 35th or 36th standard meteorological weeks and was siguificantly and negatively correlated with minimum temperature (< 23.60 °C) and raiufalt (< 24.76 mm) and positively correlated with relative humidity (> 76.32%) and sunshine hours (> 5.39).

Key words: *Ber*, epidemiology, powdery mildew, pathogen

Introduction

Ziziphus mauritiana Lamk., also known as Chinese date , a poor man's fruit crop belonging to the family Rhamnaceae grown in semi-arid and arid regions of India. It is quite nutritious and rich in vitamin C, used in Ayurveda for treating bleeding disorders, excessive thirst, fever, burning sensation etc. Its seeds possess anti cancer properties. In India, it is a minor fruit but of late the ber became an important cash crop in some areas and its acreage and production are increased. The crop is also affected by different biotic and abiotic stresses including pathogens causing many serious diseases. Among the diseases, powdery mildew, caused by *Oidium erysiphoides var. ziziphi* Yen and Wang, is a prime limiting factor in the successful cultivation of ber, causing great losses in quantity and quality of fruits. It is a regular feature on the crop from season to season and the loss in fruit yield roughly accounts for 50- 60 per cent. Even though many fungicides and resistant sources are available, meteorological factors play a major role in the development, spread and severity of powdery mildew disease (Chavan *et al.*, 1995; Balamuralikrishnan and Jeyarajan, 1997; Jahagirdar *et al.*, 2001 and Venkatesh and Jamadar, 2001) on ber. However, there are very few studies to confirm the relationship of weather in the development and severity of powdery mildew. Therefore, the present study was conducted during 1998-2015 on the above aspects with an aim to develop the forecasting models to reduce the cost of fungicide application in the effective management of this disease.

Materials and Methods

The experiment was initiated at Horticultural Research Station, Anantapuramu on five year old ber trees (variety Gola). The experiment was laid out in Randomized Block Design with three replications consisting of two trees per replication and observations were recorded on occurrence and severity of disease at weekly interval from initial appearance. The data of meteorological parameters *viz.*, temperature, rainfall, relative humidity and sunshine hours were collected from Agrometeorological Observatory, Agricultural Research Station, Ananthapuramu. The intensity of powdery mildew of ber was recorded by having five ratings

Grade	% infection
0	No infection
1	1-10% fruit/leaf area covered
2	11-25% fruit/leaf area covered
3	26-50% fruit/leaf area covered
4	51-75% fruit/leaf area covered
5	76-100% fruit/leaf area covered

Nearly twenty fruits per plant were randomly selected and fitted into different categories of ratings and the disease intensity was calculated using the formula defined by Mc Kinney (1923).

In this way, 19 years of data were recorded and the relationship of the disease incidence and spread was worked out with meteorological elements. The coefficient

of correlation of disease build up with all the meteorological elements was calculated by considering the disease as dependent variable and the meteorological elements as independent variables. Thus, the meteorological elements having high and significant correlation with the disease were identified. The procedure of the multiple regression analysis was then followed for evaluating the various combinations of independent variables for forecasting of this disease.

Results and discussion

The experimental results based on ninteen years pooled data revealed that disease initiated during 35th or 36th standard meteorological weeks with favourable T (min) < 23.60°C, Rainfall <24.76 mm, Relative humidity >76.32% and Sunshine hours > 5.39 and increased from September to December each year with its peak in the month of October. This clearly indicated that weather parameters played a crucial role in development of the powdery mildew.

The data were pooled for all the nineteen years and was subjected for regression analysis, to select the best weather elements for forecasting the disease incidence in ber. The coefficients of correlation obtained between various meteorological parameters and powdery mildew disease build up showed considerably high relationship. The data in Table 1 showed that the weather parameters exhibited significant negative correlation with minimum temperauure (- 0.57), rainfall (-0.71) while, positive with relative humidity (0.66) and sunshine hours (0.53). Similar results of suitable weather factors for development of powdery mildew was reported by Pareek and Nath (1996) and Thind *et al.* (2004) when the maximum temperature is between 24-35°C, minimum temperature between 4-22°C, morning RH 64-91% and evening RH 24-57%. The disease occurs with increased virulence during high rainfall years (Sharma, 2003). Similar temperature range of 20-25°C and relative humidity of 80-100 per cent were found to be most favourable for maximum conidial germination of powdery mildew in various crops as reported by many workers (Shahri *et al.* 2006, Jocob *et al.* 2008, Sankar and Sreeramula, 2008a and and Rakhonde *et al.* 2011).

Pandey *et al.* (2004) also investigated the effect of weather variables on outbreak and spread of powdery mildew in ber and found high humidity (85-90 per cent), moderate temperature (maximum temperature 33-34°C and minimum temperature, 23-25°C), low sunshine hours (4-7 h/day) and low wind speed (3-5 km/h) were favourable for disease initiation.

The experimental findings are also in accordance with the results of Jat and Goyal (2009) who recorded disease initiation during 39-46 standard meteorological weeks with peak PDI at an average maximum and minimum temperature of 24.7 and 4.9°C, average morning and evening relative humidity of 82.6 and 35.7 per cent respectively.

Fig 1: Ber fruits infected with powdery mildew disease

Based on the regression coefficients obtained for PDI of 19 years pooled data, linear equations were derived to predict the disease depending upon weather conditions prevailing during crop season.

Regression coefficients for PDI were obtained for independent variables viz., maximum temperature (°C), minimum temperature (°C), relative humidity (%), rainfall (mm) and sunshine hours as the dependent variable for disease incidence.

The multiple linear regression equation was fitted to the data and the equation arrived for the weather parameters was:

$Y = -440.61 + (9.83) X_1 + (0.31) X_2 + (1.56) X_3 + (0.42) X_4 + (-1.65) X_5 + (6.40) X_6$

$R^2 = 72\%$

Where, X_1 = maximum temperature (^{0}C), X_2 = minimum temperature (^{0}C), X_3 = relative humidity - I(%), X_4 = relative humidity -II(%), X_5 = rainfall (mm) and X_6 = sunshine hours

It was observed that when there was increase in one unit of maximum temperature, relative humidity and sunshine hours, the per cent disease index was increased by 9.99, 1.77 and 6.15 units respectively, whereas increase in one unit of minimum temperature the per cent disease index decreased by 1.5 units. The weather factors influenced the disease incidence to the extent of 72.0 per cent.

Table 1. Correlation coefficient of PDI (Per cent Disease Index) with weather parameters from (19 Years pooled)

S. No.	Weather Parameters	Per cent Disease Index (PDI)
1.	Maximum Temperature	-0.43
2.	Minimum Temperature	-0.57*
3.	RH1	+0.66**
4.	RH2	-0.32
5.	Rainfall	-0.71***
6.	Sunshine hours	+0.53*
*indicates significant at 5% ** indicates significant at 1% *** indicates significant at 0.05%		

Fig 2: Graph depicting the influence of significant weather parameters on PDI of ber powdery mildew in different standard meteorological weeks

References

Balamuralikrishnan, M. and Jeyarajan, R. 1997. Effect of weather factors on powdery mildew incidence in grapevine. *Journal of Mycology and Plant Pathology*, 27 (2):225-226.

Chavan, S.B., Khandge, S.V., Varshneya, M.C. and Patil, J.D. 1995. Influence of weather parameters on conidia formation in powdery mildew of grape. *Indian Phytopathology*, 48(1): 40-44.

Jahagirdar, Shamarao, Venkatesh, H. and Jamadar, M.M. 2001. Influence of antecedent weather variables on powdery mildew of grapes in Northern Karnataka. Paper presented at the National Seminar on "Agrometeorological Research for sustainable Agricultural Production" at GAU Anand, 27-28th Sept. 2001.

Jat, R.G. and Goyal, S.K. 2009. Epidemiological studies on powdery mildew of ber, *Ziziphus mauritiana* Lamarck. *Acta Horticulture*, 840: 439-446.

Jocob, D., David, D.R., Sztjenberg, A. and Elad, Y. 2008. Conditions for development of powdery mildew of tomato caused by *Oidium neolycopersici*. *Phytopathology*, 98 (3): 270-281.

Mc. Kinney, H.H. 1923. A new system of grading of plant disease. *Journal of Agriculture Research*, 26: 195-218.

Pandey, V., Patel, D.S., Patel, B.M. and Patel, S.I. 2004. Effect of weather variable on outbreak and spread of powdery mildew disease in ber. *Journal of Agrometeorology*, 6: 124-128.

Pareek, O. P. and Nath, V. 1996. Ber. In Coordinated Fruit Research in Indian Arid Zone - A two decades profile (1976-1995). National Research

Centre for Arid Horticulture, Bikaner, India: 9-30

Rakhonde, P.N., Wadaskar, R.M., Koche, M.D. and Anvikar, D.G. 2011. Influence of weather parameters on powdery mildew (*Erysiphe polygoni*) in green gram. *Crop Research*, Hisar, 42 (1/2/3): 344-347.

Sankar, N.R. and Sreeramula, A. 2008a. Morphological characterization and the effect of temperature and relative humidity on development of teak powdery mildew. *Journal of Plant Disease Sciences*, 3(2): 151-154.

Sharma, S. 2003. Relationship of rainfall with powdery mildew (*Oidium erysiphoides* f. sp. *ziziphi)* of jujube *(Ziziphus maoriflana). Indian Journal of Agriculture Science*, 73: 636-638.

Shahri, M.H., Zad, J., Tehrani, A.S., Okhovat, S.M. and Safarnejad, A. 2006. Effect of temperature and relative humidity on germination of ascospores and conidia of *Uncinula necator*, the causal agent of grape powdery mildew. [Persian]. Iranian *Journal of Agricultural Sciences*. 37(3): 487-496.

Thind, S. K., Nirmaljit, K. and Arora, J. K. 2004. Periodicity and epidemiology of ber powdery mildew in Punjab. *Progressive Horticulture*. 36(1): 164-166.

Venkatesh, H. and Jamadar, M.M., 2001, Meteorological influence on incidence of powdery midlew on ber (*Zizihus mauritianan* Lamk.) in Northern Dry Zone of Karnataka. Paper presented at the National Seminar on "Ecofreindly approaches for plant disease management" at Chennai, 22-24th Jan. 2001.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Development of non-spiny brinjal from spiny brinjal through conventional breeding

Savitha.B.K* and M.Pandiyan
Agricultural Research Station & Krishi Vigyan Kendra
TNAU, Virinjipuram -632 104
E.mail: savi_horti@yahoo.co.in
(Received: 13.02.2017, Accepted: 29.09.2017)

Abstract

The Spiny brinjal (*S. melongena*) var.VRM-1 is a familiar and promising variety in Vellore district and also main dish to make a Ennai Kathirikai for briyani side dish purpose. The spines in the stalk is a major constraints for picking and handling of brinjal fruits. A breeding initiative was undertaken at Agricultural Research Station & Krishi Vigyan Kendra, Virinjipuram to mask the spiny traits through crossing programme.

The crosses were attempted to develop non-spiny brinjal with spiny quality. The both parents are pure for respective spiny and non spiny. A total of 18 crosses were made with spiny brinjal and non-spiny brinjal progenies. The true F1 was tagged in both crosses combination. In F1 plant population of Spiny x Non spiny, 100 percent of the plants expressed spiny nature. In F1 plant population of non spiny x spiny reduced percentage of partial spiny plants were observed. From this study in both cases spiny plants are observed in F1 generation which indicates spiny is expressed as dominant characters.

Further generation studies were made with continuous selfing programme and the results revealed that 100 percent non-spiny plants were obtained with high yield from cross derivative of non-spiny x spiny 3rd cross and 5th cross during fourth generation. Comparative trials were carried out during kharif 2015 and Rabi 2015-16 with spiny brinjal VRM-1. Mean performance showed that genotype non-spiny x spiny 3rd cross (1.43 kg/plant) registered the highest fruit yield per plant followed by non-spiny x spiny 5th cross (1.56 kg/plant). These genotypes could be used for further breeding programme for the improvement of fruit yield and non-spiny trait.
Key words: *Brinjal, breeding, non spiny*

Introduction

Brinjal (*Solanum melongena* L.) is an important and widely consumed Solanaceous vegetable of India grown round the year. The crop is extremely variable in India substantiated by the presence of wild relatives of *Solanum melongena* which are perennial herb or shrub with bitter fruits (Bhaduri, 1951). Though the principal method used for improvement of this crop in India is selection from indigenous germplasm, yet comprehensive characterization of this crop has not been done (Choudhury, 1976). The spines in the stalk is a major constraints for picking and handling of brinjal fruits. Spiny brinjal (VRM-1Mullukathiri) is a pure line selection from Elavambadi village of Vellore district. Spines are present in the leaf, stem and calyx of the fruit. VRM-1Mullukathiri is high yielding (30-35 t/ha^{-1}) and most suitable for North-Eastern Zone of Tamil Nadu. Selection for non-spiny plants from the spiny brinjal population was made and Crossing work was attempted to develop non-spiny fruits. The fruit set was ranged from 80-90 per cent. An attempt has been made in the present study to develop non-spiny brinjal with spiny quality for 18 genotypes. Two crosses (i.e., Spiny x Non-spiny and Non-Spiny x Spiny) were attempted to study the inheritance of non-spiny character from Spiny brinjal. In both the crosses Non-Spiny character was obtained. Cross C1 (i.e., Spiny x Non-spiny) expressed more number of non-spiny plants. However, spiny nature was observed in both the crosses indicating the partial dominance of spiny nature in both crosses.

Materials and Methods

The experiment was laid out in a randomized block design (RBD) with two replications. Ten genotypes (nine non-spiny genotypes and one spiny genotypes) were used for crossing programme. The crosses were attempted between spiny x non-spiny and non-spiny x spiny accessions. Nine non-spiny local accessions were crossed with VRM-1 spiny brinjal and reciprocal crosses were also made. Totally eighteen crosses were obtained. The generations were also forwarded from F1 to F5. The genotypes were evaluated and characterized for spinyness and yield. Each plot consisted of 50 plants spaced at 60 x 75 cm. Five random plants per replication were selected to record observations on these characters.

Results and Discussion

i)Performance of Non-spiny character in F3 generation

Two crosses i.e., Spiny x Non-spiny and Non-Spiny x Spiny was studied for the inheritance of non-spiny leaf, stem and fruits in brinjal (Table 1) in five accessions. In both the crosses Non-Spiny character was obtained. Cross C2 (i.e., Non-Spiny x Spiny) expressed more number of non-spiny plants in F2 generation.

ii) Performance of Non-spiny character in F4 generation

The F3 was found to be non-spiny in the cross Non-Spiny x Spiny, followed by Spiny x Non-spiny but only upto a certain extent. Eventhough, Spiny nature was observed in both the crosses (i.e., Spiny x Non-spiny and Non-Spiny x Spiny) indicating the partial dominance inheritance of spiny. But, two cross from Non-Spiny x Spiny (C2 and C5) was found to be 100 per cent non-spiny nature indicating the dominance of non-spiny.

iii) Performance of Non-spiny character in F5 generation with yield characters

In this generation study, the 100 percent non-spiny plants were obtained from cross derivative of non-spiny x spiny 3rd cross and 5th cross during fivth generation. These two Crosses were compared with spiny brinjal VRM-1 as yield trials in RBD during Kharif 2015 and Rabi 2015-16.

Out of 18 entries tested only two entries were selected based on single plant yield with non-spiny character. Among these two cross combination, the cross C2-5 recorded best yield performance (34.6 t/ha) on par with VRM-1 Spiny Brinjal (34.2 t/ha) (Table 3)..

The comparative trial was repeated again during Rabi 2015-16 to check the non-spiny nature in Rabi 2015-16. The selected entries revealed 100% non-spiny nature and the cross C2-5 recorded best yield performance (33.1 t/ha) (Table 4).

Non-Spiny was observed in the present study was similar to that obtained by dominance inheritance of spiny. Similar pattern of inheritance in brinjal for spiny leaf was reported earlier by Nimbalkar & More (1980) and More *et al.* (1982).

Table 1. Inheritance of Non-spiny character in parents and crosses of VRM-1 Mullukathiri in F3 generation

	Non-spiny nature (%)					
	Acc.1	**Acc.2**	**Acc.3**	**Acc.4**	**Acc.5**	**Mean**
Parents						
Spiny Brinjal	Nil	Nil	Nil	Nil	Nil	Nil
Non-Spiny Brinjal	100.00	100.00	100.00	100.00	100.00	100.00
Crosses						
C1 (Spiny x Non-Spiny)	95.00	95.83	99.16	95.83	95.83	96.33
C2 (Non-Spiny x Spiny)	88.33	79.16	75.83	86.66	85.83	83.15

† Average of three replications containing 50 plants

Table 2. Inheritance of Non-spiny character in parents and crosses of VRM-1 Mullukathiri in F4 generation

S.No.	Crosses	Non-Spiny plants (%)	No.of spines in leaf midrib	No.of spines in leaf veins
Crosses				
C1 (Spiny x Non-Spiny)				
1	C1-1	0	3.0	2.0
2	C1-2	0	4.0	2.0
3	C1-3	0	2.5	3.0
4	C1-5	0	3.0	1.0
5	C1-6	0	3.5	1.5
6	C1-7	7.69	4.0	4.0
7	C1-8	0	3.0	3.5
8	C1-9	0	4.2	3.0
Mean		0.961	3.275	2.5
C2 (Non-Spinyx Spiny)				
9	C2-1	81.42	1.0	0.5
10	C2-2	85.20	1.5	1.2
11	C2-3	100	0	0
12	C2-4	88.24	1.3	1.5
13	C2-5	100	0	0
14	C2-6	87.15	1.4	1.7
15	C2-7	80.46	1.4	2.1
16	C2-8	80.53	1.5	2.5
17	C2-9	85.27	1.1	1.7
18	C2-10	88.34	1.7	2.2
Mean		87.66	1.09	1.34
Parents				
1	Spiny Brinjal	0	4.5	3.5
2	Non-SpinyBrinjal	100	0	0

Table 3. Yield of selected two entries in Kharif 2015

S. No	Entries	Non-spiny nature (%)	Fruit yield/plant (kg)				Fruit yield (t/ha)	% of yield increase over check
			RI	RII	RIII	Mean		
1	C2-5	100	1.52	1.63	1.54	1.56	34.6	1.15
2	C2-3	100	1.72	1.65	1.52	1.43	31.7	-7.88
Check								
1	VRM-1 Spiny Brinjal	0	1.57	1.65	1.42	1.54	34.2	-

Table 4. Yield of selected two entries in Rabi 2015-16

S. No	Entries	Non-spiny nature (%)	Fruit yield/plant (kg)				Estimated fruit yield (t/ha)	% of yield increase over check
			RI	RII	RIII	Mean		
1	C2-5	100	1.61	1.51	1.36	1.49	33.1	4.22
2	C2-3	100	1.23	1.34	1.41	1.32	29.3	-8.19
Check								
1	VRM-1 Spiny Brinjal	0	1.44	1.52	1.34	1.43	31.7	-

References

Bhaduri P.N. 1951. Inter-relationship of non-tuberiferous species of *solanum* with some consideration on the origin of brinjal. *Indian J Genet.*, 2: 75-86.

Choudhury. B. 1976. Brinjal (*Solanum melongena*). In: Evolution of crop plants. Simmonds NW (ed.) New York, pp 278-279.

More D.C. S.B. Patil and V.S. Nimbalkar. 1982. Inheritance of some characters in brinjal cross SM 2 x Nimbalkar Green Round. *J. Maharashtra Agric.Univ.*,7 : 243.

Nimbalkar V.S and D.C. More.1980. Genetic studies in b rinjal (*S. melogena* L.). *J.Maharashtra Agric. Univ.*, 5: 208.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Assessment of Biochemical changes in Date palm (*Phoenix dactylifera* L.) cultivars during fruit growth and ripening

Meena Kumari, R.S. Singh, R. Bhargava, B. D. Sharma and P. K. Yadav
ICAR-Central Institute for Arid Horticulture, Bikaner-334 006 (Rajasthan)
e-mail : rssinghl@yahoo.com
(Received: 22.02.2018, Accepted: 17.04.2018)

Abstract

The study on biochemical changes in date palm (*Phoenix dactylifera* L.) cultivars was conducted at ICAR-Central Institute for Arid Horticulture, Bikaner during the year 2014. The observations on the growth of fruits were recorded from 15th April till harvesting at 15 days intervals. The assessment of biochemical changes in date palm cultivars Halawy, Khalas, Khadrawy and Shamran at different stages of growth and maturity differed significantly among the cultivars. The qualitative characters such as sugar contents (total, reducing sugars and non-reducing sugars) and ascorbic acid content increased from initial stage to *doka* stage of harvesting whereas, acidity, protein, tannin content and anti-oxidant activity increased at initial stage but exhibited a decreasing trend at *doka* stage of fruit maturity. Per cent acidity was found minimum in cv. Halawy and Khalas (0.150 %). Ascorbic acid content was highest in cv. Khadrawy (11.22 mg/100g pulp) followed by Khalas (10.61 mg /100 g pulp) at harvesting stage. Sugar contents accumulated gradually during fruit development in all cultivars were also varied among four cultivars. Cultivar Halawy found highest in sugar content (36.30% total sugars, 5.96% non-reducing sugars and 30.34% reducing sugars). Protein content varied from 1.49 % in cv. Khalas to 1.73 % in cv. Khadrawy. Tannin content varied from 0.72% in cv. Halawy to 1.00% in cv. Khalas. Anti-oxidant activity was recorded maximum in cv. Halawy (3.50 mmolTE/g) followed by. Khalas (3.22 mmolTE/g). The results revealed that cultivar Halawy is better in respect of quality parameters followed by cv. Khalas under hot arid conditions.

Key words: *Date palm, cultivars, anti-oxidant activity, sugars, protein, tannin.*

Introduction

Date palm (*Phoenix dactylifera* L.; Family Arecaceae) also known as *khajoor, kharek* is a basic dietary component of people living in semi arid and arid regions in the world. Date palm is the most successful and extremely important subsistence crop in many of the hot arid regions of the world (Zaid *et al*,2007, Chandra *et al*,1990) . In India, maximum area of date cultivation is about 17,072 ha with production of 1, 37,476 million tonne in Kachchh region of Gujarat. In Rajasthan, its cultivation has great potential in Jaisalmer, Barmer, Bikaner, Jodhpur and some parts of Churu, Sri Ganga nagar, Hanumangarh, Nagaur districts, which falls under arid climate and provided with irrigation facilities. It is a drought hardy fruit plant species and tolerates salinity. Date fruit is used for fresh consumption as well as for processed products such as wine, starch vinegar, *arak*, jam, chutney, beverages, juice and toffees. It is highly nutritions fruit and contains high calorific value (3150 calories/kg of fresh fruits), 60-65% sugar, fair amount of fibre (2.5%), protein (2.0%), fat (2.0%), vitamins (vitamin A = 220 I.U., vitamin B_1 = 0.35 mg, vitamin B_2 = 0.38 mg), minerals up to (2.0%) i.e. iron, potassium, calcium, copper, magnesium, chlorine, sulphur, phosphorus, etc. (Gopalan *et al.*, 1985). Caramel colour produced from dates which can be used in food and pharmaceuticals industries (Zaid *et al.*, 2007). The date fruit goes through five distinct growth and ripening stages (Shobana *et al.*, 1981)). These five stages are usually referred to in terms derived from Iraqi Arabic as *"Hababouk"*, *"Kimri"*, *"Khalal"*, "Rutab" and "Tamer". *"Hababouk"* stage which starts soon after fertilization and is characterized by loss of two unfertilized carpels. The *Kimri* or *gandora* represent the pea stage and immature green colour, *doka* or *Khalal* – mature full coloured and Rutab *or dang* -soft brown, Tamer *or pind*- hard raisin like (Chandra *et al.*, 1992). In our country, maximum dates are harvested at hard ripen *doka or Khalal* stage because of early rains in July month. However in Gulf countries, fruit maturity goes up to *pind* or Tamer stage. The growth and development of the fruit follows a unique pattern in the date palm cultivars (Al-Qureshi, 2010; Iqbal *et al.*, 2012). Although, work has been reported by different workers on physical and biochemical attributes in different date palm cultivars (Chandra and Pareek, 1992; Osman, 2008 and El-Agamy *et al.*, 2001). Keeping in view, the present study was undertaken to assess the biochemical changes in date palm cultivars during fruit growth under hot arid conditions.

Material and Methods

The present study was carried out at ICAR-Central Institute for Arid Horticulture Bikaner, Rajasthan during the year 2014 having four replications. The four commercial date palm cultivars *viz.*, Halawy, Khalas, Khadrawy and Shamran were taken for fruit growth and

biochemical study. The fruit samples were collected at 15 days interval (15th April, 30th April, 15th May, 30th May, 15th June, 30th June, 15th July and at harvesting) in the month of April to July 2014 for assessment of biochemical changes during fruit growth period of date palm fruits. Percent acidity and ascorbic acid and sugars were observed in fruit samples as per standard methods described by Ranganna, (2001).

Total sugars were estimated by Anthrone reagent method described by Thayumanavan and Sadasivam (1984). The absorbance was recorded at 630nm against a reagent blank in the UV-VIS spectrophotometer (Decibel, Delhi, India). The concentrations of total soluble sugars were calculated according to the glucose standard curve.

The tannin content was analyzed using Folin-Denis method described by Schander, (1970) on dry weight basis. The absorbance was recorded at 700 nm against a reagent blank in the UV-VIS spectrophotometer (Decibel, Delhi, India). The standard graph was made by using 0-100µg of tannic acid and the concentration of tannin was expressed as percentage of fresh weight.

The soluble proteins were estimated by Lawry's method (1951). The absorbance was recorded at 660nm against a reagent blank in the UV-VIS spectrophotometer. The concentrations of soluble proteins were calculated according to the standard bovine serum albumin curve.

Total antioxidant activity was analysed by CUPRAC (cupric reducing antioxidant capacity) assay recently developed by Apak *et al.*(2004) which measured the cupper (II) ion reducing ability of polyphenols, vitamin C and vitamin E. The 2 g of fruit material was extracted using 20 ml mixture of ethanol and distilled water (80:20, v/v) by centrifuging at 10000 x g for 10 min. The supernatant was used for analysis. The absorbance was recorded at 450 nm in the UV-VIS spectrophotometer (Decibel, Delhi, India). The units were expressed in µmol Trolox/ 100g.

The experimental values were analysed statistically by using Completely Randomized Design (CRD). Means were compared using soft ware. Stat package CCSHAU, Hisar at 5% level of significance.

Results and Discussion

The biochemical attributes viz., total soluble solids, acidity percentage, ascorbic acid, tannin, protein content, sugars and anti-oxidant activity of different date cultivars were assessed at 15days intervals from *kimri* to *doka* stage of fruit growth and maturity. Fruits were harvested at *doka* stage in all cultivars. The significant differences in biochemical changes were observed among the cultivars in all the stages of fruit growth and development.

Total Soluble Solids (TSS ° Brix)

The results clearly showed that an increasing trend in TSS of fruits at all fruit development stages was recorded in date palm cultivars studied (table -1). TSS of fruits in date palm variety Halawy was 41.28 °Brix at harvesting stage which was 13.85 °Brix at initial stage of fruit development that gradually increased on 15th May to harvesting stage. It is due to accumulation of carbohydrates and decrease in tannins in fruits. The highest TSS was recorded in Halawy (41.28 °Brix) followed by Khalas (39.17°Brix), Shamran (39.13°Brix) while it was lowest in cv/ Khadrawy (37.39 °Brix %). A significant difference in TSS of fruits was recorded at fruit growth, development and harvesting stages. The findings is similar to earlier workers reported by Haider *et al* (2014) ,Bacha *et al* (1987).

Acidity (%)

The acidity content followed a decreasing trend as the fruit develops in all cultivars (Table-2).The significant difference was noticed in acidity content in fruits among cultivars. It is indicated that acidity of fruits in date palm on fresh weight basis in cv. Halawy 0.150% was at harvesting stage which was 0.160% at initial stage of fruit development that gradually increased on 30th April to 30th May and decreased from 15th June to Harvesting stage. The same pattern of increase and decrease in acidity was noticed in all cultivars during fruit growth. The highest acidity percent in fruits was recorded in Shamran (0.168%) followed by Khadrawy (0.160%) and it was at par in cultivars Halawy and Khalas (0.150%). The acidity percentage in cv. Halawy and Khalas was found less. It may be due to less astringency and more sweetness at fully matured fruits in these cultivars in comparison to other cultivars. Similar findings have been reported by Abbas *et al.*, (2002) and Ebtehal and Al-Tamin (2014). Moreover, it may possibly be due to accumulation and metabolism of organic acids in the fruit during their growth and development.

Ascorbic acid (mg/100 g fruit pulp)

The data presented in table 3 revealed that ascorbic acid content of fruits in date palm on fresh weight basis increased from initiation of fruit development to harvesting stage.). Difference among the cultivars in ascorbic acid content was significant at all the fruit development stage. In cv. Halawy ascorbic acid content was 8.04 mg/100 g at harvesting stage which was 1.04 mg/100 g at initial stage of fruit development that gradually increased on 30th April to 15th July and it was highest at Harvesting stage. The same pattern of increase in ascorbic acid was noticed in other varieties at different stages.

The highest ascorbic acid content was recorded in cultivar Khadrawy (11.22 mg/100 g) followed by Khalas (10.61 mg/100 g), Shamran (10.37 mg/100 g) and lowest in Halawy (8.04 mg/100 g. Ascorbic acid content increased from initial stage of fruit growth and was highest at *doka* stage of ripening. Sawaya *et al.*, (1983) reported that vitamin C content was higher at *Khalal* stage. Marbet et al. (2008) reported vitamin C content 24 to 46 mg/100 g whereas, Ebtehal and Al-Tamin (2014) reported 10.52 mg/100 vitamin C in Saudi Sukhari and Egyptian Sewi date palm samples. Similar results have been reported by Chandra and Choudhary (1990).

Total sugars (%)

The total sugar content of fruits in date palm cultivar Halawy was 36.30% at *doka* stage of harvesting which was 4.25% at initial stage of fruit development that gradually increased on 15th May to Harvesting. On 15th May the magnitude of sugar was 6.32%, which increased to 12.60% by 30th May. It nearly doubled (24.48%) by 15th June and then slightly increased to 28.25% by 30th June and reached to the level of 34.40% by 15th July. Total sugar content in cultivar Khalas 34.40% at harvesting stage which was 4.05% at initial *kimri* stage of fruit development which subsequently increased from 15th May to 15th July and highest at harvesting stage. Increase in total sugar was observed from *Kimri* to *doka* stage of harvest. The highest total sugars content was recorded in Halawy (36.30%) followed by Khalas (34.40%), Shamran (34.06%) while lowest in Khadrawy (32.49%). A significant difference in total sugars content in different date palm cultivars was found at fruit development stages(table-4). Total sugars are a varietal character and its quantity depends on cultivar. Total sugars increased from initial stage of fruit development which was highest at *doka* stage of harvesting. Elahmer *et al*., (2007) reported total sugars were found highest in Ammi (49.49%) followed by Tabouni (38.54%) and lowest in Brinsi (35.87%). Muhhamad *et al* (2011) reported the total sugar content was much higher in date palm grown in Dera Ismail Khan (71.05%). Similar resuhs were observed by Gasim *et al*., (1994); Awad *et al*., (2011); Taain *et al*., (2013); Ebtehal and Al-Tamin (2014).

Reducing sugars (%)

It is clearly indicated that highest reducing sugar content of fruits in date palm cultivar Halawy was 30.34% at harvesting stage which was 3.91% at initial stage of fruit development that gradually increased on 15th May to Harvesting (table -5).

Reducing sugars content was highest in Halawy (30.34%) followed by Khalas (29.05%) and Shamran (29.03%) while it was lowest in Khadrawy (27.52%). Difference among the cultivars was significant in relation to reducing sugar content at all the fruit development stages. Carbohydrate metabolism is the most activated pathway at every single stage of the fruit development and ripening in date palm with in this also, the genes directly associated with sugar metabolism are much more activated at the later stage of fruiting. This pattern accounts for gradually increasing reducing sugar content in date palm. The high level of total sugars in date fruits are due to the up gradation of sucrose phosphate synthase and inverts at the later stage of fruit growth.

Protein content (%):

The soluble protein content decreased from *kimri* to *doka* stage of maturity. Data clearly showed that protein content of fruits on fresh weight basis in cv. Halawy was 1.67% at harvesting stage which was 1.5% at initial stage of fruit development that gradually increased on 30th April to 30th May and decreased from 15th June to Harvesting stage (table 6). The significant difference among cultivars in respect of protein content was recorded. The highest protein content was recorded in Khadrawy (1.73%) followed by Halawy (1.67%) and Shamran (1.56%) while it was lowest in cv. Khalas (1.49%).The finding is similar to the results reported by Haider *et al* (2013).

Tannin content (%)

There is a significant difference in tannin content of date palm fruits at growth and development stages. (Table 7). The tannin content was estimated in fruit samples from 15th May onwards in date palm cultivars. Tannins content of fruits in date palm on dry weight basis in cv. Halawy was 0.72% at harvesting which was 1.4% at initial stage of fruit development that gradually increased on 30th May to 15th June and decreased from 30th June to Harvesting stage. Increase in tannin content was noted at initial stage of fruit growth which showed the decreasing trend of tannin content at later stage of fruit development during July month. It is because of breakdown of tannins and protein compounds in to simple soluble sugars due to the role of enzymes in fruit development process.

The highest tannin content was recorded in cultivar Khalas (1.00%) followed by Khadrawy (0.95%), and Shamran (0.82%) while it was lowest in cv. Halawy (0.72). This is in general agreement with findings of Mougthith *et al* (1976).

Anti–oxidant activity (mmolTE/g)

There is a significant difference in anti-oxidant activity among date palm cultivars at different fruit growth and development stages (table-8). The maximum anti-oxidant activity was recorded in Halawy (3.505 mmolTE/g) followed by Khalas (3.225 mmolTE/g) and Shamran cultivar (3.158 mmolTE/100 g). Lowest anti-oxidant was observed in Khadrawy cv. (3.083 mmolTE/g) at harvesting stage. The results showed the increasing trend in anti-oxidant activity, tannins contents from *kimri* to *doka* stage in all cultivars. The tannin content and total phenols are the major contributors to the antioxidant activity. An increase in anti-oxidant activity may due to high tannin and phenolic compounds during fruit development stages. However, gradual decreasing in anti-oxidant activity possibly is due to decreasing trend in tannin and other phenolic compounds at colour turning and maturity in fruits.

The finding is in accordance to results reported by Al-Farsi *et al*, (2005) in date palm cultivars.

In the present study, the changes in metabolite composition were assessed from kimri to doka stage of date fruits. It was observed that majority of the metabolites increases with the advancement of growth stage. Those such changes occur in date fruits has been demonstrated by Abbas and Fandi (2002), Ebtehal and Al-Tamin (2014), etc. In the present study too, it was reported that metabolites such as total sugars and reducing sugars increased with the stage of development. This is on account of fact that fruit acts as sink and accumulates the carbohydrates produced in the leaves. This accumulation then leads to changes in TSS, which is also apparent in our study. Thus, our study shows that fruits are highly

active sinks which accumulates the carbohydrates in the form of reducing and non reducing sugars which are then converted into other complex forms with the growth and development of the fruit. Among the varieties studied, cv. Halawy was found to be best since it has more number of berries, high TSS, sugar content, anti-oxidant activity and minimum acidity.

Table 1. TSS (°Brix) of different Date palm cultivars during fruit growth and maturity stages.

Treatments	April	May		June		July	Harvesting
	30	15	30	15	30	15	Final
Halawy	13.85	15.26	16.68	19.72	30.41	39.00	41.28
Khalas	11.45	13.84	14.06	17.33	24.06	36.04	39.17
Khadrawy	11.23	12.51	13.67	15.90	23.43	33.75	37.39
Shamran	12.45	13.17	13.75	16.09	19.86	34.03	39.13
CD at 5%	1.512	1.054	0.908	1.184	2.232	1.807	1.489

Table 2. Acidity (%) in fruits of different Date palm cultivars during fruit growth and maturity.

Treatments	April		May		June		July	Harvest
	15	30	15	30	15	30	15	Final
Halawy	0.160	0.268	0.330	0.343	0.320	0.270	0.265	0.150
Khalas	0.170	0.280	0.340	0.375	0.320	0.285	0.270	0.150
Khadrawy	0.180	0.188	0.353	0.563	0.360	0.293	0.285	0.160
Shamran	0.170	0.180	0.595	0.615	0.428	0.320	0.310	0.168
CD (P=0.05)	0.013	0.048	0.061	0.154	0.068	0.018	0.017	0.013

Table 3. Ascorbic acid (mg/100 g) in fruits of different Date palm cultivars

Treatments	April		May		June		July	Harvest
	15	30	15	30	15	30	15	Final
Halawy	1.04	1.28	1.70	2.14	3.65	6.34	7.19	8.04
Khalas	0.59	1.07	1.58	1.64	5.85	9.27	10.24	10.61
Khadrawy	1.22	1.37	1.82	2.29	4.51	8.78	10.73	11.22
Shamran	0.49	1.04	1.34	2.19	6.09	7.07	10.00	10.37
CD (P=0.05)	0.09	0.16	0.20	0.16	0.65	0.96	0.92	1.60

Table 4. Total sugars (%) in fruits of different Date palm cultivars

Treatments	April	May		June		July	Harvest
	30	15	30	15	30	15	Final
Halawy	4.25	6.32	12.60	24.48	28.25	34.40	36.30
Khalas	4.05	5.44	10.71	21.81	23.72	32.49	34.40
Khadrawy	4.17	5.88	12.29	23.72	24.48	28.91	32.49
Shamran	3.41	5.36	9.91	19.49	21.81	31.54	34.06
CD (P=0.05)	0.48	0.59	0.23	0.39	0.42	0.24	0.23

Table 5. Reducing Sugars (%) in fruits of different Date palm cultivars

Treatments	April	May		June		July	Harvest
	30	15	30	15	30	15	Final
Halawy	3.91	4.99	9.47	21.00	23.72	29.57	30.34
Khalas	3.76	4.26	7.55	18.10	18.88	27.55	29.05
Khadrawy	3.69	4.32	9.57	19.83	19.94	24.11	27.52
Shamran	3.09	4.17	7.14	16.50	17.82	27.37	29.03
CD (P=0.05)	0.07	0.04	0.06	0.06	0.14	0.06	0.08

Table 6. Protein content (%) in fruits of different Date palm cultivars

Treatments	April		May		June		July	Harvest
	15	30	15	30	15	30	15	Final
Halawy	1.50	2.64	4.76	5.21	3.94	2.88	2.23	1.67
Khalas	1.25	2.33	4.61	5.03	3.84	2.78	2.08	1.49

Khadrawy	1.56	2.74	4.86	5.32	4.20	3.11	2.30	1.73
Shamran	1.31	2.41	4.67	5.13	3.89	2.79	2.12	1.56
CD (P=0.05)	0.07	0.14	0.10	0.06	0.18	0.09	0.13	0.05

Table 7. Tannin content (%) in fruits of different Date palm cultivars

Treatments	May		June		July	Harvest
	15	30	15	30	15	Final
Halawy	1.42	1.64	2.23	2.08	1.07	0.72
Khalas	1.77	1.99	2.70	2.45	1.41	1.00
Khadrawy	1.61	1.74	2.40	2.22	1.29	0.95
Shamran	1.47	1.64	2.00	2.17	1.20	0.82
CD (P=0.05)	0.06	0.05	0.07	0.05	0.05	0.04

Table 8. Anti-oxidant activity (mmolTE/g) in fruits of different Date palm cultivars

Treatments	April		May		June		July	Harvest
	15	30	15	30	15	30	15	Final
Halawy	1.395	3.043	5.535	6.015	4.443	4.173	3.683	3.505
Khalas	1.263	2.970	5.310	5.793	4.195	3.703	3.505	3.225
Khadrawy	1.203	2.365	5.203	5.670	3.798	3.593	3.230	3.083
Shamran	1.230	2.515	5.170	5.643	3.890	3.663	3.393	3.158
CD (P=0.05)	0.089	0.479	0.081	0.071	0.073	0.074	0.099	0.153

References

Abbas, M.F. and Fandi, B.S. 2002. Respiration rate, ethylene production and biochemical changes during fruit development and maturation of Jujube (*Ziziphus mauritiana* Lamk.). *Journal of the Science of Food and Agriculture*, 82(13): 1472-1476.

Apak, R., Guelu,K. Ozyurek,M.and Karamdemir,S.K..2004. Novel antioxidant capacity index for dietary polyphenols and vitamin C and E using their cupric ion reducing capability in presence of neocuprine:CUPRAC method. *Jour. Agric and Food Chemistry*, 52: 7970-81.

Al- Qureshi, Adel D. 2010. Physico- chemical changes during development and ripening of "Helali" date palm fruit. *Journal. Food Agriculture & Environment*, 8(2): 404-408.

Al-Farsi, M., Alasalvar, C., Morris, A., Baron, M. and Shahidi, F. 2005. Composition of anti-oxidant activity, anthocyanins, carotenoids and phenolices of three native fresh and sun dried (*Phoenix dactylifera* L.) varieties grown in Oman. *Journal of Agricultural and Food Chemistry*, 53(19): 7592-7599.

Awad, M. A., Al-Qurashi, A.D. and Mohamed, A.S. 2011. Biochemical changes in fruit of an early and a late date palm cultivar during development and ripening. *International Journal of Fruit Science*, 11: 167-183.

Bacha, M.A. Nasr, T.A. and Shaheen, M.A. 1987. Changes in Physical and chemical characteristics of the fruits of four date palm cultivars. *Proc .Saudi Biol. Soc.*, 10: 285-295.

Chandra, A. and Choudhary, N.L. 1990. Performance of date palm cultivars in the Thar desert. part II. *Curr. Agric.*, 14:1-4

Chandra, A. and Pareek, O.P. 1992. A note on the performance of different date palm cultivars under Bhojka (Jaisalmer) conditions of Rajasthan. *Haryana Journal Hort. Sci.*, 21 (3-4): 205-207.

Chandra, A., Chandra, Anju and Gupta, I. C. 1992. Date palm Research in Thar Desert. Scientific Publisher, Jodhpur, 116 pp.

Ebtehal and Al-Tamim. 2014. Comparative study on the chemical compostion of Saudi Sukkari and Egyptian Sewi date palm fruit. *Journal of American Science*, 10(6): 149-153.

Elahmer, R.A., Madi, N.S., Nahaisi, M.A. and Thabet, A.I. 2007. Some physical and chemical properties of three varieties of Libyan soft dates. *Acta Horticulture*, pp. 489-895.

El-Agamy, El-Mahdi, T.K. and Khalil, O.A. 2001. A comparative study of the performance of soft date grown arid environment. Proc. In: The 2nd International Conference on Date palm, 25-27 March 2001, Al-Ain, UAE. pp. 686-710.

Gasim, A.A.A., Al-madinah, Al-munawwarah, 1994. Changes in sugar quality and mineral elements during fruit development in five date palm cultivars. *JK AU. Sci.*, 6: 29-36.

Gopalan, C. Ramasastri, B.V. and Balasubramanium, S.C. 1985. Nutritive Value of Indian Foods, National Institute of Nutrition, ICMR, Hyderabad, 87pp.

Haider, M.S., Khan, I.A., Naqvi, S.A., Jaskani, M.J., Khan, R.W., Nafees, M., Maryam and Pasha, I. 2013. Fruit development stages effects on biochemical attributes in date palm. *Pakistan Journal of Agricultural Sciences*, 5(4): 577-583.

Iqbal, M., Rehman, U.U., Niamatullah, S.M.Khan and Akhtar, A. 2012. Periodic growth and development in fruits of different date cultivars grown under the agro-climatic conditions of D.I. Khan. *Pakistan Journal Sci.*, 64(3): 259-264.

Lowry, O.H., Rosebrough, N.J., Farr, A.L. and Randall, R.J. 1951. Protein measurement with Folin-Ciocalteau reagent. *Journal Biol. Chem.*, 193: 265-275.

Muhammad, N., Salim-ur, R., Anjumand, F.M. and Bhatti, I.A. 2011. Quality evaluation of some Pakistani date varieties. *Pakistan Journal of Agricultural Sciences*, 48(4): 305-313.

Mougheith,M.G.,Hassaballa,I.A. and El-Ashram,M.M. 1976. Comparative study on fruit development, quality and bunch characteristics at harvest of some Egyptian date cultivars. Annals of Agri. Sci. Mastohar ,Egypt, 5:177-193.,

Mrabet, A., Ferchichi, A., Chaira, N., Mohamed, B.S., Baaziz, M. and Penny, T.M. 2008. Physico-chemical characteristics and total quality of date palm varieties grown in the southern of Tunisia. *Pakistan Journal of Biological Sciences*, 11(7): 1003-1008.

Osman, S.M. 2008. Fruit quality and general evaluation of Zaghloul and Samany date palm cultivars grown under conditions of Aswan. *American-Eurasian Journal of Agricultural and Environmental Science; 4(2): 230-236.*

Ranganna, S. 2000. Manual of Analysis of Fruits and Vegetables Products. 3rd Ed., Tata McGraw Hill Publishing Co. Ltd., New Delhi, India.

Schanderl, S.H. 1970. Tannin measurement with Folin-Denis reagent. In: *Method in Food Analysis*, Academic Press, New York, pp. 709

Shobana, H.R., Benjamin, N.D. and Mohammed, S. 1981. Pattern of growth and development in date palm fruit. *Date palm* Journal, 1: 31-42.

Taain, D.A., Taresh, S.H. and Ati, M.A.A.Z. 2013. Study on physical, chemical and enzymatic characteristics of date palm fruits (*Phoenix dactylifera* cv. Hilalli) during development. *Diyala Agricultural Sciences Journal*, 5(2): 203-212.

Thayumanavan, B. and Sadasivam, S. 1984. In. *Qual. Food Hum. Nutr.*, 34:253.

Zaid, A., Hegarty, V. and Kaabi, H.H.S. 2007. Proceedings of the III International Date palm Conference. *Acta Horticulture* 736, pp. 586.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Effect of GA_3 and cow urine on seed germination and seedling growth of custard apple

Vikas Yadav*, A. K. Singh and V.V. Appa Rao
Central Horticultural Experiment Station (ICAR-CIAH), Vejalpur- 389340, Panchmahals, Gujarat, India\
*Corresponding author's e-mail: vikasyadav.hot@gmail.com
(Received: 6.04.2018; Accepted: 8.05.2018)

Abstract

The objective of this study was to determine the effect of GA_3 and cow urine on seed germination and seedling growth of custard apple. The results of present study showed the significant differences with respect to effect of seed soaking in different concentration of GA_3 *i.e.*, 200, 400, 600 ppm and cow urine with 15% and 20% also and in combination. Seeds were soaked for 72 hours in all treatments Result of study revealed the positive effect of GA3 alone and in combination with cow urine in germination percentage, seedling growth, seedling diameter, no. of leaves and vigour index. Among the various treatments, GA3 (400ppm) in combination with cow urine (15%) exhibited the germination (92.405), whereas it was showed lowest in control (50.07%). However, GA_3 alone had also positive effect on its germination and seedling growth.

Key Words: *Annona squamosa, Cow urine, GA_3, Seed germination*

Introduction

Custard apple is successfully growing in humid to arid and semi arid region. It is highly suitable for the utilization of dry waste land areas due to its drought hardy nature and less water requirement. The custard apple have very short fruiting season about six month, flowering start with onset of monsoon and fruit harvest in end of October-November. The plant remains in dormant condition from December to May in hot semi arid condition. Therefore, custard apple can be successfully grown in these areas under natural delayed monsoon rain only. The propagation of custard apple through seed is difficult due to seed dormancy, which shows low uneven and irregular germination of seed. In many plants, viable seeds unable to germinate after sowing in right time and even under favourable environmental conditions. This seed condition is known as seed dormancy (Taiz, Zeieger 2002). Seeds are most important for easy propagation and future breeding programme of particular fruit crops. There are numbers of internal factors responsible for seed dormancy like hard seed coat factors, embryo factors or inhibitors (Agrawal and Dadlani 1995). Few methods are being commercially utilized to overcome dormancy, which vary from species to species, like heating, stratification, scarification and gibberellins application (Black, 1980 and Narbona et al. 2003). In above status methods, GA3 treatment of seeds were found most effective to break dormancy and influence the seed germination but it concentration vary from species to species (Karam, Al-Salem 2001).

Generally Custard apple requires 25-40 days for seed germination in normal condition (Hernandez, 1983). So far, little work has been carried out on this aspect in custard apple particularly under dry land condition. Therefore, seed treatment of custard apple with organics is required to improve germination. In order to avoid the problem of irregular germination and also to reduce germination period, seed treatment of custard apple seed is very important. Therefore, this study was conducted to find out the effect of GA_3 and organics on seed germination and seedling growth of custard apple under hot semi arid condition.

Material and Methods

The present study was carried out at nursery unit of Central Horticultural Experiment Station (ICAR-CIAH), Vejalpur, Panchmahals during 2016-2017. The experiment was laid out in randomized block design with three replications. There were twelve treatments like T_1: seed soaking in tap water for 72 hours (control), T_2: seed soaking in 15% cow urine for 72 hours, T_3: seed soaking in 20 % cow urine for 72 hours, T_4: seed soaking in 200 ppm GA_3 for 72 hours, T_5: seed soaking in 400 ppm GA_3 for 72 hours, T_6: seed soaking in 600 ppm GA_3 for 72 hours, T_7: seed soaking in 200 ppm GA_3+15% cow urine for 72 hours, T_8: seed soaking in 200 ppm GA_3 +20% cow urine for 72 hours, T_9: seed soaking in 400 ppm GA_3 +15% cow urine for 72 hours, T_{10}: seed soaking in 400 ppm GA_3+20% cow urine for 72 hours, T_{11}: seed soaking in 600 ppm GA_3 +15% cow urine for 72 hours and T_{12}: seed soaking in 600 ppm GA_3 +20% cow urine for 72 hours.

Collection of Cow Urine

Fresh cow urine of local variety of cow was collected from a local animal farm. The urine was filtered through Whatman No. 1 filter paper to get rid of debris and precipitated material was used as seed soaking.

Collection of Seeds

The seeds of custard apple were collected from fully mature fruits of Balanagar custard apple variety at Central Horticultural Experiment Station (ICAR-CIAH) farm, Vejalpur, Panchmahals.

After treatments, and completion of soaking period (72 hours) fully soaked seeds were selected and sown in 10th June 2017 at uniform distance in polythene bags. The size of polythene bag is 11 x 9 cm and each polythene bag consists of 5 seed, means each treatment has 10 polythene bags. Every polythene bag was filled with a composite media, which consists of soil, FYM and sand in ratio of 1:1:1. The percentages of germination of seeds were calculated according to the rules for seed testing (ISTA, 1996). The seedlings were allowed to grow for six months (June to November, 2017). After six months, 10 seedlings for each treatment were selected for measuring growth parameters; shoot and root length, seedling diameter and number of leaf. The data on germination and seedling growth under various treatments were statistically analyzed. Vigour index was calculated according to Abdul-baki and Anderson (1973) as germination per cent × seedling total length (total shoot + root length). The data was analyzed by statistical significant at $p<0.05$ level, S.E. and C.D. at 5 per cent level by the procedure given by Gomez and Gomez (1984).

Result and discussion

Effect on germination

The germination percentage of custard apple seed treated with GA_3, cow urine and its combination are summarized in Table & fig (1), the differences between treatments and control were significant 25, 30 and 35 day after sowing. Results showed that treatment of seeds with GA_3 and its combination with cow urine had markedly improved germination from 82.08 % and 92.4% when compare out with control 50.07%. It is clear from the Table1 that seeds treated with GA_3 alone and with combination of cow urine hasten the germination than untreated seed (control). The GA_3 and in combination with cow urine, the germination percentage at 25, 30, and 35 days after sowing was recorded as 10.56-18.42 %, 23.87-45.23 % and 26.85-34.62 %, respectfully. While in control and cow urine alone treated seed germination percentage was 6.23-10.23 %, 15.28-22.21 % and 28.56-31.23% in 25, 30 and 35 days after sowing, respectively. Result of study revealed that cow urine is not effective in hasten of seed germination. It may be due to presence of nutrients in cow urine (Phrimantoro, 1995) and very less amount of auxins substances (Palani et. al., 1995) which are unable to break the seed dormancy. High and early germination percentage for custard apple seed was found in GA_3 and in combination with cow urine treated seed. It may be due to synergic effect of cow urine and GA_3. The GA_3 hormone increase cell size of embryo (Black, M., 1980) by stimulating the cell wall to release and transmit its calcium in the cytoplasm which makes favourable condition for absorption of water and cell growth and activation of hydrolytic enzyme (Taiz & Zeieger, 2002; Roy, 1974) and cow urine might have provided essential elements that are needed by seed at time of germination such as N, P, K Ca, and Na and stimulate the hydrolytic enzyme. The highest germination percent was noted in T_9 (92.4%) followed by T_7 (87.94%), T_{11} (75.24%) and T_{12} (73.03%) while lowest was observed in T_1 (control) at 35 days after sowing (DAS) of seeds.

Effect on growth of seedling

In Table & Fig (1) results are shown the positive effects of GA_3 and cow urine treatment on shoot and root length, seedling diameter, no. of leaf/ young seedling and vigour index after germinated. The treatment T_9 gave the highest values ranging from 47.23 cm, 42.36 cm, 8.12 mm, 26.42 and 8278.116 comparing with the control 25.12 cm, 22.18 cm, 7.38 mm, 20.32 and 2368.311 respectively. Custard apple seeds treated with (400 ppm GA_3 + 15 % cow urine) germinated early and grown quickly which accelerate the difference in seedling growth, seedling diameter, number of leaf and vigour index. The present results are in agreed with the findings of Dzayi (2010). It may be due to growth promotional effect of GA_3; it stimulates and accelerates cell division, increased cell elongation and enlargement or both (Hartmann et al. 1990). Early germination caused by gibberellic acid which provided enough time to the plant for proper growth and development. However, cow urine gave positive effect on young seedling, may be due presence of essential plant nutrient and auxin substances and which ultimately resulted in increased length of root and shoot, diameter of seedling and leaf numbers. These finding more or less similar with finding of Sankaranarayanan et al. (1994); Vanagamudi (2003) in tamarind, Hango et al. (1999) in Albizia lebbeck, Ramachandrudu and Thangam (2007) in gladiolus and Swamy et al. (1999) noticed highest germination per cent, shoot length and root length when jamun seeds.

In this study, we increase period of soaking seed because long time soaked seed gave higher germination due to maximum removal of germination inhibitor (Dzayi, 2010; Al- Hawezy, 2013). These finding closely related to the Kose (1998), which reported that *A. unedo* seed gave maximum germination when treated with 400 ppm GA_3.

From the foregoing discussion it can be concluded that among the different treatment, T_9 (seed soaking in 400 ppm GA_3 + 15 % cow urine for 72 hours) is found superior and most effective for seed germination and better growth of custard apple seedlings over the rest of the treatment combinations.

Acknowledgement

We are thankful to the Director of Central Institute for Arid Horticulture (ICAR-CIAH), Bikaner and Head, Central Horticultural Experiment Station (ICAR-CIAH), Vejalpur, Gujarat, India for providing necessary facilities for research.

Table 1. Effect of GA_3 and cow urine on seed germination and growth of custard apple seedling

Treatments	Germination %			Total germination %	Length (cm)		Seedling diameter (mm)	No. of leaf/seedling	Vigour index
	25 Days	30 Days	35 Days		Shoot	Root			
T_1	06.23	15.28	28.56	50.07	25.12	22.18	7.38	20.32	2368.311
T_2	08.26	22.21	31.23	61.7	31.27	34.23	7.42	21.56	4041.35
T_3	10.23	22.18	29.45	61.86	26.45	24.16	7.32	16.25	3130.735
T_4	11.89	27.56	28.12	67.57	28.12	22.45	7.62	17.38	3417.015
T_5	12.36	24.12	34.62	71.10	41.35	35.26	7.56	20.45	5446.971
T_6	10.56	24.63	26.89	62.08	32.25	36.85	7.60	21.45	4289.728
T_7	15.56	40.12	32.26	87.94	44.12	40.18	8.09	22.63	7413.342
T_8	11.58	23.87	33.26	68.71	38.26	40.23	8.00	24.00	5393.048
T_9	18.42	45.23	28.75	92.40	47.23	42.36	8.12	26.42	8278.116
T_{10}	15.23	30.54	26.85	72.62	42.56	40.23	7.63	20.47	6012.210
T_{11}	12.83	34.86	27.56	75.25	38.62	39.75	7.78	21.62	5897.343
T_{12}	12.46	32.45	28.12	73.03	37.42	38.16	8.10	17.56	5519.607
C.D. (P=0.05)	0.44	2.50	7.15	3.22	0.04	1.17	0.26	1.34	22.06

Fig. 1: Effect of GA_3 and cow urine on seed germination % of custard apple

Fig. 2: Weather data of CHES in 2016-17

References

Abdul - Baki, A. and Anderson, J.D. 1973. Vigour determination in Soybean seed by multiple criteria. *Crop Science*, 13: 630-633.

Agrawal, P.K., Dadlani, M. 1995. Techniques in Seed Science and Technology, 2nd Ed. India, South Asian Publishers Limited: 179.

Black, M. 1980. Role of indogenous harmones in germination and dormancy of fruit crops. *Israel Journal of Botany*, 29: 181-192

Dzayi, F. H. Rahman. 2010. Effect of GA3 and Soaking time on Seed Germination and Seedling Growth Lemon (*Citrus limon* L.) High Diploma. Thesis college of Agriculture, university of Salahaddin – Erbil.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for Agricultural Research. 2nd Edition Awiley Inter Science. Publication, New York (USA).

Hattmann, H. T., Kester, D. E. and Davies F. T. 1990. Plant Propagation Principles and Practices. Englewood Cliffs, NJ: Prentice- Hall.

Hernandez, L.V. 1983. La reproduction sexually multification vegetative de las Anonaceas (Spanish) Universidad Veracruzana. Vera Cruz, Mexico. 102-122pp.

Ilango, K., Mallika, V.K., Vanangamudi, A., Venkatesh, R.S., Vinaya, R.S. and Balaji, S. 1999. Effect of growth stimulants on seed germination and seedling vigour in Albizia tebbeck (L). *Seed Research*, 27(2): 188-190.

International Seed Testing Association, International Rules for Seed Testing, Rules 1996.

Karam, N.S. and AL-Salem, M.M. 2001. Breaking dormancy in Arbutus and rachna L. seeds by stratification and gibberellic acid. *Seed Science and Technology*, 29:51–56.

Kose H., 1998. Studies on the germination of some woody ornemental plants existing in Turkish Flora. I. *Arbutus unedo* L. and *Arbutus andrachne* L. Anadolu. *Journal of Aegean Agricultural Research*, 8: 55–65.

Narbona, E., Arista, M. and Ortiz, P.L. 2003. Seed germination of *Arbutus unedo* L. (Ericaceae). *Acta Botanica Malacitana*, 28: 73–78.

Palani, M., Dasthagir, M. G. & Kumaran, K. 1995. Effect of pre-sowing chemical treatment on germination and seedling growth in *Acacia nilotica*. *International Tree Crops Journal*, 8: 189-192

Phrimantoro. 1995. Cow Urine as Element of Plant Hara Stockholm Environment Institute, *EcoSan Res Series*, 2009-10.

Ramachandrudu, K. and Thangam, M. 2007. Response of plant growth regulators, coconut water and cow urine on vegetative growth, flowering and corm production in gladiolus. *Journal of Ornamental Horticulture*, 10(1): 38-41.

Roy D.F. 1974. *Arbutus menziesii* Pursh. (Pasific Madrone). In: Seed of Woody Plants in the United States. Washington, USDA.

S M N Al-Hawezy (2013). The role of the different concentrations of GA3 on Seed Germination and Seedling Growth of Loquat (*Eriobotrya japonica* L.). Journal of Agriculture and Veterinary Science (IOSR-JAVS) e-ISSN: 2319-2380, p-ISSN: 2319-2372.Volume 4, Issue 5 (Sep. - Oct. 2013), PP 03-06.

Sankaranarayanan R. and Vijayakumar M. 1994. Cow urine for ideal seed germination in tamarind. *Indian Horticulture*, 38(4): 15.

Swamy, G.S.K., Patil, P.B., Athani, S.I. and Prabhushankar, D.S. 1999. Effect of organic and inorganic substances on germination of jamun (*Syzygium cumini*) seeds. *Advaces in Agricultural Research in India*, 11: 89-91.

Taiz, L. and Zeieger, E. 2002. Plant Physiology, 3rd Ed. USA, Sinauer Associates, Inc.: 544–546.

Vanangamudi K. and Vananganudi M. 2003. Response of tamarind (*Tamarindus indica L.*) to presowing seed treatment with growth stimulants. *Journal of Tropical Forest Science*, 15:1.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Performance of fruit trees (drip irrigation) and intercrops(Rainfed) under Agri-horti system in arid Western Rajasthan

N.D.Yadava, M.L. Soni, V.S. Rathore, and P.S. Renjith
ICAR-Central Arid Zone Research Institute, Regional Research Station Bikaner-334004 (Rajasthan), India.
(Received: 12.01.2018; Accepted: 9.06.2018)

Abstract

Moth bean (*Vigna aconitifolia* L.), cluster bean (*Cyamopsis tetragonoloba* L.Taub.) and sonamukhi (*Cassia angustifolia* Vahl.) were grown as intercrops under agri-horti-silvi system with 7-year-old plantations of citrus [*Citrus aurantifolia* (Cristm.) Swinglel, bael [Aegle marmelos (L.) Correa] and gonda (*Cordia myxa* L.) at research farm of Central Arid Zone Research Institute, Regional Research Station, Bikaner, during two consecutive years of 2008 and 2009. Highest seed and stover yield of moth bean (460 & 1881 $kgha^{-1}$ in 2008 and 320 & 1304 kg/ha in 2009) and cluster bean (623 & 2146 $kgha^{-1}$in 2008 and 533 & 1838 $kgha^{-1}$ in 2009) as well as, the leaf and seed yield of sonamukhi (323 & 53 $kgha^{-1}$ in 2008 and 415 & 80 $kgha^{-1}$ in 2009) was recorded in intercropping with citrus. Among the different levels of irrigation applied to fruit trees, irrigation at 80% of potential crop evapotranspiration (ETc) gave the highest yield and water use efficiency in all the crops, while the lowest was recorded at 40% ETc. It was also observed that cluster bean intercropped with citrus recorded the highest WUE (3.76 ($kgha^{-1}mm^{-1}$).

Key words: *Agri-horti system, drip irrigation, inter cropping, western Rajasthan*

Introduction

The Indian arid zone which covers around 12% of country's geographical area is characterized by low and erratic rainfall with extremes of temperature (1-48°C), high wind velocity and structure less sandy soil with low water holding capacity and poor nutrient status (Kaushik *et al.*, 2014). These are compounded by unsustainable use of land and increasing human population, placing unprecedented demand for food and natural resources, challenging most of the arid and semi-arid regions with the task of producing more per unit land with the innate limitations associated with them. Arable cropping in the arid region is often risky and crop yields are meagre and unstable; and consequently the income from existing cropping alone is insufficient to sustain the farmers' family. Therefore, to mitigate the risk and uncertainty of the income from conventional cropping, it is crucial to integrate various agricultural enterprises in the production programme and develop location specific land use management systems which can improve total land productivity and give sustainable agricultural production and provide economic stability to the farmers throughout the whole year.

An integrated approach of land management in arid areas is essential for efficient utilization of natural resources, to meet the requirements of farmers without deteriorating the land productivity and also to stabilize the income. With their modest rainfall, arid regions are characterized by relatively fewer species than the better-watered biomes but are endowed with appreciable agro-ecological diversity and hence various components viz. crop, animal, tree, grass, fruit tree can be integrated in production system for livelihood security. Perennials-based production systems: agri-horticulture and agro-forestry are considered effective strategy for improving productivity, employment opportunities, economic condition and nutritional security (Pareek, 1999; Chadha, 2002). They are essential for meeting the requirements of the ever-increasing population and managing natural resources. Agroforestry systems can enhance the total production by improving soil fertility (Singh, 2010), controlling erosion and replenishing nutrients removed through biomass harvest (Ilany *et al.*, 2010), improving microbial population (Yadav *et al.*, 2008; Vallejo *et al.*, 2012), economic benefits (Jianbo 2006; Fadl & Sheikh 2010), and nutrient and water-use efficiency (Anderson *et al.* 2009; Pinho *et al.*, 2011). The objective of introducing woody perennials in farming system is not only to cover the risk of crop failures but also to meet the demand for fuel, food, fruit, fodder and small timber. Traditional tree-integrated farming systems are adopted since time immemorial for security of food, fodder and fuel wood in drought-prone arid regions (Ndayambaje and Mohren, 2011; FAO, 2013), but are unable to meet the requirement of the ever increasing biotic pressure. Also, in most of the regions, people are unenthusiastic to adopt agroforestry because of lesser short term benefits from tree species.

Agri-horticultural systems which integrate horticultural species with arable crops ensure income to the farmers much earlier. Integration of horticultural species provides income at regular intervals to the farmers, in addition to production obtained from

agricultural crops during the early stages of tree establishment (Kaushik and Kumar, 2003). Agri-horticultural systems can provide increased income throughout the year and minimize the risk of total failure of the system productivity as in traditional agriculture. Keeping in view these findings, an experiment was conducted at research farm of ICAR-Central Arid Zone Research Institute, Regional Research Station, Bikaner during 2008 and 2009 with the objectives of assessing the performance of different trees and crops in agri-horti system in arid part of western Rajasthan at the higher age of trees even (up to 8 years).

Material and methods

The present investigation was carried out at the Research Farm of Central Arid Zone Research Institute, Regional Research Station, Bikaner (latitude 28.03°N, longitude 73.19°E), India during kharif 2008 and 2009 with the existing 7 year old plantation of citrus [Citrus aurantifolia (Cristm.) Swingle], bael [Aegle marmelos (L.) Correa] and gonda (*Cordia myxa* L.) maintained under drip irrigation system. The total rainfall during the year was 273.1mm & was 352.5mm (Jan-Dec) in 2008 and 2009, respectively . It was 7.05 and 62.74% higher than normal average rainfall (255 mm)during 2008 & 2009 ,respectively. During the cropping season (July-October) the total rainfall was 97.5mm in 2008 256.4 mm in 2009 (Fig. 1). The soil of the experimental site was alkaline (pH 8.3), non-saline (EC_2 0.22 dS m^{-1}), loamy sand with organic carbon 1.0 g/ kg, available N 89.7 kg/ha, available P 8.0 kg/ha and available K 234.1 kg/ha and can store moisture 112 mm m^{-1} soil profile. The plants were grown at three irrigation levels *i.e.* I_1 (40%ETc), I_2 (60%ETc) and I_3 (80%ETc) on the basis of evapotranspiration. Mothbean (*Vigna aconitifolia* L.), clusterbean (*Cyamopsis tetragonoloba* L.Taub.) and sonamukhi (*Cassia angustifolia* Vahl.) were grown as intercrops under rain-fed condition during kharif season. Recommended agronomic practices and plant protection measures were followed for individual crops and trees. The trees viz. citrus, bael and gonad were planted at 6 m x 5 m distance in which the intercrops were grown in the tree row spacing of 6 m. Fertilizers were applied as per the recommendations of tree species and inter crops. Experiment was taken under strip plot design with three replications. All growth parameter of fruit trees were taken during the month of November. Data was statistically analyzed by the procedure described by Gomez and Gomez (1984).

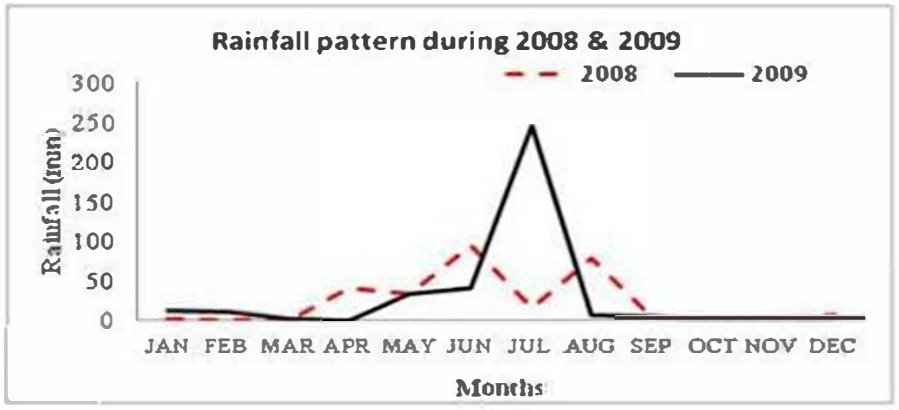


Fig 1: Rainfall pattern during crop season

Results and Discussion

Growth of fruit trees

Different irrigation levels significantly affected the growth parameters (plant height, stem girth and tree canopy) of fruit trees (Table 1). The highest plant height for all the trees was recorded at 80% ETc irrigation level, which was higher by 2.1 and 13.69 % in citrus; 5.14 and 9.29 % in *bael* and 1.37 and 4.43 % in *gonda* compared to the other two treatments ie. 60% and 40% ETc irrigation levels, respectively. The same trend was observed in case of stem girth and tree canopy which was highest in 80% ETc irrigation level but was at par with 60 % ETc irrigation level (Table 1).

Rainfed intercropping significantly affected the growth of all the fruit trees. Highest tree height of citrus and bael was recorded in intercropping with moth bean whereas highest tree height of gonda was recorded in intercropping with cluster bean. The stem girth and tree canopy of all the fruit trees were at par under intercropping with moth bean and cluster bean, but it was significantly higher compared to trees which were grown with no intercropping (Table 1).

Fruit yield

About 40 % plants were in fruiting and mean highest fruit yield of citrus (235.0 kg/ha and 248.28 kg/ha in 2008 and 2009, respectively) was recorded in citrus intercropped with moth bean giving maximum fruit yield (350.0 kg/ha in 2008 and 387.75 kg/ha in 2009) at 80% ETc irrigation level. This was 8.6 and 16.0 percent and 89.2 and 124.3 per cent higher compared to intercropping with cluster bean and sonamukhi, in the years 2008 and 2009, respectively (Table 2).

Yield of intercrops

In 2008, moth bean and cluster bean did not perform well and plant population as well as grain formation was improper and unsatisfactory, due to poor rainfall and long dry spell after sowing. During the crop season of 2009, even though total rainfall was normal, its distribution was skewed resulting in poor yield of rainfed mothbean and clusterbean. The highest seed and stover yield of both moth bean and cluster bean was recorded with citrus which was significantly higher than that with bael and gonda. Sonamukhi gave satisfactory yields and during both the years, the highest dry leaf yield (323 kgha^{-1} in 2008 and 415 kgha^{-1} in 2009) was recorded with citrus which was 7.3 and 28.9 % higher over intercropping with bael and 68.2 and 48.2 % higher over intercropping with gonda in 2008 and 2009 respectively (Table 3). At different irrigation levels, irrigation at 80% ETc of fruit trees gave the highest leaf and seed yield and lowest was at the level of 40% ETc (Table 3).

The better performance of all the intercrops associated with citrus might be due to less competition from citrus trees for moisture and nutrients in comparison to bael and gonda. Along similar lines, Yadava *et al.* (2013) reported that the highest total biological yield and seed yield of mung bean and clusterbean was recorded in intercropping with citrus compared to that with mopane (*Colophospermum mopane*) and shisham (*Dalbergia sissoo*) in Bikaner. Further, Dwivedi *et al.* (2007) also reported the highest wheat yield under citrus plantation followed by aonla and minimum crop yield under guava plantation.

Water use efficiency

Water use efficiency (WUE) of different crops varied from 0.62 to 3.76 kgha^{-1}mm^{-1} (Table 3). Among the different levels of irrigation, irrigation at 80%ETc gave the highest water use efficiency in all the intercrops. This suggests that WUE increased with the increase in levels of irrigation. This might be due to the fact that biomass produced by crops increased proportionately with the total water used by the crops. The WUE was highest with cluster bean followed by moth bean, while sonamukhi recorded the lowest WUE. The highest WUE in all the intercrops was recorded in intercropping with citrus followed by bael and the lowest was observed with gonda. In contrast, Kaushik *et al.* (2011) reported that irrigation at 40% ETc for tree species (shisham + aonla, shisham + guava, khejri + guava, khejri + aonla) gave the highest WUE in intercropped tomato. Irrigation water use efficiency (IWUE) in an agri-silvi-horti production system of semi-arid ecosystems in Haryana was found to increase with the use of drip irrigation, without any loss of yield in the different crop components (Kaushik *et al.*, 2014).

It is evident from the data that the highest yield and WUE of all the intercrops was observed in intercropping with citrus. This might be due to less competitive effect of citrus on intercrops compared to bael and gonda. Beniwal *et al.* (2008) observed that the root biomass density of citrus at a radial distance of 1.0-2.5 meter was very less (16.7 g m^{-3}) compared to shisham (74.7 g m^{-3}) and mopane (134.8 g m^{-3}). They further reported that as the root biomass and soil moisture extraction by citrus in the cropping zone (i.e. 2.5 m radial distance) was less, it could perform well in agri-horti system with minimum effect on crop growth and yield.

The study revealed that intercropping of cluster bean, moth bean and sonamukhi in agri-horti system can successfully be done in drip irrigated 7-year old citrus plantations without any reduction in productivity of intercrops as well as the growth and yield of citrus trees. Selection of horticultural and agricultural crops is very crucial for the success of the integrated system. Hence, location specific agroforestry system models have to be developed for increased yield, water use efficiency and subsequently higher total income.

Table 1. Growth of fruit trees as affected by intercrops & irrigation levels under drip irrigation system (Mean of two years, 2008 & 2009)

Trees	Tree height (cm)						
	Irrigation levels (%ETc)			Intercrops			
	80	60	40	Moth bean	Cluster bean	Sonamukhi	No crop
Citrus	275.61	257.52	231.54	322.45	237.07	207.87	214.75
Bael	333.92	297.48	278.35	406.89	283.19	263.85	237.20
Gonda	204.28	211.90	172.57	176.45	199.38	256.71	190.40
Mean	271.29	255.62	227.37	302.80	266.34	242.81	214.12
CD 5%	Irri=19.8	Irri x tree=34.31		Trees= 19.8		Tree x crop=39.62	
	Stem girth (cm)						
Citrus	34.5	31.83	30.17	34.78	30.78	28.78	24.33
Bael	31.17	29.25	25.83	28.22	30.89	28.33	27.56
Gonda	25.67	30.75	23.25	28.89	30.78	22.56	24.0
Mean	30.45	30.61	26.42	30.63	30.82	26.56	25.3
CD 5%	Irri= 2.52	Irri x tree=4.37		Trees= 2.52		Tree x crop=5.05	
	Tree canopy (m^2)						
Citrus	7.39	6.27	6.04	7.96	6.49	5.31	5.45

Bael	8.01	6.12	5.50	7.03	7.33	5.65	5.76
Gonda	6.09	6.23	4.46	6.03	4.90	4.43	4.59
Mean	7.17	6.17	5.32	6.99	6.24	5.11	5.02
CD 5%	Ini= 0.90	Irri x tree=1.56		Trees= 0.90		Tree x crop=1.81	

Table 2. Mean fruit yield (kg ha $^{-1}$) under drip irrigation system during 2008 & 2009

Agri-horti system (drip irrigation)	Irrigation levels (% ETc) 2008				Irrigation levels (% ETc) 2009			
	80	60	40	Mean	80	60	40	Mean
Citrus +Moth	350	253	102	235.00	387.75	263.87	93.24	248.29
Citrus+ Guar	322.4	235.8	90.5	216.23	334.33	258.27	53.28	215.29
Citrus + Sonamukhi	185	199.5	86.33	156.94	172.89	125.87	79.92	126.23
Mean	285.80	229.43	92.94	--	298.32	216.00	75.48	--
CD 5%	30.64				28.63			

Table 3. Yield and water use efficiency of rainfed intercrops under agri-horti system (fruit trees in drip irrigation system) during 2008 & 2009

Fruit trees	Yield of rainfed intercrops (q/ha) with fruit trees(drip irrigation)						WUE (kgha^{-1}mm^{-1}) of crops intercrop with fruit trees grown at different irrigation levels (%ETc)								
	Moth bean		Cluster bean		Sonamukhi		Mothbean			Clusterbean			Sonamukhi		
	Seed	Stover	Seed	Stover	Leaf yield	Seed yield	80	60	40	80	60	40	80	60	40
2008															
Citrus	4.60	18.81	6.23	21.46	3.23	0.53	2.87	2.50	1.83	3.76	3.39	2.61	1.37	1.26	1.01
Bael	3.63	14.85	4.87	16.76	3.00	0.65	2.19	2.03	1.46	2.92	2.50	2.19	1.33	1.20	1.13
Gonda	2.93	11.97	3.60	12.39	1.92	0.53	1.72	1.56	1.30	2.24	2.09	1.30	0.90	0.84	0.82
CD 5%	0.80	2.40	0.80	2.60	2.72	0.57									
2009															
Citrus	3.20	13.04	5.33	18.38	4.15	0.80	1.37	1.25	1.13	2.54	2.15	1.56	1.40	1.36	1.32
Bael	2.78	11.37	3.32	11.41	3.22	0.68	1.25	1.11	0.90	1.38	1.17	1.33	1.11	0.98	0.89
Gonda	2.49	10.16	2.10	7.19	2.80	0.54	1.13	1.00	0.78	0.78	0.98	0.70	0.95	0.95	0.62
CD 5%	0.18	3.42	0.32	4.20	2.93	0.55									

References

Anderson, S.H., Udawatta, R.P., Seobi, T. and Garrett, H.E. 2009. Soil water content and infiltration in agroforestry buffer strips. *Agroforestry Systems*, 75:5-16.

Beniwal, R.K., Soni, M.L. and Yadava, N.D. 2008 Soil moisture extraction pattern of arid zone trees under agri-horti-silvi system in north western Rajasthan. In: *Natural Resource Management for Sustainable Development in Western India* (Eds. S.N. Prasad, R.K. Singh, Ashok Kumar, A.K. Pandiyal, Shakir Ali, Somsundaran, V.K. Sethy, and V.N. Sharda), pp.197-198. Allied Publishers Pvt. Ltd., New Delhi.

Chadha, K. L. 2002. Diversification to horticulture for food, nutrition and economic security. *Indian Journal of Horticulture*, 52: 137-140.

Fadl, K.E.M. and Sheikh, S.E.E. 2010. Effect of *Acacia senegal* on growth and yield of groundnut, sesame and roselle in an agroforestry system in North Kordofan state, Sudan. *Agroforestry Systems*, 78:243-252.

FAO. 2013. Advancing Agroforestry on the Policy Agenda. Agroforestry Working Paper no. 1.

Food and Agriculture Organization of the United Nations. FAO, Rome.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. 2nd Edition. John Wiley and Sons. New York.

Ilany, T, Ashton, M.S., Montagnini, F., Martinez, C. 2010. Using agroforestry to improve soil fertility: effects of intercropping on Ilex paraguariensis (yerba mate) plantations with *Araucaria angustifolia*. *Agroforestry Systems*, 80:399-409.

Jianbo, L. 2006. Energy balance and economic benefits of two agroforestry systems in northern and southern China. *Agriculture, Ecosystems & Environment*, 116:255-262.

Kaushik, N., Kaushik, R.A., Kumar, S., Sharma, K.D. and Dhankhar, O.P. 2011. Comparative performance of some agri-silvi-horti systems with drip irrigation under arid regions. *Indian Journal of Horticulture*, 68(1): 12-17.

Kaushik, N., Kumari, S., Singh, S. And Kaushik, J.C. 2014. Productivity and economics of different agri-silvi-horti systems under drip irrigation. *Indian Journal of Agricultural Sciences*, 84 (10): 1166-71.

Kaushik, N. and Kumar, V. 2003. Khejri (*Prosopis cineraria*)-based agroforestry system for arid Haryana, India. *Journal of Arid Environments*, 55:433-440.

Ndayambaje, J. and Mohren, G. 2011. Fuelwood demand and supply in Rwanda and the role of agroforestry. *Agroforestry Systems*, 83:303-311.

Pareek, O. P. 1999. Dryland horticulture. In: *Fifty Years of Arid Zone Research in India*, (Eds. A. S. Faroda and Manjit Singh), pp. 475-484. Central Arid Zone Research Institute, Jodhpur, Rajasthan.

Pinho, R.C., Alfaia, S.S. and Miller, R.P. 2011. Islands of fertility: soil improvement under indigenous home gardens in the savannas of Roraima, Brazil. *Agroforestry Systems*, 81:235-247.

Singh, B., Bishnoi, M. and Baloch, M.R., 2012. Tree growth and wheat yield in agri-horti-silvi system in the arid region of Rajasthan. *Indian Forester*, 138 (8):726-732.

Singh, G. 2010. Rainfall dependent competition effected productivity of *V. radiata* in *Hardwickia binata* agroforestry in Indian Desert. *Indian Forester*, 136:301-315.

Singh, R. S., Gupta, J. P., Rao, A. S. and Sharma, A. K. (2003) Micro-climatic quantification and drought impacts on productivity of green gram under different cropping systems of arid zones. In: *Human Impact on Desert Environment* (Eds. P. Narain, S. Kathju, A. Kar, M. P. Singh and Praveen Kumar), pp.74-80. Scientific Publisher, Jodhpur, India.

Singh, R. S. and Kumar, A. (1993). Agri-horticulture systems under semi-arid conditions. *Agroforestry News*, 5(1): 3-5.

Vallejo, V.E., Arbeli, Z., Teran, W., Lorenz, N., Dick, R.P. and Roldan, F. 2012. Effect of land management and *Prosopis juliflora* (Sw.) DC trees on soil microbial community and enzymatic activities in intensive silvopastoral systems of Colombia. *Agriculture, Ecosystems & Environment*, 150:139-148.

Yadav, R.S., Yadav, B.L., Chhipa, B.R. 2008. Litter dynamics and soil properties under different tree species in a semi-arid region of Rajasthan, India. *Agroforestry Systems*, 73:1-12.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Formulation and acceptability studies of Rough lemon (*Citrus jambhiri* Lush.) squash

Ramkesh Meena*, S.V.R. Reddy, D.K. Sarolia, R.S. Singh and R. Bhargava ICAR-Central Institute for Arid Horticulture, Bikaner-334 006
*Corresponding author's e-mail: rammaya1984@gmail.com

Abstract

Rough lemon fruits are highly acidic and possess greater nutraceutical value Studies were conducted to formulate and assess acceptability of squash of rough lemon .The varying juice concentration 50, 40, 30, 20 & 10 per cent were used for preparing squesh and stored at ambient temperature (28 ± 3°C). Periodical observation were recorded at fresh (0), 3 and 6 month interval. Squash prepared with 40 per cent juice was found to be the best recipe with respect to organoleptic qualities *viz.* colour, flavour, taste and overall acceptability till 180 days of storage under ambient conditions.

Key words: *Rough Lemon, Citrus jambhiri, Squash, formulation, sensory acceptability*

Introduction

Rough lemon (*Citrus jambhiri* Lush.) is the most commonly used citrus rootstock belonging to the family Rutaceae. It is considered to be native to Assam state of India. It is considered as a hybrid between the citron and the lemon, with character traits similar to rangpur lime or *mandarin orange* (Bhuyan *et al.*, 1998). The fruits are yellow colored, rough skinned and generally used as a rootstock for other citrus fruits. This is widely used rootstock for Kinnow mandarin crop and popular in Punjab, Rajasthan and Haryana belt of India. Among various commercial citrus species, this is non-traditional due to high acidic nature and poor appearance. Hence, the fruits of this plants are of negligible use inspite of its high yield potential (more than one quintal tree^{-1}). This species of citrus hardy enough and profuse in fruiting and could act as an alternate source of income for the farmers. The fruits are perishable in nature and are available during the winter months (Ladaniya, 2008).

Citrus fruits and their juices have various health benefits owing to the presence of bioactive and nutritive components. They are basically free of fat, sodium and cholesterol. In addition they possess rich amounts of potassium, calcium, folate, thiamin, niacin, vitamin B6, phosphorus, magnesium and copper. They might also reduce the risk of heart diseases and certain kinds of cancer. They are also known to help in reducing the risk for pregnant ladies to have children with neonatal diseases. Rough lemon fruit processing generates various byproducts with significant value. These by-products are known to act as a rich source of edible and health promoting agents as polymethoxylated flavonoids, many of which were found exclusively in citrus peel (Hatamipour *et al.*, 2004). The rough lemon peel contain sugars, edible fiber and many other components that offer excellent opportunities as value-added products, particularly those components that have biological activities (antioxidant, anti-cancer, cardioprotective, and food/drug-interactions) or other attributes that are useful in the development of high-value food products from citrus peel (Widmer and Montanari, 1994). Hence, the morphological characteristics, juice extraction of rough lemon and storage study of squash at room and refrigerated temperature were carried out. Hence, an attempt was made to study the morphological characteristics, juice extraction and standardize the procedure for preparation of squash from the juice of rough lemon harvested at fully mature stage.

Material and Methods

Raw material and Squash preparation

The fruits were procured from the research plots of ICAR-Central Institute for Arid Horticulture, Bikaner, Rajasthan. Fully matured, uniformly developed fruits of rough lemon were harvested in the early morning hours using secateurs and transported to the Postharvest Laboratory for further use. In the laboratory, the fruits are washed thoroughly under the running tap water to remove the adhering soil and dust particles. Later the fruits are peeled manually and juice is extracted from the sliced halves using citrus juice press. The juice was filtered and kept at ambient temperature for 24 hours for sedimentation. The supernatant was siphoned out without disturbing the debris and used for the preparation of squash. The protocol standardized for preparation of squash from the rough lemon fruits was illustrated here under:

Fig 1: Flow chart showing the procedure for preparation of Rough lemon squash

Fig 2: Rough lemon fruit bearing branch

Fig 3: Rough lemon Squash

Physical analysis

The fruit measurements *viz.* length, width, cavity radius, flavedo thickness etc. were taken with the help Vernier calipers. Weight of the fruits was taken using a precision balance. The weight of the pulp and peel was recorded separately and expressed in g and pulp peel ratio was determined accordingly.

Chemical analysis

Freshly extracted juice was used for analysis of proximate composition initially. Total soluble soilds (TSS) was determined using digital refractometer and is expressed as ° Brix. Titratable acidity (%) and ascorbic acid content of fresh juice was estimated using the standard procedures described by Ranganna (1986).

Sensory analysis

Organoleptic evaluation was done for the developed rough lemon products by a semi-trained panel. For each sensory parameter, such as colour & appearance, body or texture, flavour, taste and overall acceptability, 100 marks were allotted and the products were given to the panelist in coded form (Attri *et al.*, 1998). The panelists washed their mouths with water intermittently during evaluation of the samples.

Results and Discussion

The obervaction regarding morphological and biochemical composition of the rough lemon fruits were depicted in the Table 1. The morphological parameters viz. average whole fruit weight (148.6 g) average fruit length (78.6 mm) and width (66.4 mm).Were recorded the flavedo weight was observed 59.13 g with a thickness of 0.36 mm. The internal fruit cavity radius was recorded 1.96 mm. The pulp and peel contents accounted for 34 and 67 per cent, respectively while the average pulp: peel ratio was observed 1.97. The average biochemical parameters were observed 9.5, 5.86 and 20.45 for total soluble solids (°B), titratable acidity (%) and ascorbic acid (mg/100g), respectively (Table 1).

The squashes were prepared from fresh juice after diluting it in lieu of maintaining strong acidity of juice *viz.*, 50 % (T_1), 40 % (T_2) , 30% (T_3), 20% (T_4)and 10 % (T_5) as per standard methodology mentioned in flow chart(Figure 1). The prepared squashes were evaluated organioleptically by a panel of eight jugdes by following nine point hedonic scale (Amerin *et al.*, 1965). Serving ratio maintained 1:3 for all the squashes.

The squash was stored at room temperature and the sensory acceptability was checked at theree month inteval *viz.* 0, 3rd and 6th month during storage. The orgnaoleptic scores were depicted in the tables 2, 3 and 5 at three month intervals. Among various treatments, the senosry acceptability of the rough lemon squash prepared with 40 per cent juice (T_2) has attained greater score for all the sensory attributes as well as the overall acceptability score followed by T_1 (50 per cent juice) and T_3 (30 per cent juice) (Table 2).

During storage at ambient conditions, the sensory acceptability of the rough lemon squash has declined gradually with time irrespective of the treatment imposed. However, among various concentrations used, the squash prepared using 40 percent juice has scored relatively higher sensory scores compared to other treatments (Table 3 & 4).

The gradual decline in the sensory attributes with storage period was clearly illustrated in the radar chart (Fig. 4) where in the colour, flavor and taste decreased significantly but the overall acceptability of the rough lemon squash remained relatively higher. Similar decline of sensory attributes with storage was also observed in Assam lemon squash (Singh *et al.*, 2015). Sweet orange squash (Syed *et al.*, 2012) and Lime (Lad *et al.*, 2013).

Thus, it can be concluded that, among squashes prepared from various juice concentrations of rough lemon juice, the squash prepared with 40 per cent juice has recorded highest sensory scores and the rough lemon fruits has the greater potential for value addition and commercialization.

Table 1. Morphological and biochemical composition of the rough lemon fruits.

S.No.	Parameters	Mean value (± SE)
1	Fruit weight (g)	148.6 ± 2.078
2	Fruit length (mm)	78.6 ± 1.101
3	Fruit width (mm)	66.4 ± 1.744
4	Flavedo weight (g)	59.13 ± 1.607
5	Flavedo thickness (mm)	0.36 ± 0.023
6	Cavity radius (mm)	1.96 ± 0.060
7	Pomace weight (g)	20.14 ± 1.136
8	Peel weight (%)	34 ± 1.155
9	Pulp weight (%)	67 ± 1.000
10	Pulp : Peel ratio	1.97 ± 0.100
11	TSS (°B)	9.5 ± 0.208
12	Acidity titrable (%)	5.86 ± 0.226
13	Ascorbic acid (mg/100 ml)	20.45 ± 1.134

Table 2. Organoleptic scores of freshly prepared rough lemon squash

Treatment	Squashes specification	Sensory evaluation of fresh squashes			
		Colour (9)	Taste (9)	Flavour (9)	Overall (9)
T_1	Juice 50%	8.5	8.5	8.0	8.3
T_2	Juice 40%	8.5	8.5	8.5	8.5
T_3	Juice 30%	8.5	8.0	8.5	8.3
T_4	Juice 20%	8.0	8.0	8.0	8.0
T_5	Juice10%	8.0	7.5	7.5	7.7

Table 3. Organoleptic scores of rough lemon squash after 3 month storage

Treatment	Squashes specification	Sensory evaluation after 3 month of storage			
		Colour (9)	Taste (9)	Flavour (9)	Overall (9)
T_1	Juice 50%	7.5	8.0	7.0	7.5
T_2	Juice 40%	8.0	8.0	7.5	7.8
T_3	Juice 30%	8.0	8.0	7.5	7.8
T_4	Juice 20%	8.0	8.0	7.0	7.6
T_5	Juice10%	8.0	7.5	7.5	7.6

Table 4. Organoleptic scores of rough lemon squash after 6 month storage

Treatment	Squashes specification	Sensory evaluation after 6 month of storage				Total of overall month of storage (27)
		Colour (9)	Taste (9)	Flavour (9)	Overall (9)	
T_1	Juice 50%	6.5	7.0	6.0	6.5	22.3
T_2	Juice 40%	7.0	7.0	6.5	7.5	23.8
T_3	Juice 30%	7.0	7.0	6.5	6.8	22.9
T_4	Juice 20%	7.5	7.0	6.0	6.8	22.4
T_5	Juice10%	7.5	6.5	6.5	6.8	22.1

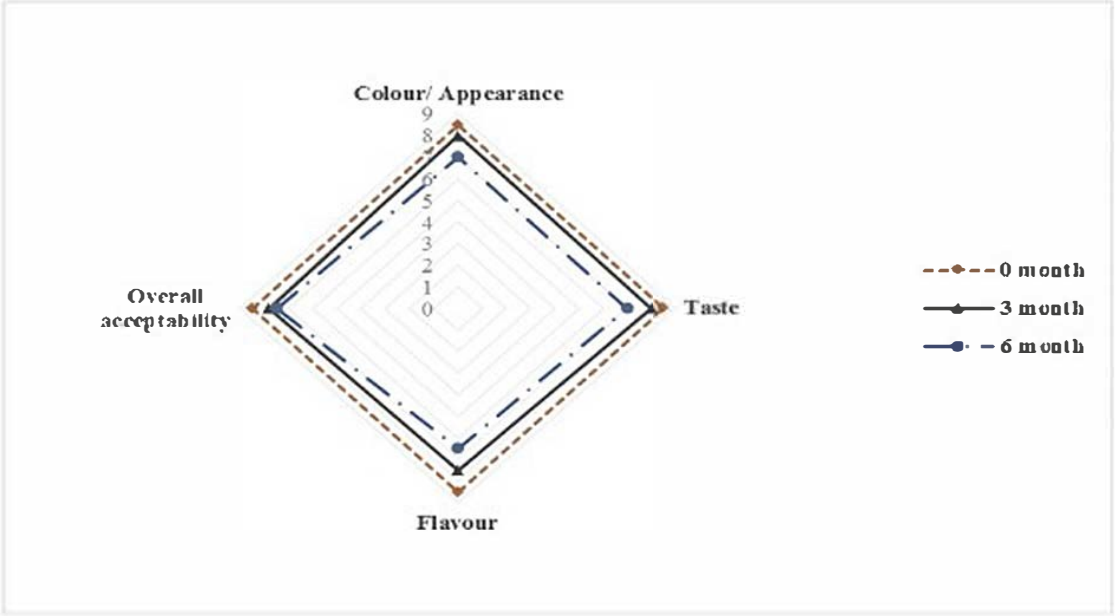


Fig 4: Radar chart depicting the changes in sensory attributes of the best treatment (T2) over the storage time.

References

Amerine, M. A., Pangborn, R. M., and Roessler, E. B. 2013. Principles of sensory evaluation of food. Elsevier.

Attri, B.L., Lal, B.B., and Joshi, V.K. 1998. Physico-chemical characteristics, sensory quality and storage behaviour of sand pear juice blended with temperate fruit juices/pulps. *Indian Food Pack*, 52:36–42

Bhuyan, H., Das, D. and Bhagabati, K.N. 1998. Physico-chemcial constituents of rough lemon (*Citrus jambhiri* Lush) fruits. In Prospects of Medicinal Plants. (Eds.) Gautham, P.L., Raina, R., Srivastava, U., Raychaudhuri, S.P. and Singh, B.B. Indian Society of Plant Genetic Resources, New Delhi. P. 208-214.

Hatamipour, M.S., Majidi, S.M., Abdi, M., and Farbodnia, 2004. Potentials for industrial utilization of citrus byproducts. CHISA 2004.

Proceeding of the 16th International Congress for Chemical and Process Engineering, August 22-26, 2004, Prague, Czech Republican. pp. 9263.

Lad, P. K., Relekar, P. P., and Pujari, K. H. 2013. Quality evaluation and storage behaviour of lime (*Citrus aurantifolia*) squash cv. SAI SARBATI. *Asian J. Hort.*, 8(1): 350-353.

Ladaniya, M.S., 2008. Nutritive and medicinal value of citrus fruits. Citrus fruit Biology, Technology and Evaluation, pp.501-512.

Ranganna, S. 1986. Handbook of analysis and quality control for fruit and vegetable products. Tata McGraw-Hill Education.

Singh, V.K., Kumar, R., Yadvika, Hazarika, M.K. and Gogoi, G. 2015. Formulation and acceptability studies of squash prepared from indigenous Assam lemon. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, 9(10): 62-65.

Syed, H. M., Ghatge, U. P., Machewad, G., and Pawar, S. 2012. Studies on preparation of squash from sweet orange. *Open Access Scientific Reports*, 1(6): 185-187.

Widmer, W.W., and Montanari, A.M. 1994. Citrus waste steams as a source for phytochemical. Proceeding of the Florida State Horticultural Society, p. 284-288.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Study of correlation and path analysis for green pod yield and its contributing traits in vegetable pea(*Pisum sativum* L.)

Kumawat, P. K.*, Singh, P., Mukherjee, S. and Kumawat, Mamta **
Department of Horticulture, S.K.N. College of Agriculture (S.K.N.A.U.), Jobner - 303 329, Rajasthan.
Corresponding author's e-mail: pramodhorti2011@gmail.com
(*AAO, **Agriculture Supervisor, Deptt. of Agriculture, Govt. of Rajasthan)
(Received: 14.09.2017, Accepted: 25.01.2018)

Abstract

Correlation at genotypic and phenotypic levels along with path coefficient analysis were studied for various yield and its component characters in twenty genotypes of pea (*Pisum sativum* L.) during *rabi*, 2009-10. Analysis of variance revealed significant difference for all the characters indicating the presence of good amount of variability in the genotypes studied. Correlation studies revealed that green pod yield per plant was positively and significantly associated with pod length, pod weight and number of grains per pod. Path coefficient analysis revealed that traits like number of pods per plant, pod weight, number of grains per pod, number of pickings and protein content were the important characters for selection of high yielding genotypes as they exerted high positive direct effect as well as positive correlation with green pod yield per plant. The result suggested that these traits could be considered as major yield contributing traits in pea.

Key words: *Pea, correlation, path analysis.*

Introduction

Pea (*Pisum sativum* L.) is an important crop grown throughout the world. In India, it is grown mainly as winter vegetable in the plains of North India and as summer vegetable in the hills. Pea is used as fresh vegetable, canned, processed or dehydrated and seeds are consumed as pulse. Green pods are highly nutritive, containing high percentage of digestible protein (7.2%), carbohydrates (19.8%) and minerals (0.8%) (Aykroyd, 1963). Correlation coefficient is a statistical measure, which is used to find out the degree and direction of relationship between two or more variables. It measures the mutual relationship between various plant characters and determines the component characters on which selection can be exercised for genetic improvement in yield. Path coefficient analysis is an important tool for partitioning the correlation coefficients into direct and indirect effects of independent variables on dependent variable. It has been widely used to identify traits that have significant effect on yield for potential use in selection. Keeping in view the study was conducted to find out correlation at genotypic and phenotypic levels and path coefficient analysis for yield and its contributing traits in pea.

Materials and Methods

The present investigation was carried out at Experimental farm, Department of Horticulture, S.K.N. College of Agriculture, Jobner, Rajasthan during *rabi* 2009–10. The experimental material consisted of twenty diverse pea genotypes namely, AP-1, AP-3, Arkel, VRP-5, VRP-6, VRP-7, VRP-16, VRP-22, VRP-90, VRP-135, VRP-138, VRP-147, VRP-158, VRP-179, VRP-216, VRP-219, VRP-238, VRP-330, VRP-343 and EC-9126. Experiment was laid out in randomized block design with three replications. The seeds were sown at a spacing of 30 cm x 10 cm. Recommended agronomic practices and plant protection measures were followed to maintain optimum plant stand. The observations were recorded on five randomly selected competitive plants from each plot in every replication for the traits *viz.* plant height (cm), days to first flowering, days to 50 % flowering, days to first fruit setting, days to first pod picking, number of pods per plant, pod length (cm), pod weight (g), number of grains per pod, number of pickings, pod yield per plant (g), pod yield per hectare (q), TSS of green seeds (%) and protein content in pods (%). The data were averaged and statistically analyzed for analysis of variance as per the method suggested by Panse and Sukhatme (1995). The genotypic and phenotypic correlation coefficients were calculated from the genotypic and phenotypic covariances and variances as described by Singh and Choudhary (1977) and as per formula given by Johnson *et al.* (1955). The estimates of direct and indirect effect were calculated by the path coefficient analysis as at both phenotypic and genotypic levels.

Result and Discussion

The analysis of variance indicated significant differences among the genotypes for all the observed characters which indicated that high amount of genetic variability was present in the genetic material.

The correlation studies revealed that in general estimates of genotypic correlation coefficients were

higher than the corresponding phenotypic correlation coefficients, which indicated a strong inherent association among different traits under study (Table 2). The lower phenotypic values might be due to environmental interactions. A significant positive correlation of pod yield per plant was observed with pod weight (0.469), pod length (0.395) and number of grains per pod (0.393) at phenotypic level and with number of grains per pod (0.764), pod length (0.664), pod weight (0.542) and number of pickings (0.377) at genotypic level, which, suggested that these characters could be considered as major green pod yield contributing characters in pea. Similar results were earlier obtained by Chaudhary and Sharma (2003), Sureja and Sharma (2004), Choudhary *et al.* (2004), Singh and Singh (2005), Nawab *et al.* (2008) and Guleria, Chongtham and Dua (2009).

Pod yield per plant registered significant and negative correlation with days to first flowering (-0.326) and days to first pod picking (-0.369), which, indicated that selection should be practiced for less days to flowering and first fruit setting (earliness). The results were in accordance with the findings of Chaudhary and Sharma (2003), Choudhary *et al.* (2004) and Sureja and Sharma (2004).

Therefore, it can be concluded that, during selection of high yielding genotypes in pea major emphasis should be given on pod weight, pod length, number of grains per pod, days to first fruit setting and days to first flowering as these are significantly associated with pod yield hense, these characters could be considered reliable indices for selection, to enhance the pod yield.

Path coefficient analysis revealed that, days taken to first pod picking exhibited maximum positive direct effect on green pod yield per plant (2.1131) at genotypic level followed by average pod weight (1.5140), number of pods per plant (1.2720), protein content (0.3887), average number of grains per pod (0.1141), days taken to 50 per cent flowering (0.1137) and average number of pickings (0.0905). The highest negative direct effect was exerted by days taken to first flowering, followed by days to first fruit setting, plant height, average pod length and TSS of green seeds. These results were in partial agreement with those of Sureja and Sharma (2004) for appearance of first flower, by Sharma *et al.* (2007) for TSS and by Sardana *et al.* (2007) for plant height.

Days to 50 per cent flowering exhibited maximum positive indirect effect on pod yield per plant via days to first pod picking, number of pods per plant, pod length and protein content at genotypic level. Days to first pod picking had positive indirect effect through number of pods per plant, pod length, days to 50 per cent flowering and protein content. Average number of pods per plant had positive indirect effect on pod yield through days to first pod picking, pod length and days to 50 per cent flowering. Average pod weight exhibited positive indirect effect via days to first flowering, days to first fruit setting, plant height, number of grains per pod, protein content, number of pickings and TSS of green seeds.

Average number of pickings had positive indirect effect on pod yield through days to first flowering, average pod weight, days to first fruit setting, plant height, protein content and number of grains per pod. Whereas, protein content exerted positive indirect effect via day to first pod picking average pod weight, plant height, number of grains per pod, days to 50 per cent flowering, number of pickings and TSS of green seeds.

Keeping in view the estimates of correlation coefficient and direct and indirect contribution of component traits toward pod yield per plant, indirect selection practices on the basis of days taken to first pod picking, average pod weight, number of pods per plant, protein content, number of grains per pod, days to 50 per cent flowering and number of pickings would be rewarding in the genotypes under study enhancing the pod yield per plant as well as per hectare.

References

Aykroyd, WR. 1963. ICMR Special Republic Series. No. 42.

Chaudhary, DK and Sharma, RR. 2003. Genetic variability, correlation and path analysis for green pod yield and its component in garden pea. *Indian Journal of Horticulture*, 60 (3): 251-256.

Choudhary, DK, Sharma, RR and Sureja, AK. 2004. Correlation and path analysis studies across the generations in garden pea. *Indian Journal of Horticulture*, 61(2): 163-167.

Guleria, Sonali, Chongtham, Nirmala and Dua, Saroj (2009). Correlation and path in pea. *Crop Research (Hisar)*, 38 (1): 179-183.

Johnson, HW, Robinson, HF and Comstock, RE. 1955. Estimates of genetic and environmental variability in soybeans. *Agronomy Journal*, 47: 314-318.

Nawab, NN, Subhani, GM, Mahmood, K, Shakil, Q and Saeed, A. 2008. Genetic variability correlation and path analysis studies in garden pea (*Pisum sativum* L.). *Journal of Agricultural Research (Pakistan)*, 46 (4): 333-340.

Panse, VG and Sukhatme, PV. 1995. Statistical Methods for Agricultural Workers. ICAR, New Delhi.

Sardana, S, Mahajan, RK, Gautam, NK and Ram, B. 2007. Genetic variability in pea (*Pisum sativum* L.) germplasm for utilization. *SABRAO Journal of Breeding and Genetics*, 39 (1): 31-41.

Sharma, A, Sood, M, Rana, A and Singh, Y. 2007. Genetic variability and association studies for green pod yield and component horticultural traits in garden pea under high hill dry temperate conditions. *Indian Journal of Horticulture*, 64 (4): 410-414.

Singh, J P and Singh, I P. (2005). Studies on correlation and path coefficient analysis in field pea (*Pisum sativum* L.). *National Journal of Plant Improvement*, 7 (1): 59-60.

Singh, RK and Choudhary, BD. 1977. Variance and Covariance analysis. Biometrical methods in

quantitative genetic analysis. Kalyani Publisher, Ludhiana (Rev. Ed., 1985). pp: 39-68.

Sureja, AK and Sharma, RR. 2004. Path analysis for yield and its attributes in garden pea (*Pisum sativum* L. sub sp. hortense Asch and Graebn). *Indian Journal of Horticulture*, 61 (1): 42-45.

Table 1. Phenotypic correlation coefficients (upper diagonal) and genotypic correlation coefficients (lower diagonal) between different traits in pea

S. No.	Traits	PH	DFF	50% F	DFFS	DFPP	P/P	PL	PW	G/P	Picking	TSS	Protein	Y/P	Y/ha
1	PH	**1.000**	0.559**	0.657**	0.631**	0.712**	0.739**	-0.477**	-0.649**	-0.265	-0.602**	0.435**	-0.136	-0.096	-0.039
2	DFF	0.597	**1.000**	0.933**	0.896**	0.944**	0.274	-0.200	-0.483**	-0.0811	-0.699**	0.3613*	0.221	-0.326*	-0.251
3	50% F	0.694	0.935	**1.000**	0.961**	0.953**	0.437**	-0.299	-0.594**	-0.142	-0.614**	0.324*	0.166	-0.318	-0.243
4	DFFS	0.686	0.912	0.977	**1.000**	0.936**	0.471**	-0.349*	-0.649**	-0.220	-0.665**	0.437**	0.136	-0.369*	-0.292
5	DFPP	0.751	0.949	0.955	0.951	**1.000**	0.459**	-0.304	-0.595**	-0.116	-0.759**	0.438**	0.130	-0.271	-0.182
6	P/P	0.933	0.364	0.561	0.573	0.578	**1.000**	0.517**	-0.785**	-0.345*	-0.380*	0.342*	-0.182	0.070	0.106
7	PL	-0.666	-0.293	-0.415	-0.499	-0.421	-0.779	**1.000**	0.602**	0.664**	0.318	-0.259	0.342*	0.395*	0.366*
8	PW	-0.828	-0.601	-0.739	-0.791	-0.734	-0.835	0.966	**1.000**	0.488**	0.475**	-0.368*	0.177	0.469**	0.438**
9	G/P	-0.475	-0.140	-0.236	-0.351	-0.195	-0.527	0.815	0.776	**1.000**	0.225	-0.306	0.182	0.393*	0.400*
10	Picking	-0.664	-0.735	-0.643	-0.693	-0.792	-0.421	0.363	0.587	0.285	**1.000**	-0.632**	0.102	0.246	0.161
11	TSS	0.583	0.454	0.397	0.528	0.543	0.506	-0.325	-0.576	-0.419	0.745	**1.000**	-0.013	-0.151	-0.100
12	Protein	-0.255	0.308	0.216	0.194	0.172	-0.163	0.517	0.168	0.231	0.092	-0.065	**1.000**	0.234	0.246
13	Y/P	-0.211	-0.488	-0.440	-0.511	-0.378	-0.017	0.664	0.542	0.764	0.377	-0.271	0.296	**1.000**	0.986**
14	Y/ha	-0.125	-0.329	-0.331	-0.398	-0.252	0.043	0.599	0.485	0.760	0.257	-0.188	0.310	0.977	**1.000**

PH = Plant height (cm), DFF = Days taken to first flowering, 50% F = Days to 50% flowering, DFFS = Days to first fruit setting, DFPP = Days to first pod picking, P/P = Number of pods/plant, PL = Pod length (cm), PW = Pod weight (g), G/P = Number of grains/pod, Pickings = Number of pickings, Y/P = Yield/plant (g), Y/ha = Yield/heetare (q), TSS = T.S.S. of green seeds (%), Protein = Protein content in pods (%).

** Significant at P = 0.01 level of significance

* Significant at P = 0.05 level of significance

Table 2. Direct (diagonal) and indirect effects of different characters on pod yield per plant in pea at genotypic and phenotypic level

Characters		PH	DFF	50% F	I-FS	I-PP	P/P	PL	PW	G/P	Pickings	TSS	Protein	Y/P
PH	P	0.4528	-0.5318	0.0209	-0.1673	0.5764	-0.0355	-0.1261	-0.2356	0.0149	0.0086	-0.0087	-0.0351	-0.0964
	G	-0.4653	0.7433	0.0790	-0.5402	1.5880	1.1873	0.1924	-1.2532	-0.0543	-0.0601	-0.0417	-0.0993	-0.2108
DFF	P	0.2535	-0.9500	0.0297	-0.2377	0.7644	-0.0132	-0.0828	-0.1752	-0.0046	0.0099	-0.0073	0.0571	-0.3261*
	G	-0.2779	-1.2447	0.1068	-0.7184	2.0045	0.4630	0.0847	-0.9102	-0.0160	-0.0666	-0.0325	0.1196	-0.4882**
50% F	P	0.2075	-0.8859	0.0318	-0.2548	0.7721	-0.0210	-0.0789	-0.2157	-0.0080	0.0087	-0.0065	0.0429	-0.3179
	G	-0.3232	-1.1636	0.1137	-0.7698	2.0182	0.7137	0.1200	-1.1196	-0.0270	-0.058	-0.0284	0.0840	-0.4402**
I-FS	P	0.2857	-0.8513	0.0306	-0.2652	0.7578	-0.0226	-0.0921	-0.2357	-0.0124	0.0095	-0.0088	0.0352	-0.3694*
	G	-0.3192	-1.1353	0.1111	-0.7876	2.0094	0.7285	0.1444	-1.1976	-0.0460	-0.0627	-0.0378	0.0755	-0.5113**
I-PP	P	0.3223	-0.8966	0.0303	-0.2482	0.8099	-0.0221	-0.0802	-0.2161	-0.0065	0.0108	-0.0088	0.0336	-0.2715
	G	-0.3497	-1.1807	0.1086	-0.7489	2.1131	0.7355	0.1218	-1.1119	-0.0222	-0.0717	-0.0389	0.0668	-0.3783*
P/P	P	0.3347	-0.2608	0.0139	-0.1249	0.3721	-0.0481	0.1365	-0.2851	-0.0194	0.0054	-0.0069	-0.0469	0.0705
	G	-0.4343	-0.4531	0.0638	-0.4510	1.2218	1.2720	0.2251	-1.2638	-0.0601	-0.0381	-0.0362	-0.0635	-0.0175
PL	P	-0.2162	0.1900	-0.0095	0.0925	-0.2460	-0.0248	0.2641	0.2187	0.0375	-0.0045	0.0052	0.0884	0.3052*
	G	0.3099	0.3649	-0.0472	0.3936	-0.8907	-0.9910	-0.2889	1.4627	0.0931	0.0329	0.0233	0.2010	0.6636**
PW	P	-0.2039	0.4584	-0.0189	0.1722	-0.4821	0.0377	0.1591	0.3690	0.0275	-0.0068	0.0074	0.0461	0.4699**
	G	0.3852	0.7483	-0.0841	0.6230	-1.5519	-1.0617	-0.2791	1.5140	0.0886	0.0532	0.0412	0.0653	0.5420**
G/P	P	-0.1199	0.0770	-0.0045	0.0584	-0.0939	0.0166	0.1755	0.1772	0.0564	-0.0032	0.0061	0.0469	0.3926*
	G	0.2215	0.1746	-0.0269	0.2764	-0.4112	-0.6699	-0.2356	1.1750	0.1141	0.0258	0.0300	0.0899	0.7637**
Pickings	P	-0.2726	0.6643	-0.0195	0.1763	-0.6146	0.0183	0.0839	0.1727	0.0127	-0.0142	0.0127	0.0261	0.2464
	G	0.3091	0.9152	-0.0731	0.5455	-1.6740	-0.5359	-0.1049	0.8895	0.0325	0.0905	-0.0534	0.0358	0.3769*
TSS	P	0.1968	-0.3461	0.0103	-0.1158	0.3544	-0.0146	-0.0685	-0.1338	-0.0172	0.0090	-0.0201	-0.0035	-0.1510
	G	-0.2712	-0.5636	0.0452	-0.4159	1.1476	0.6437	0.0940	-0.8721	-0.0478	0.0675	-0.0716	-0.0254	-0.2715
Protein	P	-0.0615	-0.2108	0.0053	-0.0362	0.1054	-0.0087	0.0903	0.0648	0.0102	-0.0015	0.0003	0.2583	0.2342
	G	0.1188	-0.3829	0.0246	-0.1530	0.3630	-0.2077	-0.1494	0.2545	0.0264	0.0083	0.0047	0.3887	0.2961

PH = Average plant height (cm), DFF = Days taken to first flowering, 50% F = Days to 50% flowering, I-FS = Days to first fruit setting, I-PP = Days to first pod picking, P/P = Average number of pods per plant, PL = Average pods length (cm), PW = Average pod weight (g), G/P = Average number of grains per pod, Pickings = Average number of pickings, Y/P = Average yield per plant (g), Y/ha = Average yield per hectare (q), TSS = T.S.S. of green seeds (^{0}B), Protein = Protein content in pods (%)

** significant at P = 0.01 level of significance, * significant at P = 0.05 level of significance, Residual effects : phenotypic = 0.511, genotypic = -0.358. (Note : Diagonal values are direct effect.)

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Short Communication

Growth and yield of Kinnow mandarin on N fertigation and drip-irrigation in Kandi area of Punjab

Yogesh Khokhar
[1]*Regional Research Station Ballowal Saunkhri, Punjab agricultural University Ludhiana, 141004*
E-mail: pomologyphd@gmail.com
(Received : 13.03.2017, Accepted: 18.12.2017)

The water resources on the earth are limited, with freshwater being estimated at 37 million km^3. Only 0.3% of this amount can be used as renewable resource. The lack of water is the major limiting factor on expansion of irrigated agriculture in the arid and semi-arid land of the world. Establishment of water-saving irrigation technology for irrigation is considered to be one of the efficient ways to improve and to develop agriculture in the 21st century in these regions. Fertigation - a modern agro-technique provides an excellent opportunity to maximize yield and minimize environmental pollution (Hagin *et al.* 2002) by increasing fertilizer use efficiency, minimizing fertilizer application and increasing return on the fertilizer invested. The application of fertilizers is highly site-specific, depending on soil type, climatic conditions and water quality. Fertilizer demand in intensive plant production systems is particularly variable, changing rapidly during the season and the year. The nutrient requirements of Kinnow mandarin trees are very much dependent on the biological stage of growth and varying from vegetative to fruiting periods. Using micro irrigation system for Kinnow production has greatly increased the adaptation of fertigation products. Bravdo *et al.* (1993) stated that shoot growth extension varied considerably according to irrigation system. El-Wazzan *et al.* (2001) on Valencia orange improved that irrigation system had announced effect on the yield. Assuming that frequent N fertigation over most of the growing season stimulate vegetative growth due to the constant availability of N to plant. This work aimed to investigate the effect of varying amount of drip irrigation and N fertigation on the vegetative growth and the yield of Kinnow mandarin trees.

A study was carried out for investigating the varying N fertigation rates 400, 600, 800 and 1000 gm N/ tree and annually added at 21, 23, 30 and 34 equal doses on the vegetative growth and yield of Kinnow orchards of six year old in Kandi area located in foothills of Shivalik (Punjab) during four successive years from 2011-14. The amount of water applied via drip irrigation was 16, 20, 24 and 30 m^3/ tree per year and different combinations between them were also studied. Average spring shoot length (cm) - number of leaves per spring shoot- leaf area (cm^2)-percentage of N and P of the leaves, fruit yield were determined according to standard methods. The data was statistically analyzed according to Panse and Sukhatme (2009). The different combinations of (a) = quantity of water applied and (b) = N fertigation frequencies were as a_1b_1, a_1b_2, a_1b_3, a_1b_4, a_2b_1, a_2b_2, a_2b_3, a_2b_4, a_3b_1, a_3b_2, a_3b_3, a_3b_4, a_4b_1, a_4b_2, a_4b_3 and a_4b_4.

Varying quantities of water applied via drip irrigation from 16-30 m^3 water /tree/year had a positive effect on shoot length, number of leaves/shoot and leaf area of Kinnow mandarin. The vegetative growth was stimulated with increasing quantities of water per tree (16-30 m^3 water/tree/year). Higher differences in these growth aspects were detected among all levels except the two higher ones. The maximum and minimum values were detected on the trees irrigated with water at 30 and 16 m^3 per tree, respectively (Figure 1-3). Results indicated that growth parameters of Kinnow mandarin trees were gradually stimulated with increasing levels of nitrogen fertigation from 400-1000 gm/tree. Maximum differences of these growth traits were observed between all levels of N except between 800 and 1000 gm N/tree. The results are in agreement with those of Sharawy (2005) on Balady lime trees. Increasing nitrogen frequencies from 21 to 23 affect in positive manner these vegetative parameters (shoot length, Number of leaves per shoot and leaf area). Increasing nitrogen frequencies from 30-34 had in most cases a slight effect. Combinations between quantities of water and nitrogen fertigation levels and frequencies had a great effect on growth characters of Kinnow mandarin trees (Fig 1-3). The maximum values were obtained with irrigation the trees with 30 m^3 water and added 1000 gm N at 23 doses. These results are in harmony with the results of Koulka *et al.* (2000) on Balady orange trees. There was a progressive increase on the percentages of N and P in the leaves of non- fruiting shoots of Kinnow mandarin trees with increasing water quantities applied via drip irrigation from 16 to 30 m3/tree/years. The important role of water in increasing nutritional status of the trees was emphasized by Nakhlla *et al.* (1998) on Navel orange trees. Increasing nitrogen fertigation from 400 to 1000 gm N/tree was followed by a gradual promotion on percentage of N in the leaves. These results were supported by those of Sharawy (2005) on Balady lime trees. Increasing quantities of water applied via drip

irrigation from 16 to 30 m^3 water/tree/year caused a gradual promotion on the yield expressed as kgs (Fig 10-12). The two higher rates of applied water (24 and 30 m^3 water/tree/year) did not concerning their influence on the yield per tree. Therefore, the recommended amount of water added to Kinnow mandarin trees for gaining an economical yield at 24 m^3 water/tree/year (Fig. 10). Increasing N fertigation from 400-1000 gm N/tree resulted in increase in the yield/tree (Fig. 11). Similar results were reported in navel orange by Thompson *et al* (2002); Schumann *et al* (2003).The difference between 800 and 1000 gm N/tree was meaningless. Fruit TSS (°Brix) was recorded highest 24 m^3 water/tree/year and 800gm N/tree and 23 doses (Fig 13-15). Similar results were reported by the Alva *et al.* (2006) in Valencia orange. As a conclusion, one can state that adding water at 24 m^3 /tree annually and nitrogen at 800 gm via drip irrigation is recommended.

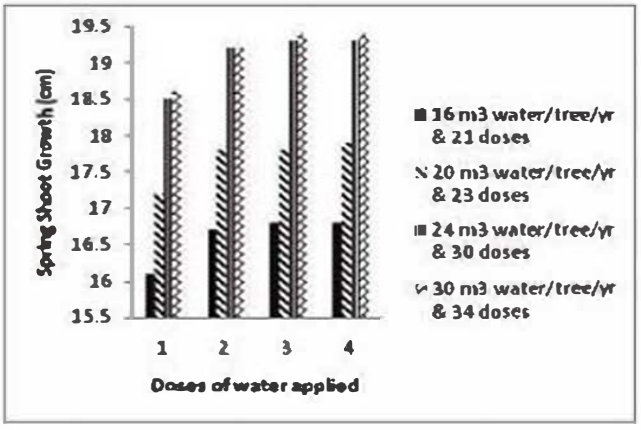


Fig. 1.

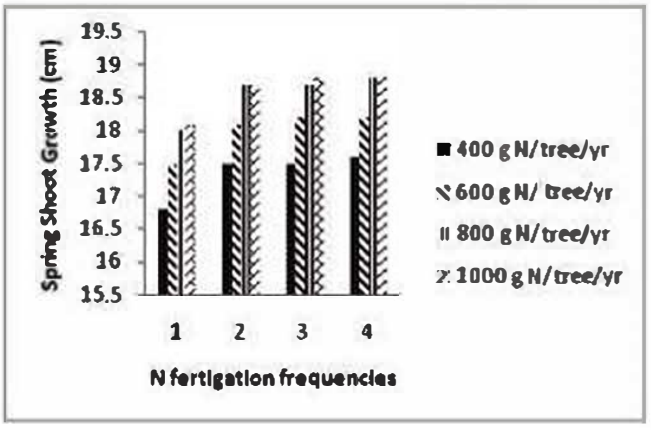


Fig. 2.

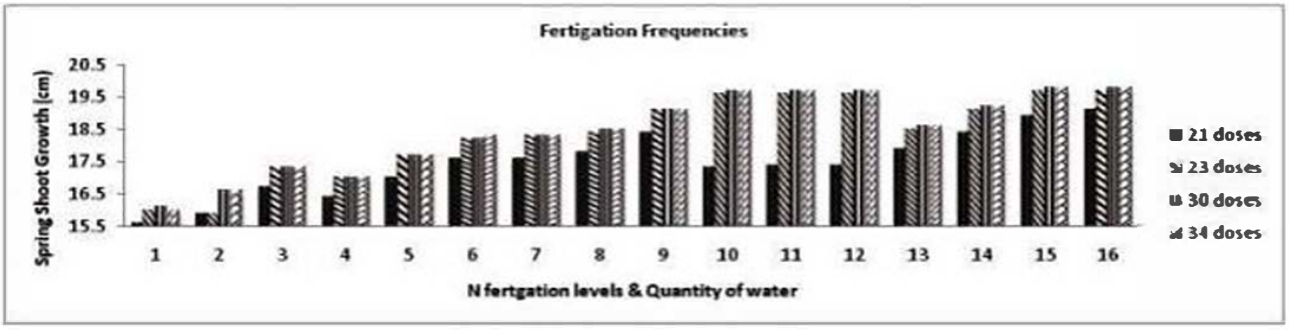


Fig. 3.

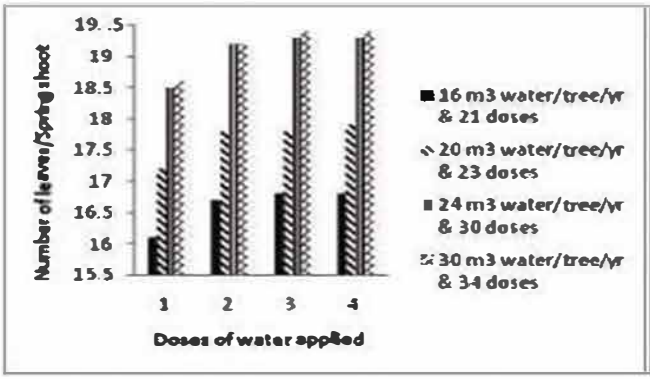


Fig. 4.

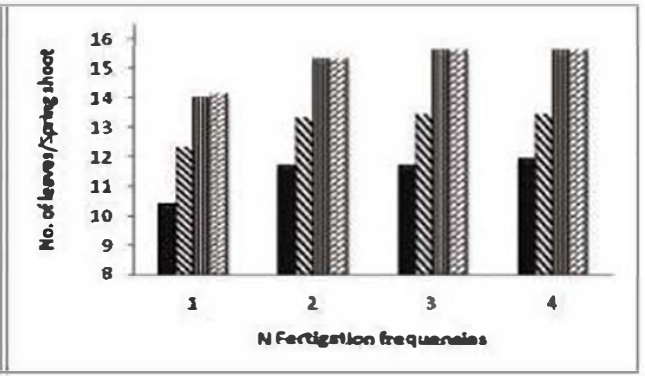


Fig. 5.

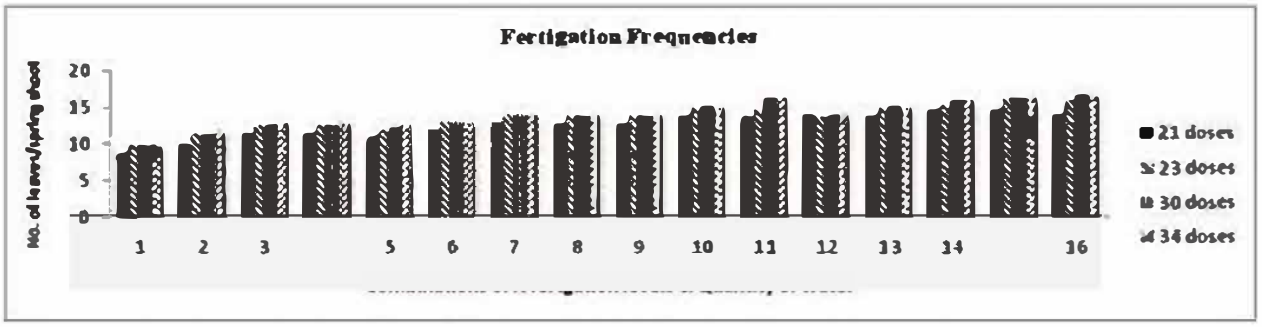


Fig. 6.

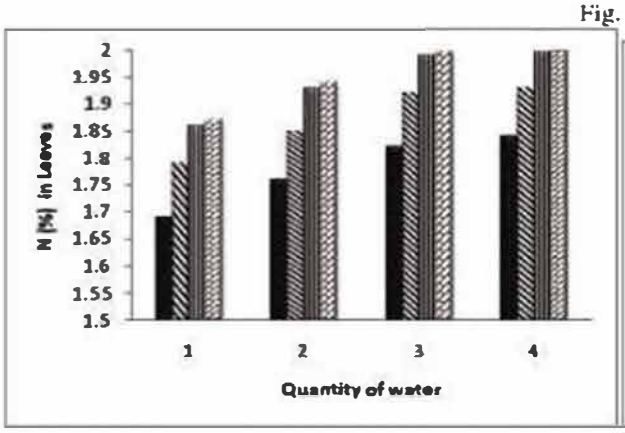


Fig. 7.

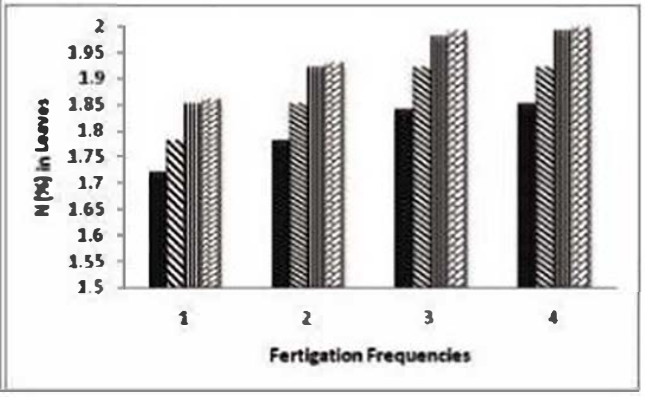
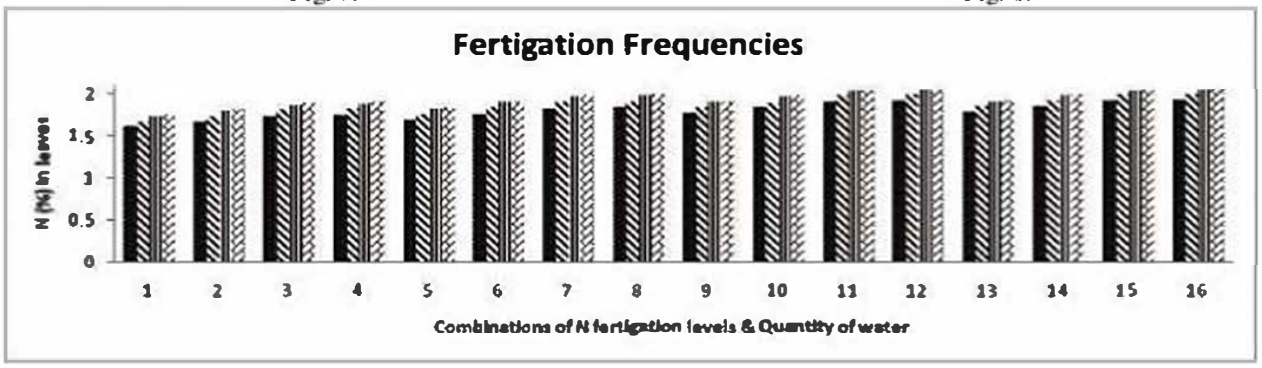


Fig. 8.



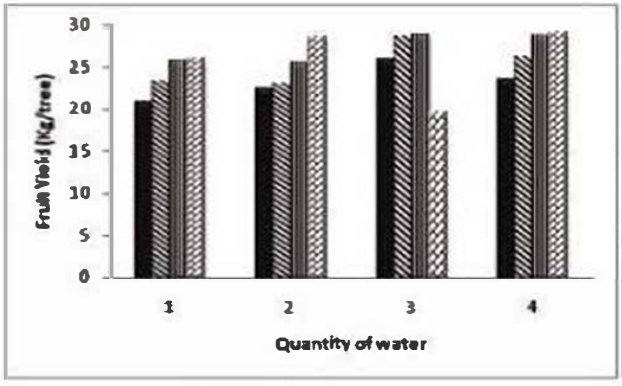


Fig. 9.

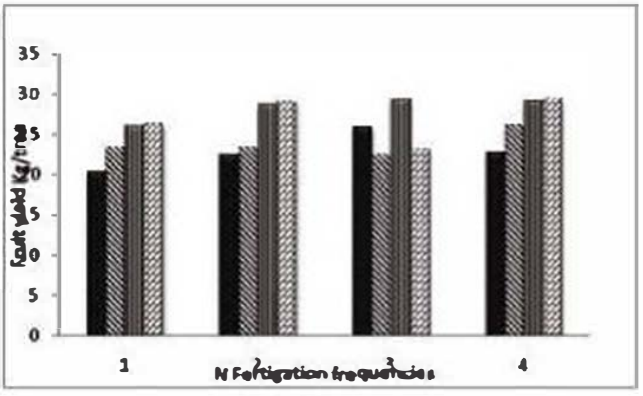


Fig. 10.

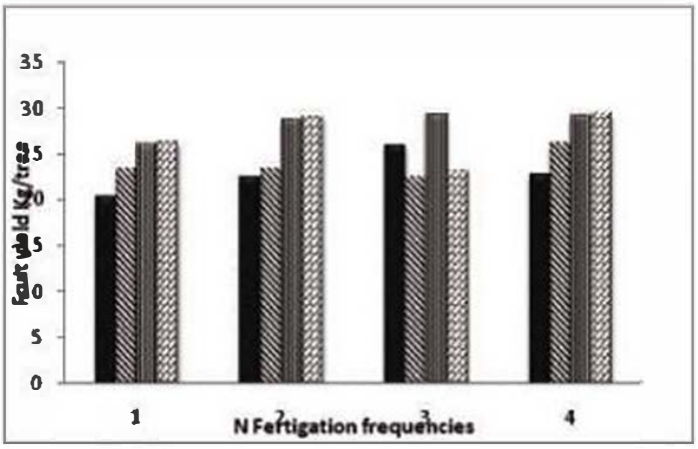


Fig. 11

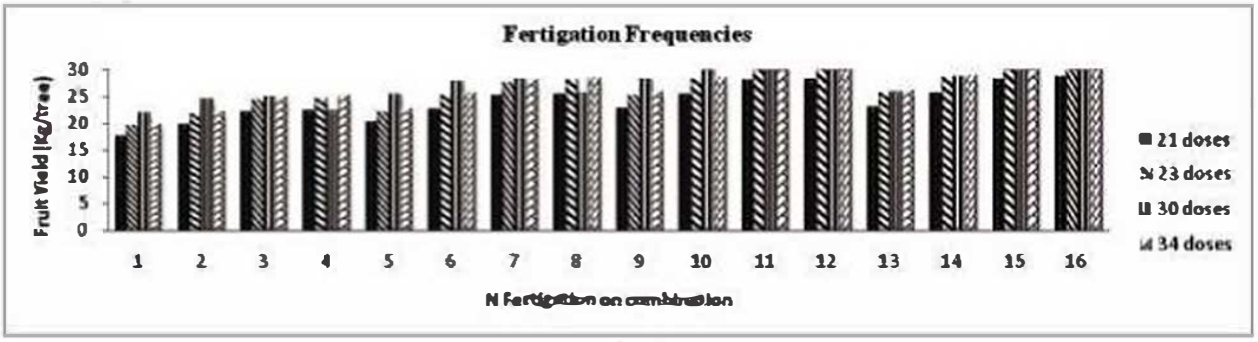


Fig. 12.

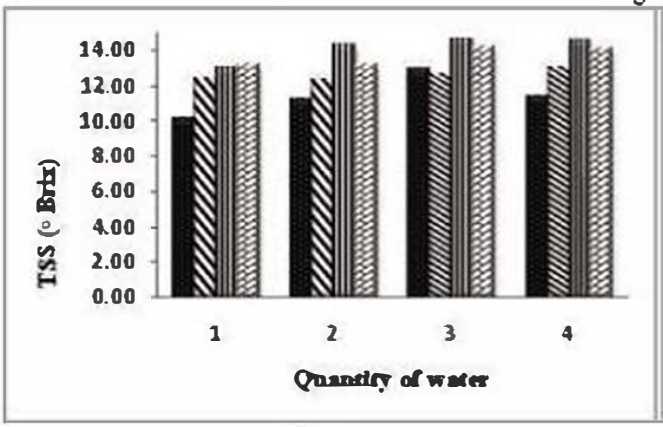


Fig. 13.

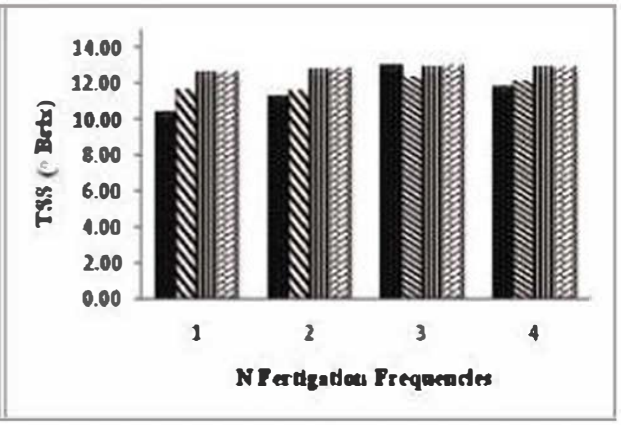


Fig. 14.

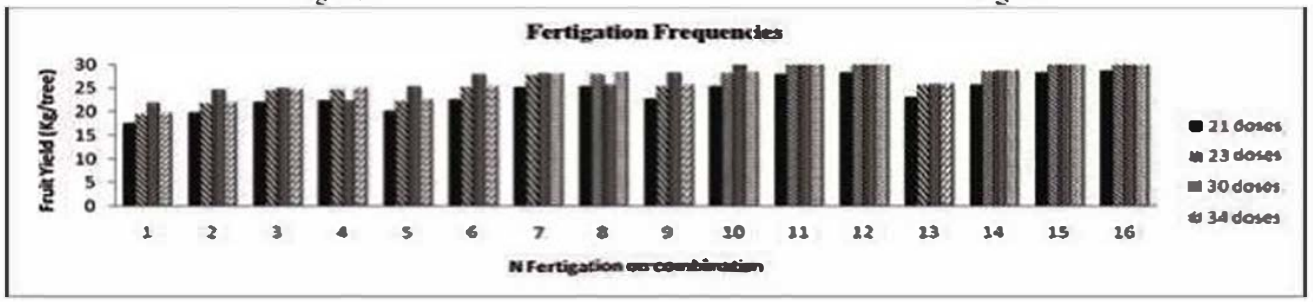


Fig. 14.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Short Communication

Efficacy of bioagents and fungicide in controlling of ber powdery mildew

Shashi Kant Goyal*, Shailesh Godika, Ram Phool Ghasolia, and Jitendra Sharma

Department of Plant Pathology, S.K.N. College of Agriculture (SKNAU) Jobner -303329 Jaipur, Rajasthan (India)
*Corresponding author's Email: shashikant69@gmail.com
(Received: 23.04.2016, Accepted: 12.09.2017)

Ber (*Ziziphus mauritiana* Lank.) is an ancient and poor man fruit crop, one of the most important underutilized fruit owing to its hardy nature and grown in semi-arid and arid regions of India and other few countries. Powdery mildew of *ber* incited by *Oidium erysiphoides* f. sp *ziziphi* is a serious problem in *ber* growing areas in India (Kapoor et al 1975 ; Gupta et al 1978 ; Yadav et al 1981) causing great loss in productivity and quality of fruits (Prakash, 1984 ; Rawal, 1988). The disease was first reported from Allahabad (Mitter and tandon 1930). Kumar et al (1978) noted the occurrence of powdery mildew of *ber* (*Ziziphi* spp.) in Indian arid zones. The fungus produces whitish powdery mass of spores on all the aerial plant parts resulting in pre-mature drop of flower buds and fruits (Rawal,1988). Infected fruits show discolouration, cracking and become mummified and foil to develop. Owing to expansion of ber orchards, working out of management strategies are also equally important to sustain the yield and quality of ber fruits. The bio control method against powdery mildew is very limited in most of the crop plants. Therefore, an attempt was made for management of the disease through bioagents along with effective fungicide.

A field experiment was conducted on susceptible local *ber* cultivar'Kali' at farmer's orchard at Udaipuria village (Chomu) in statistically randomized block design in the six consecutive years (2006-2007 to 2011-2012). Each treatment was replicated thrice by keeping single tree per replication. An equal ntumber of unsprayed plants were kept as control. The native isolates of *Trichoderma* and *Pseudomonas* were provided by CIAH, Bikaner to compare their efficacy along with karathane fungicide which is found most effective against the pathogen (Gupta et al 1977; Reddy et al 1990; Yadav and Singh 1985). Under the study different bioagents alone and alongwith effective fungicide (T_1= 1% *P. fluorescens* (CIAH-196)+ 0.05% karathane, T_2 = 1% *P. fluorescens* (NR)+ 0.05% karathane. T_3= 1%*Trichoderma* (CIAH-240))+ 0.05% karathane. T_4= 1%*Trichoderma* (NR)+ 0.05% karathane, T_5= 0.05% karathane and T_6= 0.1 % karathane were tested against ber powdery mildew . Three foliar sprays were given at 15 days interval and disease intensity was recorded after 20 days of last spray. First spray was given just to start initiation of the disease symptoms. The data on the development of powdery mildew on ber fruits were recorded on the randomly four marked fruiting twigs at each directiou per plant. Diseased fruits were graded into six categories of disease incidence i.e. 0 = healthy, 1 = 1-10, 2 = 10.1-25, 3 = 25.1-50, 4 = 50.1-75, 5 = > 75 % fruit area covered with powdery mildew.

The per cent disease index (PDI) and per cent disease control (PDC) were calculated according to the following formula:

$$PDI = \frac{\text{Sum of all numerical ratings}}{\text{Total number of fruits examined X 5}} X \ 100$$

$$PDC = \frac{\text{PDI in control -- PDI in treatment}}{\text{PDI in central}} X \ 100$$

Fruit yield of the tree was also recorded in each treatment at the time of fruits harvesting.

Six years pooled data presented in Table 1 revealed that all the treatments tested against ber powdery mildew were reduced the disease and intensity and also increased the fruit yield significantly in comparison to control. Karathane (0.1%) reduced the disease intensity significantly in comparison to control and other treatments. Minimum disease intensity (13.74%) was obtained in karathane (0.1%) followed by 1% *P. fluorescens* (NR) + 0.05% karathane (19.94 PDI). Whereas, in control PDI was 55.14. Maximum per cent disease control (75.06) was obtained in karathane (0.1%) followed by 1% *P. fluorescens* (NR) + 0.05% karathane (63.80) and also increased fruit yield significantly in comparison to other treatments. To circumvent pollution hazard due to injudicious use of agrochemicals and also to avoid development of resistance in pathogenic fungi to commonly used fungicides, use of biocontrol agents for the management of plant diseases has been tremendously increased in recent years. Keeping in view the bioagents were applied against the ber powdery mildew. In many cases, hyperparasites like *Ampelomyces quisqualis* has been exploited in other horticultural crops. Hofstein et al. (1996) have developed new product known as 'AQ10' for the management of powdery mildews with suggestions that it could be included as preventive control agent. The native isolates of *Trichoderma* (CIAH-240) and *Pseudomonas fluorescens* (CIAH-196) along with 50 per cent less concentration than recommended dose of fungicide (karathane) were found effective against the ber powdery mildew (Nallathambi et al. 2007). During the

present studies for the management of this disease, karathane 0.1 % was found most effective. These findings are in close agreement with results of Jain and Jat 1988; Reddy et al 1990; and Reddy et al 1996) who reported that karathane was most effective fungicide against the ber powdery mildew. Thind et al (2007) also reported thet Bayleton and karathane was found most effective in controlling the ber powdery mildew. In the present investigation economic of different treatments applied against the powdery mildew disease was also find out and the results revealed (Table 2) that maximum cost: benefit ratio was found with karathane (0.1 %). Three foliar sprays of karathane (0.1 %) at 15 days interval is recommended for control of ber powdery mildew. The prophylactic spray must be given just to start initiation of disease symptoms.

Table 1: Effect of different bioagents and fungicide against ber powdery mildew (Pooled 2006-2011)

S.N.	Treatments	Percent disease index (PDI)		Percent disease control (PDC)	Fruit yield (Kg/tree)
1	1% *P. fluorescens*(CIAH-196)+ 0.05% karathane	30.13	(33.27)	45.33	68.73
2	1% *P. fluorescens*(NR)+ 0.05% karathane	19.94	(26.48)	63.80	76.96
3	1%*Trichoderma*(CIAH-240))+ 0.05% karathane	23.16	(28.76)	57.96	72.86
4	1%*Trichoderma*(NR)+ 0.05% karathane	26.40	(30.92)	52.07	70.56
5	0.05% karathane	30.16	(33.31)	45.26	71.36
6	0.1 % karathane	13.74	(21.72)	75.06	80.40
8	Unsprayed check	55.14	(47.95)	-	49.86
	S.Em. $\pm$	(0.266)			0.529
	C.D. at 5%	(0.8069)			1.606

Figures in parentheses are angular transformed values

References

Gupta, P.C., Madan, R.L. and Grover, R.K. 1978. Occurrence of powdery mildew of ber in Haryana and its control. *Indian Phytopathology*, 31 : 440-443.

Hofstein, R, Daoust, R.A. and Aeschilmann, J.P. 1996. Constraints to the development of biofungicides: The examples of 'AQ10', a new product for the controlling powdery mildews. *Entomophaga*, 1(1) : 47-56.

Jain, S.C. and Jat, R.G. 1988. Efficacy of fungicides for the control of ber powdery mildew. *Indian J Myco Pl Pathol*., 18 (1) :100.

Kapoor, S.P., Cheema, S.S. and Singh, M.P. 1975. Occurrence and control of powdery mildew of ber (*Zizyphus mauritiana* Lamk) in Punjab. *J. Res.*, 12 : 26-29.

Kumar, K, Bhansali, R.P. and Arya, H.C. 1978. A note on the occurrence of powdery mildew on ber (*Zizyphus* spp.) in Indian arid zone. *Annals Arid Zone*, 17 (3) : 323-325.

Mitter, J.N. and Tandon, R.N. 1930. The fungus flora of Allahabad. *J. Indian Botanical Society*, 9 : 197.

Nallthambi, P., Umamaheswari, C., and More, T.A. 2007. Biological control of arid fruit diseases. *Indian J Arid Horticulture*, 2 (1) : 52-56.

Prakash, V. 1984. Studies on powdery mildew of ber caused by *Oidium erysiphoides* Ph.D. Thesis, Punjab Agricultural University, Ludhiana, India.

Rawal, R.D. 1988. Assessment of yield loses in ber fruit due to powdery mildew. *Pl Disease Research*, 3 :138.

Reddy, M.M., Rao, D.M. and Reddy, G.S. 1990. Preliminary field evaluation of some fungicides in the control of powdery mildew (*Oidium erysiphoides* fr.) on ber (*Zizyphus mauritiana*) in alfisols of arid zone of Andhra Pradesh. *Madras Agri J*., 77 (5-6) : 229-230.

Reddy, M.M., Reddy,G.S. and Madhusudan, T. 1996. Efficiency of fungicides against powdery mildew (*Oidium erysiphoides* f.sp. *ziziphi*.) of ber (*Zizyphus mauritiana* Lamk). *Indian J Pl Protection*, 24 : 64-68.

Thind, S.K., Nirmaljit, K. and Aulakh, P.S. 2007. Efficacy of fungicidal spray schedules in controlling ber powdery mildew. *Pl Disease Research*, 22 (2) : 129-131.

Yadav, G.R., Nirwan, R.S, and Prasad, B.1981. Powdery mildew of ber in U.P. and its control. *Progressive Horticulture*, 2: 27-32.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Genetic diversity in *ber* (*Ziziphus mauritiana L.*) accession collected from Haryana and Rajasthan

Hare Krishna, P.L. Saroj, Dhurendra Singh and Lokesh Kumar
ICAR-Central Institute for Arid Horticulture, Bikaner-334 006, Rajasthan
(Received: 7.05.2018, Accepted: 30.05.2018)

The Indian jujube commonly known as *ber* (*Ziziphus mauritiana* Lamk.) is one of the important fruit crops of the hot arid regions in India as it forms an integral part of the life of the locals as a source of nutrition and other purposes (Krishna and Parashar, 2013). The tree is an example of extremely drought hardy species which can be grown in dry land areas and on degraded, eroded, gravelly, saline and sodic wasteland. The jujube tree has great commercial importance owing to the usefulness of almost all its parts (Krishna *et al.*, 2016 a). A wide range of variability exists in *ber* in India for all important characters suggesting substantial scope for improvement; however, such genetic diversity need to be identified and conserved as plant breeders require genetic variation (genotypes) for crop improvement (Trivedi *et al.*, 2013). Further, reduction in genetic variability makes a crop increasingly vulnerable to diseases and adverse climatic changes (Saran *et al.*, 2006). Therefore, proper attention for exploration, collection, conservation and characterization of genetic resources of *ber* is the need of hour, especially, in view of dynamism in market demand for improved varieties and necessity for development of climate resilient varieties.

Most of the present day commercial cultivars were developed through seedling selection only by the farmers depending upon their economic characters (Awasthi and More, 2009). Therefore, with the view to identify suitable genotype(s) having desirable characters, a survey followed by collection of desirable genotypes was made in selected districts of Haryana and Rajasthan.

An exploration tour during the fruiting season in February, 2017 was conducted in four districts of Haryana and Jhunjunu district of Rajasthan to collect available genetic diversity of *ber*. Formal and informal conversation with local farmers was adopted as a strategy to collect the information about the *ber* germplasm available in the area. At each location, three-four farmers were consulted before identification of a genotype for collection. Accessions were selected randomly at fruit maturity stage from twenty sites across the four districts (Hisar, Bhiwani, Mahendragarh and Rewari) of Haryana and one site in Chidawa, Jhunjhunu, Rajasthan (Fig. 1) during survey. The available diversity was collected from population through selective sampling technique along with passport information (Table 1). Only disease-free plants bearing fruits with unique traits of horticultural importance were identified for collection. Plant vigour, fruit size, fruit colour, fruit weight etc. were the main parameters for identifying a genotype for collection. The quantitative data collected were subjected to statistical analysis following analysis of variance. The difference between the two groups was assessed by computation of least significant difference taking 't' values for error at the 5% level of significance.

The results clearly indicated a wide genetic variability among all the collected accessions. A wide variation was observed among the collected accessions for the studied traits (Fig.2; Table 2 & 3). Fruit weight varied from 1.3-16.2 g, while stone weight varied from 0.42-1.15 g. Fruit size (length x breadth) vary in relation to fruit weight (Krishna *et al.*, 2016 a). In the present study, highest fruit weight was noted in HR Coll. 15 (16.2 g) followed by the collection HR Coll. 18 (14.45 g), while, largest fruit size was recorded in HR Coll. 15 (34.9 x 27.8 mm) followed by HR Coll. 18 (36.7 x 22.2 mm) and HR Coll. 17 (32.3 x 22.3 mm). Likewise, pulp weight, which is an important observation for getting more amount of pulp for value addition, was highest in HR Coll. 15 (15.32 g) followed by HR Coll. 18 (13.67 g) and lowest in HR Coll. 10 (0.8 g) (Table 2). Lowest stone weight was noted in Chidawa Coll. 2 (Table 2). Fruits of most of the accessions were round in shape; however, oval and ovate were also found. Fruit cavities were either present exclusively on stem end or at both stem and stylar ends in collected accessions (Table 2). Three types of stone shapes namely, round, oval and ovate were noted in the collected accessions. However, round stone shape was the dominating one (Table 2). Amongst fruit characters, stylar and stem end cavities and fruit and stone shapes are the most dependable characters for classification (Bal, 1992; Azam-Ali *et al.*, 2006; Krishna *et al.*, 2016a). The TSS in different accessions as noted to be highest in Chidawa Coll. 1 (21.6 °B) followed by 20.8 °B in HR Coll. 19 and HR Coll. 13,while the lowest TSS content (11.2 °Brix) was noted in HR Coll. 4. Similarly, the highest contents of ascorbic acid was noted in HR Coll. 15 (220.37 mg/100g) followed by HR Coll. 14 (201.5 mg/100g) and HR Coll. 7 (201.5 mg/100g) (Table 3).

Variations in physico-chemical attributes of collected accessions may be due to differences in their genetic make-up and prevailing agro-climatic conditions. Such variabilities among accessions had earlier been reported by Ghosh *et al.* (2012) and Krishna *et al.* (2016 b) in wood apple, Trivedi *et al.* (2013) in pear and Singh *et al.* (2015) in *bael*.

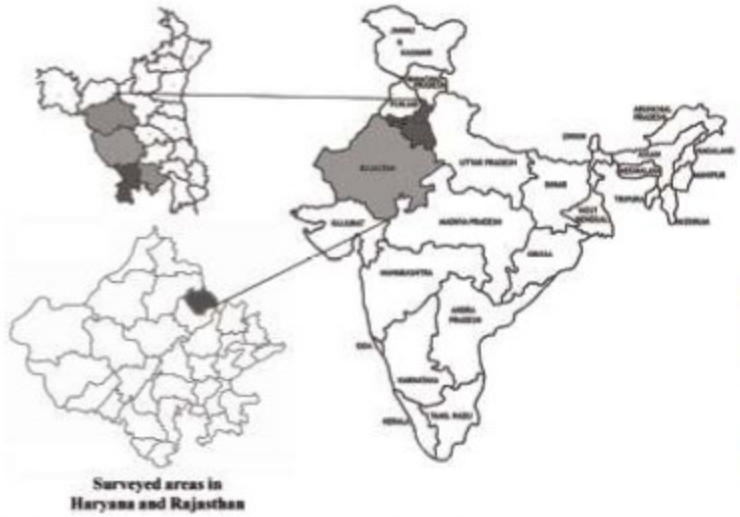


Fig. 1: Site of *ber* germplasm collection.

Fig. 2: Genetic variability in *ber* accessions collected from Haryana and Rajasthan.

Table 1. Passport data of *ber* germplasm collected during exploration.

S. No.	Accession	Place of collection	Latitude	Longitude	Altitude (m)
1	HR Coll.-1	Mothsara	N 29^0 15.119	E 075^0 34.471	199
2	HR Coll.-2	Malapur	N 29^0 15.159	E 075^0 34.471	212
3	HR Coll.-3	Malapur	N 29^0 15.119	E 075^0 34.789	212
4	HR Coll.-4	Sishwal	N 29^0 14.420	E 075^0 30.559	205
5	HR Coll.-5	Loharu canal	N 28 28.200	E 075^0 59.335	259
6	HR Coll.-6	Loharu canal	N 28^0 28.222	E 075^0 59.362	268
7	HR Coll.-7	Loharu canal	N 28^0 29.155	E 075^0 59.982	260
8	HR Coll.-8	Dhanasari	N 28^0 26.858	E 075^0 58.320	273
9	HR Coll.-9	Barda	N 28^0 19.631	E 075^0 59.627	316
10	HR Coll.-10	Balwadi	N $28^0$12.874	E 076^0 25.210	255
11	HR Coll.-11	Khaleta	N 28^0 13.339	E 076^0 25.042	261
12	HR Coll.-12	Khaleta	N 28^0 13.339	E 076^0 25.042	261
13	HR Coll.-13	Dhawana	N 28^0 13.965	E 076^0 22.478	268
14	HR Coll.-14	Bawal	N 28^0 04.176	E 076^0 35.381	257
15	HR Coll.-15	Bawal	N 28^0 04.176	E 076^0 35.381	257
16	HR Coll.-16	Fakirawala	N 28^0 04.363	E 076^0 35.473	253
17	HR Coll.-17	Fakirawala	N 28^0 04.363	E 076^0 35.473	253
18	HR Coll.-18	Adahedi	N 28^0 04.429	E 076^0 35.146	261
19	HR Coll.-19	Motlakalan	N 28^0 17.921	E 076^0 27.952	228
20	HR Coll.-20	Bashirpur	N 27^0 59.854	E 076^0 02.842	325
21	Chidawa Coll.-1	Chidawa	N 28^0 13.905	E 075^0 39.015	322
22	Chidawa Coll.-2	Chidawa	N 28^0 13.905	E 075^0 39.015	322

Table 2. Fruit and stone characteristics of collected accessions of *ber*.

S. No.	Accession	Fruit characters						Stone characters			
		Fruit shape	Fruit cavity	Weight (g)	Pulp weight (g)	Length (mm)	Width (mm)	Shape	Weight (g)	Length (mm)	Width (mm)
	HR Coll.-1	Round	Present	3.62	3	18.72	17.01	Oval	0.62	11.93	7.01
	HR Coll.-2	Round	Present	4.56	3.49	18.43	18.19	Oval	1.07	12.77	9.84
	HR Coll.-3	Oval	Absent	5.81	5.33	22.73	16.42	Club	0.48	16.55	6.89
	HR Coll.-4	Round	Present	12.2	11.41	21.85	24.47	Oval	0.79	12.3	10.22
	HR Coll.-5	Round	Absent	1.43	1.01	13.9	12.97	Oval	0.42	9.69	6.84
	HR Coll.-6	Round	Absent	4.81	4.27	20.14	19.85	Oval	0.54	13.09	9.83
	HR Coll.-7	Round	Present	2.5	1.99	16.23	17.29	Oval	0.51	11.42	8.88
	HR Coll.-8	Round	Absent	15.13	14.08	28.77	26.93	Oval	1.05	16.83	10.36
	HR Coll.-9	Round	Present	4.86	4.18	22.06	21.15	Oval	0.68	13.17	9.38
	HR Coll.-10	Round	Absent	1.30	0.78	12.86	13.48	Round	0.52	9.67	7.91
	HR Coll.-11	Oval	Present	6.92	6.33	23.29	21.26	Oval	0.59	11.91	6.01
	HR Coll.-12	Round	Absent	5.25	4.67	21.7	20.16	Oval	0.58	14.47	8.47
	HR Coll.-13	Round	Absent	4.37	3.35	17.39	17.46	Round	1.02	10.59	9.69
	HR Coll.-14	Ovate	Present	10.03	9.44	27.25	21.85	Club	0.59	16.4	6.84
	HR Coll.-15	Oval	Present	16.2	15.32	34.89	27.79	Club	0.88	18.64	8.1
	HR Coll.-16	Oval	Present	9.32	8.56	29.63	23.38	Club	0.76	19.41	7.44
	HR Coll.-17	Oval	Present	7.83	6.98	32.33	22.35	Oval	0.85	17.96	7.55
	HR Coll.-18	Oval	Present	14.45	13.67	36.69	22.20	Club	0.78	22.65	6.72
	HR Coll.-19	Oval	Absent	11.62	10.47	23.55	22.21	Oval	1.15	16.76	9.48
	HR Coll.-20	Oval	Present	12.37	11.76	28.31	19.45	Club	0.61	18.1	6.66
	HR Coll.-21	Oval	Present	10.79	9.91	27.35	22.89	Oval	0.88	15.09	8.18
	HR Coll.-22	Oval	Present	4.56	4.06	19.97	14.72	Club	0.5	14.21	6.4
$CD_{0.05}$		-	-	2.04	1.27	2.63	1.87	-	0.18	1.92	0.49

Table 3. Fruit quality attributes of *ber* collections.

S. No.	Accession	TSS (^{0}Brix)	Acidity (%)	TSS: Acid ratio	Ascorbic Acid (mg $100g^{-1}$)
1.	HR Coll.-1	11.6	0.34	34.12	186.34
2.	HR Coll.-2	13.7	0.57	24.04	172.48
3.	HR Coll.-3	13.8	0.44	31.36	83.16
4.	HR Coll.-4	11.2	0.39	28.72	189.42
5.	HR Coll.-5	19.1	0.54	35.19	141.13
6.	HR Coll.-6	18.8	0.47	40.00	150.15
7.	HR Coll.-7	13.2	0.42	31.43	202.14
8.	HR Coll.-8	14.2	0.38	37.37	189.42
9.	HR Coll.-9	16.6	0.43	38.60	170.94
10.	HR Coll.-10	19.4	0.37	52.43	147.07
11.	HR Coll.-11	17.4	0.34	51.18	164.78
12.	HR Coll.-12	16	0.38	42.11	156.31
13.	HR Coll.-13	22.8	0.51	40.78	175.56
14.	HR Coll.-14	16.4	0.38	43.16	201.74
15.	HR Coll.-15	17.8	0.32	55.63	209.44
16.	HR Coll.-16	13.2	0.40	33.00	143.99
17.	HR Coll.-17	17.6	0.32	55.00	154.31
18.	HR Coll.-18	14.2	0.31	45.81	140.14
19.	HR Coll.-19	20.8	0.48	43.33	181.72
20.	HR Coll.-20	17.8	0.47	37.87	124.74
21.	Chidawa Coll.-1	21.6	0.54	40.00	201.43
22.	Chidawa Coll.-2	17.2	0.58	29.66	180.95
$CD_{0.05}$		2.17	0.08	3.58	20.71

References

Azam-Ali, S., Bonkoungo, E. and Bowe, C. 2006. Breeding. (*in*) *Ber and Other Jujubes*. P. 289. deKock C, Godara A, Williams JT (Eds). International Centre for Underutilised Crops, Southampton, UK.

Bal, J. S. 1992. Identification of *ber* (*Ziziphus mauritiana* L.) cultivars through vegetative and fruit characters. *Acta Horti.*, 317: 245-253.

Das, S.C. and Prakash, J. 2011. Minor fruits: a livelihood opportunity for the tribal peoples of Tripura. *Acta Horti.*, 890: 65-70.

Ghosh, S.N., Banik, A.K., Banik, B.C., Bera, B., Roy, S. and Kundu, A. 2012. Conservation, multiplication and utilization of wood apple (*Feronia limonia*) - a semi-wild fruit crop in West Bengal (India). *Acta Horti.*, 948: 279-283.

Joshi, P. and Jain, S. 2008. Products from wood apple (*Limonia acidissima*) fruit and their quality evaluation. *J. Food Sci. Tech.*, 45: 270-271.

Krishna, H. and Parashar, A. 2013. Phytochemical constituents and antioxidant activities of some Indian jujube (*Ziziphus mauritiana* Lamk.) cultivars. *J. Food Biochem.*, 37: 571-577.

Krishna, H., Bhargava, R., Chauhan, N. and Sharma, S.K. 2016a. Morphological descriptors for DUS testing of Indian jujube (*Ziziphus mauritiana* Lamk.) varieties. *Indian J. Agri. Sci.*, 86(6): 809-814.

Krishna, H., Singh, R.S., Bhargava, R. and Sharma, B.D. 2016b. Genetic diversity in woodapple (*Feronia limonia*) germplasm collected from Gujarat. *Indian J. Arid Horti.*, 11(1-2): 137-139.

Pandey, S., Satpathy, G. and Gupta, R.K. 2014. Evaluation of nutritional, phytochemical, antioxidant and antibacterial activity of exotic fruit "*Limonia acidissima*". *J. Pharmacogn. Phytochem.*, 3(2): 81-88..

Saran, P.L., Godara, A.K., Yadav, I.S., Schrawat, S.K. and Lal, G. 2006. Morphological diversity among Indian jujube (*Ziziphus mauritiana* Lamk.) genotypes collected at Hisar, India. *J. Food Agri. Environ.*, 4(2):172-175.

Singh, R.S., Meena, S.R., Singh, A.K., Bhargava, R. and Sharma, B.D. 2015. Variability in *bael* (*Aegle marmelos* Correa) germplasm collected from Rajasthan. *Indian J. Arid Horti.*, 10(1-2):91-93.

Trivedi, A. K., Krishna, H., Verma, S. K., Tyagi, R. K. and Arya, R. R. 2012. Genetic diversity of pear (*Pyrus* spp.) in Uttarakhand Himalayas. *Indian J. Plant Genet. Resour.*, 26(1): 32-37.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Short communication

Effect of shoot Pruning on Yield and fruit quality of Jamun cv. Goma Priyanka

Sanjay Singh, A.K. Singh, D.S. Mishra and V. V. Appa Rao
Central Horticultural Experiment Station (ICAR-CIAH), Vejalpur-389340, Godhra, Gujarat
(Received: 28.01.2018; Accepted: 12.03.2018)

Jamun (*Syzygium cuminii* Skeels) is one of the important fruit crops belonging to the family Myrtaceae. It is indigenous to India, Burma and to the Andman Islands (Zeven and de Wet, 1982) and available throughout Indian plains as well as in Kumaon hill up to 1,600 m (Mishra *et al.*, 2015). Fruits are used as an effective medicine against diabetes, heart and liver trouble. Owing to its varied uses, it has now emerged as a potential fruit crop of country (Singh *et al.*, 2016). In Gujarat, it is grown commercially in Vadodara, Anand, Navsari, Kheda and Junagarh districts. Most of the plantations of jamun in these areas are established through planting of seedling types. However, now farmers are showing much interest in the plantation of grafted planting material of Goma Priyanka developed by the station. Jamun trees whether seedlings or grafted grow erect and reaches to a height of 25-30 m due to which harvesting and other management practices become difficult. In the absence of proper canopy management practices orchards become overcrowded which pose problem for orchard access and for adequate light interception needed for optimum photosynthesis, flowering, fruit set and quality (Mishra and Goswami, 2016). Pruning has been used as a tool to regulate tree size and shape to achieve a desired architecture of the canopy and also to reduce the foliage density by removing the unproductive branches of the tree. To maintain the dwarf framework of the jamun tree, toping of main stem (4–6 meters) is needed which also facilitates easy harvesting of the fruits. It is also observed that pruning of 50 % annual extension growth after harvesting was effective to reduce the plant canopy and to improve the fruit quality attributes (Singh et al., 2011). Pruning is a practice which performed in a manner to provide the plant such a shape and size so that its marketable yield can be enhanced. There was an increase in marketable yield in Konkan Bahdoli jamun trees when subjected to different pruning intensities (Lawande *et al.*, 2014). The fruit bearing branches in jamun are present on the periphery of canopy throughout its height. Also all fruits on a tree do not mature at once. Therefore, at least 3-4 pickings are required for harvesting of fully ripened firm fruits from a tree. The jamun fruits are also delicate and have very thin peel; therefore, fruits are to be essentially harvested by hand picking. For this, it is necessary to climb up the jamun tree. Thus, harvesting in jumun becomes tedious and 25 to 30 % fruits are spoiled due to mechanical damage during harvesting. The jamun being a non-climacteric fruit, fully ripened fruits essentially has to be plucked for getting desirable fruit quality. As hand picking is the only way to harvest fruits, managing tree canopy at suitable height is the only lasting option to have clean harvest of ripe fruits in economical manner. Pruning in jamun has not been considered as a regular practice to contain the tree canopy so far. In view of this, different intensities of pruning were imposed on mature bearing tree of jamun cv. Goma Priyanka to see its effect on fruit yield and quality.

Uniformly grown, 8 years old grafted plants of jamun cv. Goma Priyanka spaced at 5x5 m were selected at CHES, Godhra experimental farm and all the trees were maintained under uniform cultural practices. The soil is medium black and the climate is semi-arid with a rainfall of 700-800 mm annually. Selected jamun trees were of average 6.15 m height with an average spread of 5 m. The experiment was conducted in Randomized Block Design with four treatments viz. T1 - 25 % shoot pruning, T2 - 50 % shoot pruning, T3- 75 % shoot pruning of annual extension of growth and T4 - control (no pruning). All treatments were replicated four times with a unit of two trees per treatments per replication. Each respective treatment was pruned by the heading back in month of September. The observations on flowering, fruit yield (kg/tree) and physico-chemical characters were recorded using standard procedures. From each treatment, twenty five fruits were randomly selected from all the directions for recording the data and brought to the laboratory of Central Horticultural Experiment Station, Vejalpur, Panchmahal (Godhra), Gujarat. TSS of fruits was measured with the help of hand refractrometer while titratable acidity, ascorbic acid, protein, anthocyanin and sugar contents were determined by AOAC (1990) methods. The data were statistically analyzed as per method of Gomez and Gomez (1984).

Different levels of pruning recorded significant variation in per cent of flowering shoots and other yield attributing characters except fruit retention percentage. The maximum percentage of flowering shoots (70.33 %), panicle length (13.97 cm), number of flower/panicle (46.25), pollen viability (93.80 %), pollen germination (37.29 %), fruit set (45.74 %), fruit length (3.84 cm), fruit

width (2.96 cm) and fruit weight (20.50 g) with 25 % shoot pruning. It was followed by 50 % shoot pruning in which 60.17 % shoots flowered with 13.12 cm panicle length, 43.91 flowers/panicle, 92.27 % pollen viability, 36.01 % pollen germination, 42.27 % fruit set, 3.80 cm fruit length, 2.90 cm width and 20.25 g weight (Table 1). Whereas in case of pulp percentage, the maximum value was recorded with 50 % shoot pruning (88.50 %) non-significantly followed by 25 % shoot pruning (88.0 %) and the minimum pulp content (84.20 %) was observed with control (Table 2). In control, 42.12 per cent shoots recorded flowering with the minimum panicle length (12.43 cm), number of flowers/panicle (35.70), pollen viability (88.57 %), pollen germination (34.05 %), fruit set (38.23 %), length (3.69 cm), width (2.73 cm) and weight (18.06 g). This increment in yield attributing characters at 25 % level of pruning might have been resulted in the stimulation of optimum vegetative and floral growth at this intensity, which might have brought a balance between fruiting wood and leaf area. Earlier workers also recorded higher flowering and yield attributing characters in citrus (Goswami *et al.*, 1993), litchi (Mishra *et al.*, 2013) and jamun (Lawande *et al.*, 2014) through imposition of various levels of pruning. Also, Serrano et al. (2008) reported that the light pruning increased the number of productive branches and number of fruits per branch of guava cv. Paluma.

The fruit yield was reduced with the increase in intensity of pruning, however, all the levels of pruning recorded significantly higher yield than the control tree (Table 2). This may be attributed to the reduction in concentration of vital substances from severely pruned shoots. The maximum fruit yield was obtained in the trees with 25 % level of pruning (42.70 kg/tree) followed by 50 % level of pruning (38.33 kg/tree). The non-pruned trees produced significantly lower yield (25.05 kg/tree), however, it was found at par with 75 % level of pruning (27.02 kg/tree). Mistry and Patel (2009) also found beneficial effect of heading back on earliness and yield in mango cv. Alphonso. This finding is also in agreement with the reports of Lawande *et al.* (2014) and Singh *et al.* (2011) for getting higher yield in jamun.

Fruit chemical quality characters were also significantly affected by various levels of shoot pruning (Table 2). In respect to chemical parameters of fruit quality, significant improvements have been observed in TSS (18.20^0 Brix), TSS/acidity ratio (49.18), pulp protein (0.70 g/100) and anthocyanin content (1.90) with 25 % shoot pruning. However, the maximum total sugar (14.0 %), reducing sugar (7.12 %) and vitamin C (51.40 mg/100 g pulp) were recorded with 50 % pruning of annual extension growth. The minimum values for these chemical quality parameters were recorded in control. Improvement in fruit quality parameters may be due to the improved light penetration inside the canopy and assimilation of more photosynthates. These results are in agreement with Mishra et al. (2013) in litchi and Mistry and Patel (2009) in mango. In conclusion, 25 % shoot pruning may be adopted to increase yield with improved fruit weight and quality in jamun.

Table 1: Effect of shoot pruning on yield atributing characters of jamun cv. Goma Priyanka

Treatments	Flowering shoot (%)	Panicle length (cm)	No. of flower panicle^{-1}	Pollen viability (%)	Pollen germination (%)	Fruit set (%)	Fruit retention (%)	Fruit Length (cm)	Fruit width (cm)	Fruit weight (g)
25 %	70.33	13.97	46.25	93.80	37.29	45.74	30.01	3.84	2.96	20.50
50 %	60.17	13.12	43.91	92.27	36.01	42.27	28.48	3.80	2.90	20.25
75 %	45.66	12.65	42.48	90.33	35.45	39.98	27.33	3.77	2.84	18.23
Control	42.01	12.43	35.70	88.57	34.05	38.23	27.02	3.69	2.73	18.06
CD (P= 0.05)	6.12	0.33	4.28	1.22	0.62	4.14	NS	0.04	0.07	0.64

Table 2: Effect of shoot pruning on fruit yield and quality attributes of jamun cv. Goma Priyanka

Treatments	Yield tree^{-1} (kg)	Pulp (%)	TSS ^{0}Brix	Acidity (%)	TSS:acidity	Total sugar (%)	Reducing sugar (%)	Vitamin C (mg/100g)	Protein (g/100 g pulp)	Anthocyanin (OD)
25 %	42.70	88.00	18.20	0.37	49.18	13.50	6.50	49.00	0.70	1.90
50 %	38.33	88.50	18.00	0.39	46.15	14.00	7.12	51.40	0.65	1.83
75 %	27.02	85.10	17.00	0.39	43.58	13.00	6.00	47.20	0.60	1.80
Control	25.05	84.20	16.50	0.40	41.25	12.00	5.42	46.50	0.59	1.76
CD (P= 0.05)	4.22	1.10	1.12	NS	0.05	0.14	0.15	1.25	0.05	0.02

References

AOAC 1990. *Official methods of analysis*. 17th edn. Association of Official Analytical Chemists, Washington DC, USA.

Gomez, K. A. and Gomez, A. A. 1984. Statistical Procedure for Agricultural Research, 2nd edn., John Wiley and Sons Inc., New York.

Goswami, A. M., Saxena, S. K., & Kurian, S. 1993. High density planting in citrus. In: Advances *in Horticulture*, (Eds.) Chadha, K. L. and Pareek, O. P., New Delhi: Malhotra Publishing House, Vol. II, pp. 645-48.

Lawande, K. E., Haldankar, P. M., Dalvi, N. V. and Parulekar, Y. R. 2014. Effect of pruning on flowering and yield of Jamun cv. Konkan Bahadoli. *Journal of Plant Studies*, 3(1):114-118.

Mishra, D. S., Singh, A., Kumar, R., Singh, S., Singh, A. K. and Swamy, G. S. K. 2014. Jamun. In: *Tropical and Sub Tropical Fruit Crops*: Crop Improvement and Varietal Wealth, Part.II (Ed) Ghosh, S.N. Jaya Publshing House, Delhi, pp. 375-387.

Mishra, D. S. and Goswami, A. 2016. High density planting in fruit crops. *HortFlora Research Spectrum*, 5(3):261-264.

Mishra, D. S. and Lal, R. L. 2013. Canopy management in overgrown litchi orchards for improving yield and quality. In: *Canopy Management and High Density Planting in Subtropical Fruit Crops* (Eds.) Singh, V.K. and Ravishankar, H., Army Printing Press Lucknow pp. 225-228.

Mistry, P. M. and Patel, B. N. 2009. Impact of heading back plus paclobutrazol on rejuvenation of old and over crowed Alphonso orchards. *Indian Journal of Horticulture*, 66(4), 520-521.

Serrano, L. A. L., Martins, M. V. V., Lima, I. De M., Marinho, C. S. and Tardin, F. D. 2008. Effect of pruning time and intensity on Paluma' guava trees, in Pinheiros, ES, Brazil. *Revista Brasileira de Fruticultura*, 30(4): 994-1000.

Singh, S., Singh, A.K., Singh, H.P., Bagle, B.G. and More, T.A. 2011. Jamun. ICAR. pp.1-46.

Zeven AC and de Wet JMJ (1982) *Dictionary of Cultivated Plants and theirRegions of diversity: excluding most ornamentals, forest trees and lowerplants*. Centre for Agricultural Publishing and Documentation (Pudoc), Wageningen. I-II.

Singh, S., Singh, A.K., Appa Rao, Bhargava, R., Mishra, D.S. and Saroj, P.L. 2016. In National seminar on Noni and Medicinal Plants for Health and Livelihood Security, Lucknow, Dec. 3-4, 2016, pp. 52.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Management of fruit borer, *Meridarchis scyrodes* Meyrick (Carposinidae: Lepidoptera) in ber, *Zizyphus mauritiana*

Rajeshwari, G*, Srinivasulu, B, Deepthi, P and Subramanyam, K
Dr. Y.S.R. Horticultural University, [1]Horticultural Research Station, Rekulakunta, Anantapuramu, A. P
*Corresponding author's e-mail: raji.ento@gmail.com
(Received: 20.12.2017, Accepted: 25.04.2018)

The Ber, *Zizyphus mauritiana* belongs to family Rhamnaceae is an important arid zone fruit crop cultivated all over India. The major ber growing states are Madhya Pradesh, Bihar, U. P, Panjab, Haryana, Rajasthan, Gujarat, Maharastra and Andhra Pradesh. Ber is most drought hardy fruit tree which can stand salinity and saline water. Some of the xerophytic characters and its ability to stand drought makes it as a "king of fruits" of arids. Among insect-pests belonging to 33 families attacking ber (Nair, 1986), Fruit borer *Meridarches scyrodes* Meyrick is a major pest causing 70 per cent yield loss under severe infestation (Karuppaiah, 2013). The borer damage was mainly observed in southern and western India (Pareek and Nath, 1996 and Sonawane and Dorge, 1971). A field survey in Karnataka indicated fruit borer is a major pest in ber (Balikai, 1999). The reddish larvae of fruit borer bore into the fruit and feed on the pulp and accumulate faecal frass which are visible when fruit is opened, within affecting the fruit quality. The moths are small, dark brownish in colour. Keeping in view the severe losses, the present study is conducted to evaluate the newer insecticides and botanicals which are effective against the fruit borer.

Field experiment was laid out in randomized block design with six treatments comprising both synthetic and botanical insecticides viz., Spinosad 2.5 SC, Indoxacarb 14.5 EC, 5 % NSKE, Azadirachtin-3000 ppm, Azadirachtin-10000 ppm and one untreated check and each treatment replicated four times. The ber cultivar Gola was selected for the study. The treatments were imposed by spraying chemicals on marble sized fruits when the moth activity was observed in the orchard. A total of three sprays were given at twenty days interval. At each harvest, hundred fruits were collected randomly (covering four sides of the tree) and per cent borer infestation was recorded. Data were subjected by analysis of variance (ANOVA).

$$\text{Per cent borer infestation} = \frac{\text{sum of damaged fruits}}{\text{total number of fruits collected}} \times 100$$

The results of the field experiments revealed that application of different treatments can provide control of larval population which is comparable with untreated check. Observations were recorded for eight years from 2008 to 2015 and data presented in Table.1. The mean pooled data of eight years revealed that, all the treatments differed significantly with control in reducing the per cent borer infestation in ber. However, significant differences between ecofriendly management strategies and synthetic chemical insecticides were observed with respect to fruit damage and yield. Lowest per cent borer infestation with significantly higher yield (80.91 kg/plant) was recorded with Indoxacarb 14.5 EC @ 1ml/l (18.06) followed by spinosad 2.5 SC @ 1ml/l (22.02). Highest per cent borer infestation was recorded with control (43.72) followed by azadirachtin 10000 ppm @ 1ml/l (34.88), azadirachtin 3000 ppm @ 2.5 ml/l (32.41) and NSKE 5% (32.11). The present findings are also in agreement with findings of Sudheer and Subramanyam (2001), who reported that botanicals were less effective for fruit borer control in ber. The bioefficacy of synthetic insecticides in the management of fruit borer was superior to botanical insecticides.

The variation in fruit damage and yield in different treatments might be due to the slow rate of kill in ecofriendly management strategies compared to synthetic insecticides. The efficacy of spinosad in the control of fruit borer on ber has been reported earlier by Adiroubane and Raghuraman, 2008. These results are in agreement with the findings of Ravi *et al.* (2008). The mean per cent borer infestation was relatively high in all the treatments as compared to Indoxacarb 14.5 EC @ 1ml/l.

Table 1. Effect of different insecticides against ber fruit borer during 2008 to 2015 (pooled for 8 years)

S. No.	Treatments	Mean per cent borer infestation		Mean Fruit yield (kg/plant)	Cost:Benefit ratio
1.	Spinosad 2.5 SC @1ml/l	22.02	(27.98)*	70.71	1:0.78
2.	Indoxacarb 14.5 EC @1ml/l	18.06	(25.15)	80.91	1:1.54
3.	NSKE @ 5%	32.11	(34.50)	65.38	1:1.13
4.	Azadirachtin 3000 ppm @ 2.5 ml/l	32.41	(34.68)	63.81	1:1.09
5.	Azadirachtin 10000 ppm @ 1ml/l	34.88	(36.18)	62.45	1:1.05
6.	Control	43.72	(41.38)	54.42	1:0.79
SE.m±		0.21		0.49	
CD at 5%		0.64		1.48	

*Figures in the parentheses indicate the arc-sine transformed values

Significant differences were also observed among the treatments for fruit yield per plant in ber. Highest fruit yield per plant was recorded in Indoxacarb 14.5 EC @ 1ml/l (80.91 kg/plant) followed by Spinosad 2.5 SC @ 1 ml/l (70.71 kg/plant). Lowest fruit yield per plant was observed with azadirachtin 10000 ppm (62.45 kg/plant) and 3000 ppm (63.81 kg/plant) and NSKE 5% (65.38 kg/plant) treated plots and were significantly differed with control. With regard to cost:benefit ratio, highest cost:benefit ratio was recorded with Indoxacarb 14.5 EC @ 1ml/l (1:1.54) followed by NSKE 5% (1:1.13) and were significantly differed with control (1:0.79).

The per cent infestation of ber fruit borer was decreased (21.40 to 14.41) over years from 2008 to 2015 with Indoxacarb 14.5 EC @ 1ml/l followed by spinosad 2.5 SC @ 1ml/l (23.13 to 17.91). Highest borer infestation was recorded with control treatment (48.03) in 2011 than other years.

Spraying of Indoxacarb 14.5 EC @ 1ml/l at twenty days interval starting from marble size fruits was found effective in management of fruit borer in ber. The Cost:Benefit ratio was also high in Indoxacarb 14.5 EC @1ml/l treated fruits.

Fig. 1: Effect of different insecticides against ber fruit borer over years

References

Adiroubane, D. and Raghuraman, K. 2008. Plant products and microbial formulation in the management of brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guenee.). *J. of Biopest.*, 1(2):124 - 129.

Balikai, R. A. 1999. Pest scenario on ber (*Zizyphus maritiana* Lamarck) in Karnataka. *Pest Management in Horticultural Ecosystem*, 5 (1): 67-69.

Karuppaiah, V. 2013. Managing fruit borer menace on ber (*Ziziphus maritiana* Lamk.). Central Institute for arid Horticulture, Bikaner, India: 1-5.

NAIR, M. R. G. K. 1986. Fruit crops "Ber". *In insects and mites of crops in India*, ICAR, New Delhi, p.194.

Pareek, O. P. and Nath, V. 1996. Ber. In Coordinated Fruit Research in Indian Arid Zone - A two decades profile (1976-1995). National Research Centre for Arid Horticulture, Bikaner, India: 9-30.

Ravi, M., Santharam, G. and Sathiah, N. 2008. Ecofriendly management of tomato fruit borer, *Helicoverpa armigera* (Hubner). *J. of Biopest.*, 1(2):134-137.

Sonawane, B. R. and Dorge, S. K. 1971. Biology and control of fruit borer (*Meridarchis seyrodes* Meyrick) on ber. *Poona Agric. College Magazine*, 61(1/2):1-4.

John Sudheer, M. and Subramanyam, 2001. K. Preliminary study on the management of ber fruit borer Meridarchis seyrodes Meyrick (Carposinidae, Lepidoptera). *Pest Management in Horticultural Ecosystems*, 7(1): 79-81.

Fig 2: (A) Fruit borer typical symptoms on fruit (B) Larvae inside the fruit when split open (C) Accumulated faecal frass

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Short Communication

Performance of sweet potato germplasm in arid region of north western Rajasthan

M K Jatav*, Roop Chand Balai, Ajay Kumar Verma and Anita Meena
ICAR-Central Institute for Arid Horticulture, Bikaner-334 006 (Rajasthan)
*Corresponding author's e-mail: mkjatav2008@gmail.com)

The tuber crops are among oldest on earth. In many areas, especially in the wet tropics, they were the only staples and fed extensive populations before the introduction of cereals. Today, they represent the second most important set of food crops in developing countries, closely followed the cereals (Rathore, 2016). They are produced with low inputs but are an important source of income and employment in marginal areas. These crop are mostly consumed by the poorest, they contribute greatly to food security and are held in high esteem culturally (Lebot, 2009). Sweet potato [*Ipomoea batatas (L). Lam.*] belonging to the family *convolvulaceae* is an important tuberous root crop having tremendous potential for utilization in food, feed and industrial sectors, especially for the production of starch, flour, glucose and alcohol. They are good sources of vitamin A, C, B2, B6 and E as well as dietary fibre, K, Cu, Mn and Fe. The high nutrient content coupled with its anticarcinogenic and cardio-vascular disease preventing properties has gained recognition for the crop as a health food (John, 2011). They are widely grown in the tropics and warm temperate regions of the world. In developing countries, it is ranked fifth in economic value, sixth in dry matter production, seventh in energy production and ninth in protein production (Lobenstein, 2009). In India, it is the third most important tuber crop after potato and cassava. Globally, India occupies twelfth, eighth and fifth rank in area, production and productivity respectively. It is cultivated predominantly as a rainfed crop in Eastern India, especially in Orissa, West Bengal, Uttar Pradesh, Bihar and Jharkhand, accounting for 77% of area and 82% of production (Edison et al., 2009). Sweet potato can be grown in a wide range of soils and climate. Sweet potato can be grown on a wide range of soil types but sandy or sandy loam soils having good porosity and aeration with reasonably high organic matter content and permeable sub soil are ideal (Jansson and Ramon, 1991, Bouwkamp (1985).

Sweet potato is not a new crop for the state of Rajasthan but mostly confined to the areas with better soil and good rainfall conditions like; Ajmer, Barmer, Bundi, Dholpur, Jodhpur, Jalor, Jhalawar, Nagaur, Sikar, Udaipur. In Rajasthan, sweet potato is grown in 693 ha with a production of 2629 t. (Directorate of Horticulture, 2014). Rajasthan being the largest state of India and blessed with various ecological zones but maximum area (49.61%) is under hot arid zone. The twelve district of north-western Rajasthan (Barmer, Bikaner, Churu, Sri Ganganagar, Hanumangarh, Jaisalmer, Jalore, Jhunjhunu, Jodhpur, Nagaur, Pali and Sikar) accounts for 63.4% area of the hot arid realm of the country (Saroj *et al.* 2004), where very negligible area is under sweet potato cultivation. The main reasons of non-adoption of sweet potato in hot arid region are; sandy soils with poor fertility and subjected to wind erosion, very low (average of about 213 mm/ annum) and erratic rainfall, extremes of temperature and frost during winter, poor water resource, lack of situation specific knowledge about scientific cultivation of sweet potato *etc.*

Therefore, in order to increase the area under sweet potato, there is need to venture non-traditional areas like hot arid zone under sweet potato cultivation through better scientific management as per edaphoclimatic conditions. Keeping above facts in view, at attempt was made to assess the performance of sweet potato varieties at ICAR-Central Institute for Arid Horticulture, Bikaner (Rajasthan).

An investigation was carried out at Experimental Farm of ICAR-Central Institute for Arid Horticulture, Bikaner (Rajasthan) to assess the performance of sweet potato cultivars under hot arid region during consecutive year 2017. The experiment was laid out in factorial randomized block design and replicated six times. The analysis of variance was done. The rooting cuttings of three sweet potato cultivars *viz. Sree Bhadra, CO 3-4, Sree Arun, Local-1 and Local-2* were procured from AICRP on tuber crop and two strain local-1 and local-2 were collected from farmer's field. Cuttings were planted in the 1nd week of July during the years under with recommended management practices. In this experiment, 1/3rd of N was applied through neem coated urea and DAP in side-band along with a uniform dose of 80 kg P_2O_5 through di-ammonium phosphate and 100 kg/ ha K_2O through muriate of potash during planting time while 1/3rd of N was applied as through neem coated urea at 35 days after planting *i.e.* at the time of earthing up and the remaining 1/3rd N was applied through neem coated urea at 50 days after planting *i.e.* at the time of bulking stage. The vines were cut at 160 days. Irrigation was applied through sprinklers at weekly intervals. The observation on

growth parameters viz., vine length, number of vines/plant and number of leaves/plant at 35 days was recorded. The yield and yield attributing characters of tubers were recorded after harvesting of the sweet potato.

Various growth parameters *viz.*, initiation of buds from cuttings, vine length (cm), number of leaves/plant and number of vines/plant for all the varieties grown has been recorded at different days after planting. Data presented in table 1 and fig no. 1 and 2 data indicated that as days of planting advances in different days, all vegetative growth parameters were increased irrespective of variety. The mean vine length at 60, 70, 80 and 90 days after planting in Sree Bhadra, CO 3-4, Sree Arun, Local-1 and Local-2 were 108, 96, 100, 91, 97 respectively.. Meanwhile, the mean of days to initiation buds, number of leaves at 35 DAP and number of vines/ plant at 35 DAP were 13.4, 63.8, 2.78. Among different sweet potato varieties, maximum mean vine length was 108 cm and recorded in Sree Bhadra followed by Sree Arun (99.75 cm) followed by Local-2 (97.25 cm), while minimum in Local-1 (91.25). However, the number vines and number of leaves/ plant did not follow the same trend, which is obvious that these variations are due to their genetic nature of the variety.

Data presented in table 2 regarding yield and yield attributing characters of different sweet potato cultivars revealed that mean number tuber yield/plant was 3.3 irrespective of cvs, thought the tuber yield/plant varied significantly giving highest number tuber/plant in Local-2 (3.9) followed by Local-1 (3.8), CO 3-4 (3.6) while lowest number of tuber yield/plant was recorded in Sree Bhadra (2.2). As far as average tuber weight is concerned more than 100g tubers were obtained in Co-3-4 (126g) and Local-2 (129 g) while minimum average weight of tuber was observed in Sree Bhadra (28g). The mean tuber yield/plant was recorded 317g with highest yield/plant in Local-2 (502g) followed by CO-3-4 (454g) and lowest tuber yield/plant was recorded in Sree Bhadra (62g). The tuber yield/ha also varied significantly among different cultivars. The highest tuber yield was recorded in Local -2 (277 q/ha) followed by Co-3-4 (249 q/ha), Local-1 (175 q/ha) and minimum yield in Sree Bhadra (34 q/ha). These observations suggest that Co-3-4 were high yielder while Sree Bhadra was low yielder under hot arid region.

Sweet potato cultivars differ in their growth and yield potential; hence there is a differential response to agro-climatic conditions and bulking rate even if they belong to same maturity group. Duynisveld *et al.*, (1988) and Sharifi *et al.*, (2007) have also reported that different cultivars of sweet potato behave different in term of yield and bulking rate.

It can be concluded from the present study that yield of sweet potato can be improved markedly by exploiting varietal differences in sweet potato. Sweet potato cultivars showed wide variation in yield in western Rajasthan. Local-2 and CO 3-4 was the highest yielder and agronomically most efficient variety. These variety were more suitable than the other most common varieties of the region and convert, it into yield most economically. Sweet potato has great potential in the state in the arid part of Rajasthan. Presently the major constraint is the availability of quality planting material. As the tuber crops are vegetative propagated, using quality disease free planting material is important to reap good harvest of crops. Besides, tuber crops requires huge amount of mother corms which necessitate huge transpottation cost and logistic facilities. Extremity in weather is another factor responsible for the low productivity of tuber crops. Rajasthan state is having highest rainfall variation in the country. Extreme weather conditions can adversely affect tuber production.

Table1. Sweet potato performance in the non-traditional areas of western Rajasthan

Varities/germplasm	No. of tuber/plant	Avg. weight of tuber (g)	Yield/plant (g)	Yield (q/ha)
Sree Bhadra	2.2	28	62	34
CO-3-4	3.6	126	454	249
Sree Arun	2.8	89	247	136
Local-1	3.8	84	318	175
Local-2	3.9	129	503	277
Mean	3.3	91	317	174

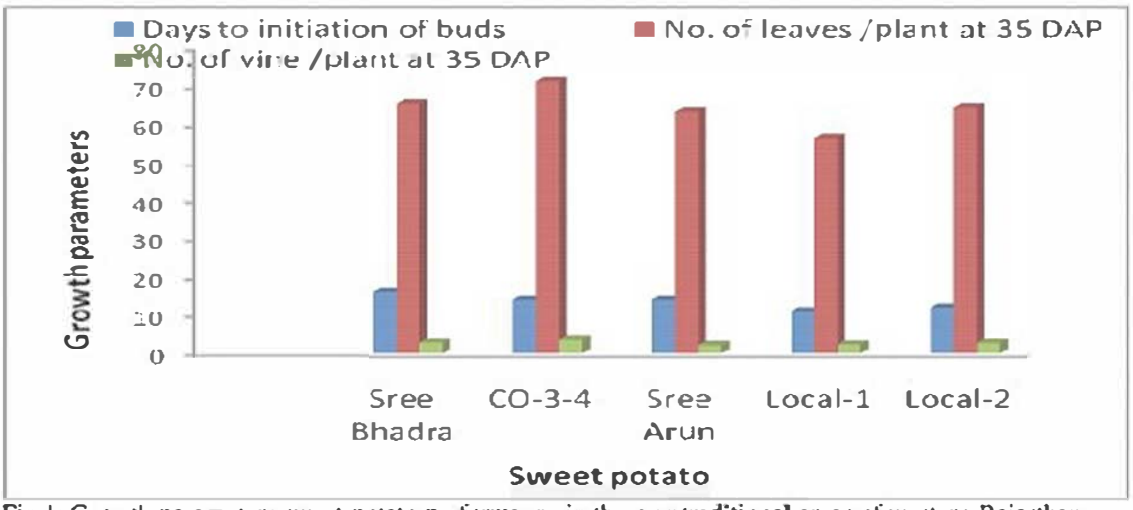


Fig.1: Growth parameters sweet potato performance in the non-traditional areas of western Rajasthan

Fig.2: Vine length sweet potato performance in the non-traditional areas of western Rajasthan

References

Bouwkamp, J.C. 1985. Production requirements. In: Sweet Potato Products: A Natural Resource for the Tropics. Bouwkamp, J.C. (Ed.). CRC Press, Boca Raton, FL. pp.1-33.

Directorate of Horticulture. 2013. Horticulture Statistics. Directorate of Horticulture. Pant Krishi Bhawan, Government of Rajasthan, Jaipur.

Duynisveld WHM, Strebel O and Boticher J .1988. Are nitrate leaching from arable land and nitrate pollution of ground water avoidable. *Ecol Bull.* 39: 116-25

Edison, S., Hegde, V., Makesh Kumar, T., Srinivas, T., Suja, G. and Padmaja, G. 2009. Sweet potato in the Indian sub continent. In: The Sweet Potato. Lobenstein, G. and Thottappilly, G. (Eds.). Springer Science Publishers, pp.391-414.

Jansson, R. K. and Ramon, K.V. 1991. Sweet potato pest management: A global over view. In: Sweet Potato Pest Management: A Global Perspective. Jansson, R.K. and Ramon, K.V. (Eds.). West view press Inc., Boulder, Co. pp. 2-12.

K. Susan John. 2011. Soil-Plant Nutrition of Sweet Potato and Minor Tuber Crops: A Review. *Journal of Root Crops*, 37 (2): 111-124

Lebot, V. 2009. Tropical Root and Tuber Crops: Cassava, Sweet Potato, Yams, Aroids. *CABI*, UK. pp. 1-413.

Lobenstien, G. 2009. Origin, distribution and economic importance. In: The Sweet Potato. Lobenstein, G. and Thottappilly, G. (Eds.). Springer Science Publishers, pp. 9-12.

R.S. Rathore, Sunil Pareek, Manish Kalal, James George. 2016. Tuber Crop Cultivation in *Mewar* Region of Rajasthan: Opportunities and Strategies. *Journal of Root Crops*, 42 173-176.

Saroj PL, Vashishtha BB and Dhandar DG.2004. Changing Scenario in Arid Horticulture Editors Saroj PL, Vashishtha BB and Dhandar DG. Advances in Arid Horticulture, Vol. 1, pp. 1-28.

Sharifi M, Bernie JZ and Coleman W.2007. Screening for nitrogen-use efficiency in potato with a recirculating hydroponic system. *Commun Soil Sci Plan*, 38:359-70

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Two New Leaf Spot Disease of Bael (*Aegle marmelos* Correa.) From Uttar Pradesh.

Sanjeev Kumar*, Santosh Kumar, S.K. Pandey and Prashant Mishra
Department of Plant Pathology, N.D.U.A. & T. Kumarganj, Faizabad, Uttar Pradesh .
Received 14.03.2017; Accepted: 11.12.2017)
*Corresponding author's Email-drsanjeev44@gmail.com.

Aegle marmelos Correa is one of the most utilitarian medicinal plants of India; it grows under adverse agro climatic conditions. It has capacity to adapt successfully to a wide range of habitat from arid, semiarid to mesophytic conditions and a wide temperature tolerance (from -7^{0}C to 48^{0}C). The importance of *Aegle marmelos* lies in its curative properties, which make the tree one of the most useful medicinal plants of India.

Myrothecium roridum This species is responsible for causing leaf spot disease in *Aegle marmelos*, this is first report from Uttar Pradesh. The symptoms were found on leaves as small, circular in shape which are brown in colour but later on these spots enlarges and cover the more area. Chlorosis around the lesions may be seen and concentric rings appears in the middle of the spot are characteristic symptoms. Disease symptoms recorded first during rainy season (July- August), 15-20 days after symptom production concentric rings are produced. Characteristic symptoms of this disease are formation of shot hole due to shedding of necrotic tissues of the leaves. In severe condition number and size of lesions increases, sporodochia may be seen on older lesions which are black in colour (Fig. 1).

Fungus produces creamy white colonies on PDA which are 1.5 cm diameter after 3 days at 25^{+}2^{0}C. Concentric pattern of sporodochia of *Myrothecium roridum* which are black in colour as seen in fig. 2 formed on PDA after 10-15 days of inoculation. Conidia were rod shaped (Fig.2). Pathogenicity were tested, using *M. roridum* culture isolated from bael leaves and inoculated on healthy seedlings. The inoculated plants produced symptoms within 7-10 days period. Symptoms produced on inoculated plants are similar to those observed in the field. Cultural characters of the test organism which were reisolated and grow on PDA were similar to the previous culture.

Fig. 1: Leaf spot on *Aegle marmelos* caused by *Myrothecium roridum*

Fig. 2: *Myrothecium roridum* mycelium, sporodochia and conidia

Fusarium pallidoroseum (Cooke) Sacc. The fungus *Fusarium pallidoroseum* causing leaf spot/ blight on *Aegle marmelos* has been reported first time from India. The disease appeared during post rainy season (September) as irregular pustules which were brown in colour, increased very fast and covered the most of the leaf area, affected leaves become dry and fall off (Fig. 3). Much vegetative loss have been recorded in the nursery with this disease. The review of literature showed that it is a new record on *Aegle marmelos* from India.

Fusarium pallidoroseum produce smooth and creamy white colony. The fungus produces both macro and micro conidia which are hyaline, septate and ends are also hook shaped. Mycelium are thin and septate (Fig. 4). Macro conidia were produced from phialides on unbranched or branched conidiophpres. Macro conidia borne in sporodochia were curved, possess a foot cell, 3-5 septate. Micro conidia are single celled, smooth, hyaline, ovoid to cylindrical.

Fig.3: Leaf spot and dieback caused by *Fusarium pallidoroseum*

Fig.4: Mycelium and conidia of *Fusarium pallidoroseum*

References

Anonymous 2010. The cause of wilting/drying in bael plants. *Annual Progress Report of AICRP on Arid Zone Fruits* (ICAR), pp-196.

Anonymous 2011. Oregon State University Extension. Leaf spots and shothole. The *Royal Horticultural Society 2011/RHS* Registered Charity No 222879/SC038262.

Harsh NSK, Tiwari CV and Nath V. 1989. Foliage diseases in forest nursery and their control. *Journal of Tropical Forestry*, 5: 66-69.

Kim DK., Bae DW, Lee SC, Han KS and Kim HK. 2003. Detection of *Myrothecium* leaf spot, a new disease of watermelon. *Plant Pathol. J.*, 19: 200-202.

Naseema A, Praveena R, Nair RR and Peethambaram RK. 2006. Control of Water Hyacinth by *Fusarium pallidoroseum*, *Curr. Sci.*, 86: 770-771.

Seebold K.W, Jr Langston DB, Jr Kemerait RC and Hudins JE. 2005. First report of a leaf spot and stem canker caused by *Myrothecium roridum* on watermelon in the United States. *Plant Dis.*, 89: 342.

Tange A, Kongsdal O, Ngoko Z, The C and Mathur SB. 2003. *Fusarium pallidoroseum* in maize samples of three agro-ecological zones of Cameroon. *Journal of Stored Product Research*, 39(4): 367-374.

Yam KJ, Park EW. 1990. Soybean leaf spot disease caused by *Myrothecium roridum* Tode ex Fries. Korean *J Plant Pathol.*, 6: 313-317.

INDIAN JOURNAL OF
ARID HORTICULTURE
2017, Vol. 12 (1-2):1-15

Short Communication

Standardization of processing techniques for karonda (*Carissa carandas*) products for commercial utilizatoin

Lalit Kumar[1], R. N. Singh[2] and Gajanand Jat[3]
Amar Singh P.G. College, Lakhawati, Bulandsahar (UP)
[1]Fertilizer Association of India, New Delhi
[2]Ex- Reader, Amar Singh P.G. College, Lakhawati, Bulandsahar (UP)
[3]Assistant Professor (Soil Science), Rajasthan College of Agriculture, Udaipur (Rajasthan)
(Received: 13.02.2017, Accepted: 28.04.2018)

Karonda (*Carissa carandas* L.) is an underutilized indigenous fruit crop of India. It bears wider adaptibility and thrives well throughout arid and semi-arid areas of the country. Being astringent in taste, it is not popular as dessert fruit but it is rich source of essential vitamins and minerals required for adequate human health. The ripe fruit have antioxidant properties and reported to be useful in curing certain diseases like bilious (Watt, 1972) and intestinal worming (Vasu, 1986).

Besides, the karonda fruit also has good potential of processing and has potential for export as fresh fruits and processed products such as preserve, jam, candy, juices, pickles etc (Chandra and Jindal, 2001). Further, huge harvest of the produce during peak harvesting season creates glut and the growers are compelled to sale their produce at low prices which reduces the markets value of the fruit. The post harvest losses in karonda vary from 30-40%. Besides, being acidic in nature karonda is not consumed as fresh and not popular as table fruit. Hence, value addition through processing would be the only effective tool for economic utilization of karonda. Since, karonda is a seasonal fruit, its preservation in different products is necessary to avoid its spoilage and to make its availability round the year (Parvathi and Anby, 1997).

The storage of fresh karonda fruits for longer time is not quite feasible; therefore, its processing into different products is essential. Also, longer shelf life of value added products of karonda is important from consumers and marketing point of view. Very little attempts have been made to study the standardization of processing techniques of karonda in to various products. Keeping these points in view, the present investigation was undertaken to study the standardization of processing techniques for karonda products (candy, squash, jelly and jam) for ensuring the longer storage life and better organoleptic acceptibility.

The present investigation was carried out at the Post-harvest Technology Laboratory, Department of Horticulture and Food Processing, Uttar Pradesh, Saharanpur, India, during June to November, 2007 and 2008 to standardize the processing techniques for karonda products for commercial processing. Healthy and matured karonda fruits of 'Green with Purple blush' genotype were used for the experimentation. Four products *viz.*, candy, squash, jelly and jam were made from karonda. The five recipes each of candy and squash; and six recipes each of jelly and jam were prepared (Table 1-4). The method of preparation of various products was common for all recipes. Different recipes of the products were taken for estimating biochemical parameters like total soluble solids (TSS °Brix) and acidity (%) by hand refractometer and standard solutions of *p*H 4.0 and 7.0, respectively. Organoleptic analysis of different recipes of karonda products was done by the panel of 9 judges on a 9 point hedonic scale to assess the acceptability of the products based on the various sensory attributes like colour and appearance, texture, flavour, taste, after taste and overall acceptability. The data of the various recipes' of karonda products were analyzed statistically in Completely Randomized Design with three replications.

Table 1. Different recipes of candy prepared from karonda fruits

Recipe No.	Contents	Fruit: sugar ratio	Additives
1.	Fruits blanched with water i.e. (*control*)	1 : 1.5	-
2.	Whole fruit without pectin coating	1 : 1.5	Citric acid
3.	Segmented fruit without pectin coating	1 : 1.5	Citric acid
4.	Whole fruit with pectin coating	1 : 1.5	Pectin
5.	Segmented fruits with pectin coating	1 : 1.5	Pectin

Table 2. Different recipes of squash prepared from karonda fruits

Recipe No.	Juice : sugar ratio	Acidity (%)
1	1 : 1.0	1.01
2	1 : 1.2	1.21
3	1 : 1.5	1.00
4	1 : 1.6	1.21
5	1 : 1.7	1.01

Table 3. Different recipes of jelly prepared from karonda fruits

Recipe No.	Juice extract : sugar ratio	*p*H
1	1 : 1.0	3.0
2	1 : 1.1	3.2
3	1 : 1.2	3.4
4	1 : 1.3	3.0
5	1 : 1.4	3.2
6	1 : 1.5	3.4

Table 4. Different recipes of jam prepared of karonda fruits

Recipe No.	Pulp : sugar ratio
1	1 : 1.0
2	1 : 1.4
3	1 : 1.5
4	1 : 1.6
5	1 : 1.7
6	1 : 1.8

Candy

Data reveals that karonda candy prepared of 'whole fruit with pectin coating' having TSS of 78.8 ^{0}Brix and 0.42% acidity scored significantly highest for organoleptic quality (Table 5). Organoleptic score (7.57) of this recipe was differed significantly with all other recipes. All the recipes were with acceptable organoleptic score i.e. like moderately. Kumar (1990) and Deen (1992) were also supported this contention for candy preparation.

Squash

Results indicate that a composition of juice and sugar in the ratio of 1:1.5 containing 51.8 ^{0}Brix TSS and 0.23% acidity was found suitable for preparation of quality squash of karonda (Table 6). Organoleptic score (7.74) of this recipe was differed significantly with all other recipes. All the recipes were with acceptable organoleptic score i.e. like moderately. The increase or decrease in acidity and TSS beyond this level reduced the organoleptic quality of karonda squash. Similarly, Ashraf (1987) suggested ideal recipe of jamun squash containing 40% juice, 50% TSS and 1.2% acidity whereas, Waskar and Khurdiya, (1987) reported that S35% juice, 40 ^{0}Brix TSS is ideal composition for phalsa squash.

Jelly

Data indicates that jelly prepared of using juice extracts and sugar ratio of 1:1.3 with 70.8 ^{0}Brix TSS and 0.31% acidity was recorded significantly highest organoleptic score (8.09) (Table 7). Though, it was found at par with recipie containing juice extracts and sugar ratio of 1:1.4 with organoleptic score of 8.02. All the recipes were with acceptable organoleptic score i.e. like moderately and like very much. A good quality jelly can be prepared from karonda fruits because its' juice is rich in both pectin and acidity. Juice and sugar ratio of 1:1.3 with 70.8 ^{0}Brix TSS and 0.31% acidity were found suitable for making an excellent quality of jelly. Since, only a particular proportion of sugar for particular fruit juice containing pectin can produce best jelly. Sugar aids in forming hydrogen bonds between pectin molecules (Speiser *et al.*, 1947) hence, these bonds facilitates the ideal setting of jelly. The rate of jelly setting is also modified by hydrogen ion concentration. The present result is supported by the findings of Ashraf (1987).

Jam

Jam prepared of using karonda pulp and sugar ratio of 1:1.6 with 75.2 ^{0}Brix TSS and 0.23% acidity was recorded significantly highest organoleptic score (8.01) followed by and considered as an ideal recipe for making jam from karonda fruits (Table 8). All the recipes were with acceptable organoleptic score i.e. like moderately. Many workers pointed out that higher the sugar concentration higher is the jam strength.

The present investigation suggests that karonda candy prepared of 'whole fruit with pectin coating' having TSS of 78.8 ^{0}Brix in fruit to sugar ratio of 1:1.5 scored significantly highest for organoleptic quality. A composition of juice and sugar in the ratio of 1:1.5 containing 51.8 ^{0}Brix TSS was found suitable for preparation of karonda squash. It can also be concluded that jelly prepared of using juice extracts and sugar ratio of 1:1.3 with 70.8 ^{0}Brix TSS and Jam prepared of using karonda pulp and sugar ratio of 1:1.6 with 75.2 ^{0}Brix TSS were recorded significantly highest organoleptic score of 8.09 and 8.01, respectively.

Table 5. Biochemical and organoleptic analysis of different recipes of karonda candy (mean of 2 years)

Recipe No.	Recipe	TSS (^{0}Brix)	Acidity (%)	Organoleptic quality	
				Score	Rating
1.	Fruits blanched with water	72.8	0.41	7.23	Like moderately
2.	Whole fruit without pectin coating	74.2	0.41	7.45	Like moderately
3.	Segmented fruit without pectin coating	75.7	0.41	7.36	Like moderately
4.	Whole fruit with pectin coating	78.8	0.42	7.57	Like moderately
5.	Segmented fruit with pectin coating	77.6	0.42	7.21	Like moderately
S.Ed.		1.17	0.04	0.034	
CD at 5%		2.6	NS	0.07	

Table 6. Biochemical and organoleptic analysis of different recipes of karonda squash (mean of 2 years)

Recipe No.	Juice : sugar Ratio	TSS (°Brix)	Acidity (%)	Organoleptic quality	
				Score	Rating
1.	1 : 1.0	45.8	0.24	7.51	Like moderately
2.	1 : 1.2	51.2	0.24	7.54	Like moderately
3.	1 : 1.5	51.8	0.23	7.74	Like moderately
4.	1 : 1.6	53.8	0.24	7.47	Like moderately
5.	1 : 1.7	56.1	0.24	7.46	Like moderately
S.Ed.		0.77	0.03	0.093	
CD at 5%		1.7	NS	0.21	

Table 7. Biochemical and organoleptic analysis of different recipes of karonda jelly (mean of 2 years)

Recipe No.	Juice : sugar ratio	TSS (°Brix)	Acidity (%)	Organoleptic quality	
				Score	Rating
1.	1:1.0	66.88	0.29	7.26	Like moderately
2.	1:1.1	67.29	0.29	7.11	Like moderately
3.	1:1.2	67.72	0.31	7.13	Like moderately
4.	1:1.3	70.83	0.31	8.09	Like very much
5.	1:1.4	69.88	0.32	8.02	Like very much
6.	1:1.5	68.86	0.32	7.27	Like moderately
S.Ed.		1.102	0.03	0.171	
CD at 5%		2.38	NS	0.37	

Table 8. Biochemical and organoleptic analysis of different recipes of karonda jam (mean of 2 years)

Recipe No.	Pulp : sugar ratio	TSS (°Brix)	Acidity (%)	Organoleptic quality	
				Score	Rating
1.	1:1.0	74.26	0.23	7.46	Like moderately
2.	1:1.4	74.29	0.24	7.59	Like moderately
3.	1:1.5	75.28	0.24	7.82	Like moderately
4.	1:1.6	75.23	0.23	8.01	Like moderately
5.	1:1.7	77.21	0.23	7.67	Like moderately
6.	1:1.8	81.22	0.25	7.88	Like moderately
S.Ed.		1.121	0.04	0.092	
CD at 5%		2.42	NS	0.20	

References

Ashraf, S.M. 1987. Studies on post-harvest technology of Jamun (*Syzygium cumini* Skeeles) fruit. Ph.D. Thesis, N.D. Univ. of Agric. and Tech., Faizabad (U.P.).

Chandra, Atul and Jindal, P. C. 2001. Sustainable fruit production in arid regions for export. *Current Agri.*, 25(1/2): 13-16.

Deen, B. 1992. Studies on screening of aonla (*Emblica officinalis* Gaertn.) genotypes for processing. M.Sc. Thesis, N.D. Univ. of Agric. and Tech., Faizabad (U.P.).

Kumar, S. 1990. Studies on post-harvest technology of papaya (*Carica papaya* L.) fruits. Ph.D. Thesis, N.D. University of Agric. and Tech., Faizabad (U.P.).

Parvathi, S. and Anby, S. 1997. Karonda delicious. *Indian Hort.*, 42(1): 11-13.

Speiser, R.M., Copley, J. and Nutting, G.C. 1947. Effect of molecular association and change distribution on the jelation of pectin. *J. Phys. Colloid Chem.*, 51: 117.

Vasu, N. 1986. Encyclopedia India. Vol. IV. B.R. Pub. Corp., Delhi.

Waskar, D.P. and Khurdiya, D.S. 1987. Processing and storage of 'Phalsa' beverages. *Indian Food Pack.*, 41(5): 7-16.

Watt, G. 1972. A dictionary of the economic products of India. Vol. II. Cosmo Pub., New Delhi.