Total geographical area of the country = 328.7 mha
Area under Arid zone = 38.7 million ha
% Area under Arid zone including cold arid = 11.77 %

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Arid horticulture : An overview

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Abstract

The arid region is spread over 38.7 million hectane mainly in states of Rajasthan, Gujarat, Haryana, Punjab and Andhra Pradesh. The area is marked by extreme chimatic conditions due to which the cultivation of traditional crops is non-economical. In a situation such as this, arid horticulure has ample scope to develop the arid regions. The present communication attempts to perform an overview of the technologies developed which can be used to make arid ecosystem a horticulural bowl and provide income and nutritional security to the inhabitants.

Key words : *Arid Horticulture, emeging issues, nutrient management, orchard management*

The arid regions are spread over about 38.7 million ha including both hot arid and cold arid regions mainly in the States of Rajasthan, Gujarat, Andhra Pradesh, Punjab and Haryana. The hot arid region inhabit on an average 61 persons per square km making up a population of nearly 20 million people besides a high population density of animals. The Indian arid zone is characterised by high temperature and low and variable precipitation which limit the scope for high horticultural productivity. However, these conditions greatly favour development of high quality in a number of fruits such as date palm, ber, aonla, grapes, kinnow and in vegetables cucurbitaceous crops, spices and some medicinal plants. The existing low productivity could be increased by following optimized technologies and inputs. It is now realized that there is a limited scope for quantum jump in fruit and vegetable production in the traditional production areas. The amelioration of the extreme conditions is also considered vital for life support to the inhabitants of this area. The recent awareness regarding the potential of these ecologically fragile lands for production of quality horticultural produce has not only opened up scope for providing economic sustenance for the people of this region, but also for bringing in new areas to increase production. The state wise distribution of arid land is given in Table 1.

Table 1. Area under arid region in India

State	Total area (M ha)
A. Hot arid region	
Rajasthan	19.6
Gujarat	6.2
Punjab	1.5
Haryana	1.3
Peninsular India	3.1
B. Cold arid region (J&K)	7.0
Total	38.7

Constraints in arid horticulture

The arid zone soils are very poor in fertility. The soils of the north-western arid region described as 'desert soils' and 'grey brown soils' of the Order Aridisols are light textured. The solum of these soils is moderately calcarious (0.2% $CaCO_3$) and below this solum at depths of 40-120cm, a sharply differentiated zone rich in alkaline earth carborates (5-45% $CaCO_3$) is present in the form of hard crystal-like concretions, which may be many metres thick. Most of arid areas (about 64.6%) are duny where the soils often contain only abut 3.2-4 per cent clay and 1.4-1.8 per cent silt. The brown light loam soils occupy 1.7 per cent area, which has loamy fine sand to fine sandy loam on the surface and heavier subsoil underlain with calcium carbonate concretions. Besides this, about 5.9 per cent area is covered by soils having hard pan, 5.6 per cent is under hills and pediments, 6.8 per cent area is alluvial duny and 1.6 per cent is sierozems extending from the soils of Haryana and the Punjab. In Gujarat also, grey brown soils are widespread besides a large area having deltaic alluvium with small area in Kachchh having deep black and medium black soils. In the peninsular India, a considerable part of arid region has red sandy soil and some parts have mixed black soils.

The soils are poor in organic matter having per cent organic carbon of 0.03 in bare sand dunes to 0.1 in the

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stabilized dunes. The Soils are generally rich in total potassium and boron but are low in nitrogen, phosphorus and micronutrients such as copper, zinc and iron. The soils often have high salinity.

The ground water resource is not only limited owing to poor surface and sub-surface drainage but is also generally highly saline. The depth of water ranges from 10m to as high as 140m. The other irrigation water resources in the region are seasonal rivers and rivulets in Gujarat, surface wells and some runoff water storage devices (e.g., tanks, *khadins*). Thus, the water resources in arid region are limited and can irrigate hardly 4% of the area.

The mean annual rainfall in the Indian arid regions is very low and varies from 100 mm in north-western sector of Jaisalmer to 450 mm in the eastern boundary or arid zone of Rajasthan. In Gujarat, it varies from 300 to 500 mm and in Haryana and Punjab from 200 to 400 mm. In peninsular region, the rainfall varies from 520 mm in Bellary (Karnataka) to 748 mm in Cuddapah (Andhra Pradesh). Most of the precipitation in north western arid region occurs during July-September in about 19-21 rain spells.

Prospects in arid horticulture

Vast land resource, surplus family labours, increasing canal irrigated area, developing infrastructural facilities, plenty of solar radiation, etc. are the strength in arid region for research and development in arid horticulture. However, appropriate management practices are required for success of arid horticulture. Some of the important aspects in field of arid horticulture are mentioned below.

1. Selection of hardy crops and varieties

While selection of fruit crops for dryland horticulture, one of the basic requirements is that those crops, which complete their vegetative growth and reproductive phase during the period of maximum moisture availability should be selected. The fruit such as *ber*, guava, pomegranate, custard apple, aonla and sour lime, conform to this prerequisite. The crops must have xeric characters such as deep root system (e.g. aonla, ber), summer dormancy (e.g. ber), high 'bound water' in the tissues (e.g. cactus pear, fig), reduced leaf area (e.g. Indian gooseberry, tamarind), leaf surface having sunken stomata, thick cuticle, wax coating and pubescence (fig, ber, phalsa, tamarind), and ability to adapt to shallow soils, rocky, gravelly, and undulating wastelands (pomegranate, aonla, bael). Some of the crops suitable for dryland areas are given in Table 2.

Varietal variation in endurance to drought has also been observed in horticultural crops. Early ripening cultivars seem to escape stress conditions caused by the receding soil moisture stored in the soil profile during the monsoon. Ber cultivars Gola, Seb and Mundia for extremely dry areas, Banarasi Karaka, Kaithli, Umran and Maharwali for dry regions, and Sanaur-2, Umran and Mehrun for comparatively humid regions have been recommended. Apart from morphological parameters, plants should also have physiological parameters for endurance to drought for commercial cultivation in this region. Some physiological parameters identified in ber are no mid day depression in photosynthetic rate, low rate of transpiration, maintenance of leaf water balance, growth, canopy development, dry matter allocation, high water use efficiency, etc. It has been demonstrated that plant having capacity for drought endurance are able to maintain tourgour, dry matter allocation, leaf and fruit growth even under low soil moisture level. Suitable cultivars of some crops have been identified (Table 3).

Table 2 : Fruit crops for drylands in different rainfall zones of India

Rainfall (mm)	Tropical and subtropical zone
< 500	Jhar ber, Gonda or Iasora, Karonda, Ker, Khejri, Ber, Phalsa, Custard apple, Bael, Pilu, Jamun
500-1000	Ber, Aonla, Jamun, Woodaple, Mahua, Custard apple, Wild date palm, Indian almond, Guava, Sour lime, Lemon, Mango, Palmyra palm, Tamarind, Bael, Custard apple, Chironji, Wood apple, *Karonda*, Mango, Cashew nut, Grape fruit, Pomegranate, Passion fruit.
> 1000	Mango, Litchi, Jackfruit, Persimmon, Mandarin, Avocado, Tamarind, *Jamun, Kokum*, Palmyra palm, Guava, Cashew nut, Barbados cherry, Pomegranate.

Table 3 : Promising cultivars of fruit and vegetable in drylands

Crop	Cultivars
Fruit's	
Ber	Gola, Seb, Umran, Mundia, Kaithali, Banarasi Karaka, CIAH H-1 and CIAH Sel.-1
Bael	NB 5, NB 9, Pant Aparna, Pant Suwarna
Pomegranate	G 137, GKVK 1, IIHR selection, Mridula, Bhagwa
Aonla	NA 7, Kanchan, Krishna, Balwant, NA 6, NA 10
Sweet orange	Blood Red Malta, Mosambi, Pineapple, Valencia
Custard apple	Arka Sahan, Balanagar, Mammoth, Island, Gem, Red Sitaphal
Guava	Allahabad Safeda, L-49, Kohir Safed, Safed Jam, Chittidar
Papaya	Coorg Honeydew, Pusa Delicious, Pusa Majesty, Pusa Dwart, Pusa Giant, Co 1, Co 2
Sapota	Kalipatti, Cricket Ball
Fig	Poona, Dianna, Dinkar, Conadaria, Excel
Mango	Banglora, Neelam, Keshar, Bombay Green, Langra, Chausa, Dashehari
Tamarind	PKM 1, Pratisthan, Yogeshwari
Vegetable's	
Chilli	Pusa Jwala, Mathania, Pant C-1, Arka Mohani, Arka Gaurav, Arka Basant, Bharat, Indira

Cowpea	Pusa Dofasali, Pusa Phalguni, Pusa Barsati, Pusa Rituraj
Cluster bean	Pusa Sadabahar, Pusa Mausami, Pusa Navbahar, Durga Bahar
Onion	Patna Red, Nasik Red, N-53, Pusa Red, Pusa Ratnar, Pusa White Round, Pusa White Flat, Punjab Selection, Agrifound Dark Red, Arka Pragati
Tomato	Pusa Ruby, Pusa Early Dwarf, Pusa-120, HS-102, Sweet-72, S-12, Mangla, Punjuab Chhuhara
Brinjal	Pusa Purple Long, Pusa Purple Round, Pusa Kranti, Pusa Anmol, Arka Sheel, Arka Shirish, Arka Kusumakar, Arka Navneet
Amaranth	Co-1, Co-2, Co-3, Chhoti Chauali, Badi Chaulai
Okra	Pusa Makhmali, Punjab No. 13, Punjab Padmini, P-7, Parbhani Kranti
Pumpkin	Arka Chandan, Co-1, Co-2
Musk melon	Pusa Sharbati, Pusa Madhuras, Hara Madhu, Punjab Sunehri, Durgapura Madhu
Watermelon	Sugar Baby, Arka Manik, Arka Jyoti, Durgapura Meetha, Kesar, Mateera (AHW-19 and AHW 65)
Bottle gourd	Pusa Summer Prolific Round, Pusa Summer Prolific Long, Pusa Meghdoot, Pusa Manjari, Pusa Naveen
Bitter gourd	Pusa Do Mausmi, Arka Harit, Pride of Gujarat
Kachri	AHK 119 and AHK 200
Snapmelon	AHS-10 and AHS 82
Kakdi	AHC-2 and AHC-13

2. Orchard establishment

Fruit plants propagated in the nursery are generally used to raise orchards. Such plants, invariably lose their tap roots as a result of repeated transplanting. Plants raised in containers develop coiled roots. For success in drylands, plants must have a root architecture with a strong tendency to penetrate deep into the soil. *In situ* technique of orchard establishment is preferred under such situation (Saroj *et. al.* 1994). Rootstock seedling of ber are raised in the nursery in 300 gauge polythene tubes (25 cm length and 10 cm diameter, open at both ends), filled with a mixture of farm yard manure (FYM), sand, and clay in 1:1:1 ratio. The seedlings can be budded when about 90-100 days old. These plants become ready for transplanting, 1-2 months after budding. This technique helps to retain the straight growth of the tap root as the tubes are open at the bottom. Thus, the tubes neither restrict root growth nor induce coiling. Budded plants raised by this technique are also suitable for transportation to distant place (Pareek, 1978). Planting of stem cuttings of pomegranate, phasla, fig and mulberry in such polytubes would also induce straight roots.

The plant density mainly depend upon the plant type, soil fertility status and management practices while planting system to be adopted in drylands depends largely upon the topography of the land, fruit species and soil type. In the plains, planting is generally done in square or rectangular system. On slopy lands, fruit trees are planted on contour terraces, half moon terraces, trenches and bunds, and microcatchments. On marshy and wet areas mounding and ridge-ditch method of planting have been suggested. The trenches and bunds made across the slope are staggered (Saroj *et al.*, 1994). In a microcatchment, which may be triangular or rectangular, trees are planted at the lowest point where runoff accumulates.

Some of the seed originated plants having very poor fruit quality are already growing in some of the degraded areas. They can be rejuvenated by top working. Cold arid of the Himalay region is quite rich in this context. The wild plants of ber, bael, aonla, guava, custard apple etc. growing in waste lands of plains can be rejuvenated into productive conditions by top working (Saroj *et al.*, 1994).

3. Training and Pruning

Training at initial stages of growth gives proper shape and strong frame to the trees. The bushy pomegranate should be trained keeping 3-5 stems from the ground level (Anonymous, 1985) while in other fruits, single stem training keeping 3-4 main branches is adopted. However, pruning is essential to regulate reproductive phase of plants. *Ber* is pruned during January in Tamil Nadu, by the end of April in Maharashtra, and by the end of May in north India. The main shoots of the previous season are cut back retaining 15 to 25 nodes, depending upon location, cultivar, and age and vigour of tree (Anonymous, 1991). All the secondary shoots are completely removed. As a result of light pruning for several years, long non-flowering shoots develop. To eliminate this, half the number of shoots on the tree should be pruned keeping normal length and remaining half should be pruned keeping one to two nodes to induce new growth for fruiting in the following year. In *phalsa*, the time of pruning should be regulated according to the flowering period and should result in maximum number of new shoots on which bearing takes place. Established *phalsa* bushes should be pruned at 150 cm height once a year during January in north India and twice a year (December and June) in south India. Pruning from ground level is done either to rejuvenate old bushes or to train young plants into bush form.

4. Water management

Water is the major constraint in commercial cultivation of arid horticultural crops. Hence, the need of the hour is to develop technologies which not only requires low water input but also have high water use efficiency.

Water being a rare commodity in arid eco-system, the first and foremost requirement is to conserve the available soil or rain water. For conservation of rain water both *in situ* and *ex-situ* technologies have been developed. Pareek (1993) have reported that microcatchment slopes greater than 5 per cent did not significantly affect runoff at Jodhpur and that the highest *ber* yields were obtained when 0.5 per

cent and 5 per cent slopes had 8.5m and 7m length of run, and 72 m^2 and 54 m^2 catchment area per tree, respectively. Work done at Aruppukottai (Tamil Nadu) and Anantapur (Andhra Pradesh) has indicated usefulness of *in situ* water harvesting technique for fruit production (Anonymous, 1989).

Arora and Mohan (1988) found V-shaped microcatchment with run-on surface mulched with grass to enhance the productivity of lemon, sweet orange and plum in Doon valley. At Hyderabad, micro-reliefs of 3 m width and 25 cm height, spaced 9 m from ridge to ridge, have been used to store extra rain water for fruit trees such as kagzi lime, coorg mandarin, and sweet orange with tomato and okra as intercrops.

Mulching with organic materials (e.g., hay, straw, dry leaves, and local weeds) has been found highly beneficial in reducing evaporation loss. The practice also suppresses weed growth, prevents erosion, and adds organic matter to the soil (Gupta, 1995). Black polythene mulch is very effective in *ber* orchards in western India (Anonymous, 1989). Although, local organic mulch materials are cheaper than polythene mulches but these require proper care to maintain effective cover thickness. Leaf mulch has been used to conserve soil moisture in *sapota* orchards in Karnataka, Tamil Nadu, and Andhra Pradesh. Sugarcane trash mulch in pomegranate, fig, and custard apple was found effective in Maharashtra (Anonymous, 1989).

At CIAH, Bikaner, the work on in-situ water harvesting has been undertaken in Pomegranate, aonla and vegetables. It has been demonstrated that application of black polythene mulch and local weeds helps in conserving soil moisture status in above crops. It has been demonstrated that plant growth and development remains optimum with use of above mulching materials (Anonymous, 1998; Anonymous, 2003). Mulching studies with respects to soil hydro thermal regimes in brinjal revealed that organic mulches curtailed soil temperature during warm months, while an increase was recorded during the winter month. Significant increase in fruit yeld by 66 and 58% could be obtained through *lasoda* (*Cordia* spp.) and *kheep* (*Leptodenia pyrotechnica*), Awasthi *et al.* (2006).

Among the *ex-situ* water conservation methods, in arid ecosystem, emphasis has been given mostly on pressurized irrigation system. It has been demonstrated that fruits and vegetables can be grown economically by use of drip or sprinkler irrigation system. At CIAH, Bikaner and its regional station it has been demonstrated that crops such as pomegranate and ber can be grown succesfully under drip irrigation system. It has been proved that water saving to the tun of 25% can be achieved if pressurized irrigation system is used as compared to conventional flooding or bubbler system (Anonymous, 2003).

The use of drip alone or in combination with mulching has been demonstrated as a successful technology for cultivation of pomegranate at Anantapur (Anonymous 2006). The studies have shown that highest number of 'B' grade pomegranate can be harvested under drip + mulch.

Application of pitcher irrigation was attempted in cactus pear at CIAH, Bikaner and it was recorded that growth of cactus pear was better under this treatment as compared to control.

The use of double ring system to conserve the moisture applied for production of fruit crops was attempted in aonla. It was observed that by this method the water is applied in zone having functional roots and hence, water use efficiency is enhanced (Shukla *et al.* 2006)

Water loss due to transpiration can be reduced by use of radiation reflectants, stomata closing chemicals, and plastic films. Spraying of 4-6 per cent Kaolin, 0.5-1.0 per cent liquid paraffin, and 1.5 per cent power oil, after occasional rains in low rainfall areas and after the post monsoon rains in high rainfall areas, considerably reduce plant water losses (Anonymous, 1989; Pareek and Sharma, 1991). Chemicals such as phenyl mercuric acetate (PMA), decinyl succinic acid (DSA), abscisic acid (ABA), and cetylalcohol cause stomata closure and thereby reduce transpiration (Jones and Mansfield, 1971; Chundawat, 1990). Shelterbelt and windbreaks can reduce evapotranspiration by reducing the wind speed and stabilizing microclimate (Muthana *et al.*, 1984).

Control of weeds has special significance in rainfed orchards in reducing soil moisture losses. Timely weeding is essential to improve fruit quality even in high rainfall zones. Application of pre-emergence weedicides such as diuron, bromacil, and atrazine @ 2-3 kg ha^{-1} and post-emergence weedicides such as grammaxone (paraquat) and glyphosate @ 1 L ha^{-1} have proved effective in checking weed growth.

5. Nutrient Management

Use of manures and fertilizers in required doses at appropriate time according to the age of plants is essential. In *ber* orchards, besides 10-15 kg organic manure, annual application of 100 g N, 50 g P_2O_5 and 50 g K_2O per tree is recommended. Fertilizer doses should be raised according to the age of plants and soil fertility of the region. Application of 15-20 kg FYM per tree has been found beneficial in aonla, custard apple, and tamarind. At Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, in addition to 50 kg FYM, 625 g N, 225 g P_2O_5 and 225 g K_2O has been recommended for application to 5-year-old pomegranate trees (Anonymous, 1985). At Bangalore, application of 500g N + 250g P + 125g K produced six times higher yield than in the control (Anonymous, 1989). In 6 to 7 years old fig trees planted at 5m x 5m spacing, fertilization with 900g N + 250g K improved fruit production (Anonymous, 1985).

The nutritional trials has been undertaken in arid fruits at CIAH, Bikaner and centres of AICRP on Arid Zone Fruits.

The studies conducted on Date palm at Abohar showed that application of 300-400 g N/tree/year gave maximum number and weight of bunch. Similarly in pomegranate it has been demonstrated that application of 50% recommended dose of Nitrogen at monthly interval gave best performance (Anonymous, 2006).

In order to conserve the costly input such as fertilizer, attempts were made to supply this along with water under pressurized irrigation system. The studies conducted in pomegranate and *ber* has demonstrated that fertilizer saving to the tune of 25% can be achieved if plants are ferti-irrigated through drip.

Keeping in view the export potential of pomegranate, attempts have been made to assess the organically production of this crop. In this pursuit, substitution of in-organic with organic fertilizers were attempted. The results have demonstrated that a good crop of pomegranate can be harvested by giving 50% RD of NPK through Vermicompost and 50% through inorganic fertilizer. Thus, the use of inorganic fertilizers can be reduced to half through this technology (Anonymous, 2003).

Micronutrients are often found deficient in semi-arid and arid soils. Foliar feeding of nutrients such as nitrogen (0.5-2.0% urea), zinc (0.05 to 1.0% zinc sulphate), and boron (0.05 to 1.0% borax) has given beneficial results in these areas (Pareek and Sharma, 1991). In the medium rainfall region of eastern Uttar Pradesh, application of FYM, pond soil, gypsum, and pyrite in sodic soils resulted in better establishment and growth of *aonla* and *bael* plants (Pareek and Vishal Nath, 1996).

6. Fruit based cropping system

Monoculture in arid zone is highly risk prone due to crop failures, hence a suitable tree crop combinations is essential for alleviating the risk, generation of income, improvement productivity per unit area/volume as a result of efficient use of natural resources and inputs, and ameliorate and improve adverse agroclimate. Agri-horticultural combinations with legume intercrops such as mung bean, moth bean, cluster bean, and cowpea are beneficial. In the rainfed orchards of guava and *ber*, cluster bean, okra, and cowpea in *kharif* (rainy season) proved good in the medium rainfall region of Gujarat (Raturi and Hiwale, 1988). At Godhra, growing cluster bean as *kharif* intercrop in *ber* and guava a net return of Rs. 14,630 ha^{-1} was obtained. Even vegetables such as brinjal and chilli could be grown as intercrops. Besides, cover cropping with grasses such as *Cenchrus ciliaris* and pasture legumes such as *Stylosanthes hamata* could be done without deleterious effect on the fruit trees. At Hyderabad, cowpea, green gram, cluster bean and horse gram in *ber* orchards and bitter gourd, tomato and okra in acid lime orchards have been grown as intercrops.

In areas with large livestock population, horti-pastoral system would be beneficial. In the arid areas, the system could have combinations such as *khejri* (*Prosopis cineraria*)+ber+*dhaman* (*Cenchrus ciliaris, C. setigerus*) or *sewan* (*Lasiurus sindicus*), or *tumba*. In semi-arid areas, perennial trees (Mango, *mahua*, tamarind, *sapota*, jackfruit and palmyra palm) could be grown with fodder crops.

Fruit trees can also be planted in association with forest trees, and they yield wood for packaging and fuel. Multi-storey combinations incorporating large trees, small trees, and ground crops can be used. In low rainfall (300-500 mm) zone, combinations such as *khejri* or ber+ber or drumstick+ vegetables (Legumes and cucurbits); in 500-700 mm rainfall zone, combination of mango or *ber* or *aonla* or guava +pomegranate or sour lime or lemon or drumstick+solanaceous or leguminous or cucurbitaceous vegetables; and in 700-1000 mm rainfall zone, combination of mango or jackfruit or *mahua* or palmyra palm or tamarind or guava+sour lime or lemon or pomegranate or *aonla* + vegetables can be adopted (Pareek, 1999).

In arid ecosystem, attempts have been made to develop models for crop diversification. Keeping in view the traditional overstorey crops as *ber* and new introduction aonla, the cropping models have been developed. It has been demonstrated that in ber based cropping system cultivation of Indian aloe can be taken up as a remunerative model Dhandar *et al.* (2004). Similarly, in aonla based cropping system, it has been demonstrated that model consisting of aonla + ber alongwith moth bean or fenugreek can be adopted as a sustainable model for nutritional and income security of the inhabitants (Awasthi, 2006).

7. Pest and disease management

Besides wild animals, rodents and birds there are many insects and diseases causing severe loss of crops. Major diseases of arid horticultural crops and their control are presented in Table 4.

Termites cause considerable damage particularly in low rainfall areas. Heptachlor dust (5%) should be applied in the pits (50 g pit^{-1}) dug for planting fruit trees. Subsequently, water soluble insecticides (chloropyriphos) should be applied with irrigation water. Fruitfly (*Carpomyia vesuviana*) causes serious damage to *ber* fruits. To keep the infestation under check, the chemical spray schedule should consist of spray at pea stage with 0.03 per cent monocrotophos, second spray after 15 days with 0.05 per cent fenthion, and third spray after another 15 days with 0.1 per cent carbaryl XLR. During maturity of the fruits, if necessary, sprays should be done with 0.5 per cent malathion mixed with 0.5 per cent *gur* or sugar solution. This schedule has also been found effective against fruit borer (*Meridarchis scyrodes*) which causes serious damage in southern and western India. Pomegranate butterfly (*Virachola isocrates*) causes considerable damage to pomegranate fruits. Bagging of fruits with butter paper gives good protection. For control, 0.02 per cent deltamethrin and 0.2 per cent carbaryl 50 WP sprayed in rotation at 21

Table 4 : Major pests and diseases of arid horticultural crops and their control measures.

Crop	Pests/disease	Control measures
Pests		
Ber	Fruit Fly	Comprising digging of soil in basin, mixing of 50g insecticidal dust, spray of 0.05% Monocrotophos at monsoon, 3-spray of Monocrotophos (0.3%) at pea stage.
Pomegranate	Fruit borer	Two spray of Deltamethrin (0.02%) and carbaryl 50 WP (0.2%) at 21 days interval.
	Barkeating caterpillar	Plugging of holes with mud followed by spray Dimethoate/ Monocropthos (0.08%).
Aonla	Leaf gall midge	Spray of Endosulphon (0.05%) minimize the problem.
Diseases		
Pomegranate	Leaf and fruit spot	One spray of Ziram (1.0%) or Bordeaux (1.0%) at flowering or fruit setting and subsequent 4 sprays at 20 days interval.
Date palm	Graphiola leaf spot	Spray of Bavistin (0.1%) or Blitox 50 WP (40%) minimize the disease
	Fruit rot	Spray of Carbendazim (0.1%) minimize the rotting.
Aonla	Rust	Three spray of Moncozeb (0.3%) at 15 days interval from diseases initiation (Faizabad). Four spray of Chlorothalonil (0.2%) at 10 days interval.
Fig	Rust	Two spray of Moncozeb (0.3%) is effective.

day intervals starting from fruit set is the most cost effective.

For the control of *ber* powdery mildew, fungicides such as 0.1 per cent dinocap or carbendazim or triademorph or thiophenate methyl and 0.2 per cent wettable sulphur have been found most effective when sprayed 2-4 times at 15 to 20 day interval starting from initiation of the disease (Anonymous, 1989; Pareek and Vishal Nath, 1996). One spray of the fungicide at initiation of new growth after pruning is an effective prophylactic measure. Black leaf spot (*Isariopsis indica*), found under more humid conditions, can be controlled by 2-3 sprays of 0.2 per cent captafol or copper oxychloride or mancozeb and 0.1 per cent carbendazim at 15 day intervals (Anonymous, 1985). For the control of leaf and fruit spot in pomegranate, four sprays with 0.25 per cent ziram and 1 per cent bordeaux mixture at 15 day intervals are most effective. Since, the intensity of the disease is more under humid conditions during *mrig bahar* as many as 10 sprays at 10 day intervals may be necessary. Fungicides such as captafol, mancozeb, carbendazim, copper oxychloride, and thiophenate methyl could also be used. For the control of rust in *aonla*, 4 sprays of 0.2 per cent chlorothalonil at 15 day intervals soon after initiation of symptoms give the best control (Anonymous, 1997).

Apart from chemical control, attempts have also been made to use bio pesticides for control of pests in arid fruit crops. It has been demonstrated that application of Neem Seed Kernal Extract (2.5-5%) on various crops effective in controlling pests in pomegranate, aonla, chilli and brinjal (Anonymous, 2003).

Similarly use of bio-control measures to control ber powdery mildew was also attempted. It has been demonstrated that isolates of *Trichoderma* has potential to be used as bio-control of ber powdery mildew. The isolates thus obtained are resistant even to fungicides and hence can be used in combination with pesticides (Anonymous, 2003).

The studies conducted on control of date palm scale insect has revealed that *Chilocorus nitritus* is a potential predator of *Parlatoria*. It has further shown that during larval period on an average 437.35 scales are consumed by various instars. The adults consumed 20.86 scales/day and an average of 1317.72 scales during the life period (Anonymous, 2006)

Emerging issues in arid horticulture

Although, great effects have been made to develop technology compatible for commercial production of arid horticultural crops, yet there is a need to address various issues for further refinement of technology, improvement in socio-economic status of arid region and development of sustainable agro-horti-system. The major issues are,

- Efficient utilization of water resource
- Rehabilitation of degraded lands
- Utilization of solar and wind energy
- Conservation of biodiversity
- Breeding for resistance to abiotic stresses
- Diversified farming systems
- Value addition
- Human Resource Development

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Perennial medicinal plants for rainfed farming system in arid region

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Abstract

In arid region, growing interest, awareness and cultivation of medicinal crops are discussed on several fora. The needed attention was not given to indigenous woody species adapted to harsh climatic conditions over the introduced ones. There is need to enhance farmer livelihoods through increased farm income by integrating suitable woody and herbaceous medicinal plant species in existing farming system. The present paper reviews the woody perennials of medicinal importance and possible avenues for integrating them in various ALUS in farming system perspective.

Key Words : *Arid ecosystem, farming system, fodder, medicinal plant, woody perennials*

Introduction

Rise in population, inadequate supplies of drugs in certain parts of the world, high cost and toxic effect of synthetic drugs have created renewed interest in natural drugs. This led to spurt in the use of herbal medicine and consequently the international trade in medicinal plants has recorded a sharp rise (Prathibha *et al.*, 1999). The use of herbals in veterinary sector is also blooming up as dietary supplement or therapeutic use on health and productivity of livestock e.g. adaptogeneic herbs in equines (Dwivedi, 2005) and their use is gaining scientific footing over synthetic drugs in developed countries (Lawson, 1994).

Thar desert is endowed with considerable diversity of medicinal plants and well documented by various researchers (Chopra *et al.*, 1960; Chopra and Abrol, 1964; Gupta *et al.*, 1966; Shekhawat and Anand, 1984; Singh and Pandey, 1998; Pandey *et al.*, 1989; Kumar and Parveen, 2000; Kasera *et al.*, 2002; Sharma and Prajapati, 2002; Singh *et al.*, 2002; Chaudhari *et al.*, 2005; Kumar *et al.*, 2005; Singh and Sharma, 2005). Recently, Awasthi and Dhandar (2003) gave an account of medicinal fruit plants of arid region. Dinesh Kumar (2000), Kumar (2000), Anjaria (2002), Kumar *et al.* (2004), and Dwivedi (2005) dealt veterinary aspect of herbal drugs. In recent past the natural vegetation of Thar Desert witnessed drastic change due to increasing grazing pressure, urbanization, introduction of irrigation etc. All these factors resulted into change in composition of natural vegetation and depletion of important economic plants (Singh *et al.*, 2002) including medicinal plants.

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Integration of medicinal species in various Alternate Land Use Systems (ALUS), suitable to specific agro ecological and socio-economic conditions in farming system perspective is key to assure sustained supply of these herbal products. There is an urgent need to design medicinal plant based farming system which can cater diverse needs of farming community along with higher biological productivity, more income and employment generation. The integration of indigenous multipurpose woody perennials viz. fodder cum medicinal species, fruit cum medicinal species, fuel wood cum medicinal species and medicinal cum bio fence species in existing farming system seem to be viable option in this regard. This paper is an attempt to highlight indigenous multipurpose perennial species having medicinal properties along with suitable land use systems for integrating them, as organized information on this aspect is scanty.

Medicinal Plants Cultivation:

In western Rajasthan, some medicinal crops are cultivated commercially, such as Senna (*Cassia angustifolia* Vahl), Isaphgol (*Plantago ovata* Forsk.), Aloe (*Aloe barbadenensis* Mill.), and Ashwgandha (*Withania somnifera* (L.) Dunal) to some extent. The fruit crops having medicinal value viz., Aonla (*Emblica officinalis* Gaertn.), Anar (*Punica granatum* L.), Bael (*Aegle marmelos* (L.) Corr.), Ber (*Ziziphus mauritiana* Lamk.), Gonda (*Cordia dichotoma* Forst. f.), Nimbu (*Citrus aurantifolia* (Chiristm.) Swingle) etc. are also in cultivation in the area. Anar (pomegranate) is placed as one of the premier health fruits in this century and known for its antioxidants properties

(Damania, 2005). The species like Anar, Aonla, Bael, Ber have demand in pharmaceuticals in local market and for export. Bael has approximate Rs. 200-250 million domestic sales in India (Rawat and Garg, 2005). Ber (Jujube) has important place as an important arid fruit crops with medicinal value. Paris and Dilleman (1960) mentioned, "The Jujube also has definite emollient properties for which it was formerly classed as one of the four 'pectoral' fruits for making pectoral cough drops". However, these species have their own limitations during water scarcity, prolonged drought and frost injury in arid ecosystem. Attention needs to be paid therefore, to the indigenous adapted species for rainfed arid ecosystem involving multiuse species. The following woody perennials need attention for rainfed system in western Rajasthan.

***Acacia jacquemontii* Benth. (Leguminosae)**

Local names : Bawli, Bui-bawli

This much-branched shrub naturally occurs in sand dunes and well adapted to drought and frost. Its gum is used to cure body ache, joints pain and also in sunstrokes. Its gum is reputed with high medicinal value in the area and has local demand.

***Acacia senegal* (L.) Willd. (Leguminosae)**

Local names: Kumat, Kumatiyo

This much-branched thorny tree with pale smooth bark is commonly found on hillsides, stabilized sand dunes and adapted to adverse arid climatic condition. Its gum is one of the main cash crops of the desert (Paris and Dillemann, 1960) and used as a demulcent and emulsifying agent in pharmaceuticals (Chopra *et al*, 1960).

***Balanites aegyptiaca* (L.) Del. (Balanitaceae)**

Local names: Hingota, Hingotio, Hingorni, Ingudi

This spinous shrub or a small tree is one of the characteristic woody species of dry parts and commonly found in open sandy areas. Its fruits are the source of diosgenin.The outer rinds of the fruit is used as a remedy for skin diseases and cough. Its seeds, fruit, bark and leaves are reported to be anthelmintic and purgative properties. Seed oil applied in rheumatic pain (Maheshwari and Singh, 1988). Fruit stone pounded with chilly and paste given to cattle for constipation. Leaf paste is applied on eye for conjunctivitis in cattle (Sikarwar, 1996). Stem bark powder is given to cattle for intestinal worms (Singh and Pandey, 1998).

***Calligonum polygonoides* L. (Polygonaceae)**

Local names: Phog, Phogaro

This is much-branched leafless shrub, which is the key woody perennial species of Thar Desert particularly on sand dunes. The roots used as gargle for sore gums (Kirtikar and Basu, 1935). Branch juice used as antidote to milky juice of Aak (*Calotropis procera*) when enters in the eyes (Bhimaya *et al.*, 1961). The flower buds have a cooling effect and used in treating sunstrokes (Shekhawat, 1961). Also used as antiemetic, and in typhoid (Kumar *et al.*, 2005).

***Capparis decidua* (Forsk.) Edgew. (Capparaceae)**

Local names: Ker, Kerro, Kair

It is much-branched leafless spiny shrub or a small tree and naturally occurs on rocks, gravel and sandy plains. Its bark and fruits are utilized in Ayurvedic and Yunani medicines. Its bark is acrid, laxative, diaphoretic, anthelmintic and useful against cough, asthma and inflammation. The root and bark are given in cases of intermittent fever and rheumatism (Chopra *et al.*, 1960). The fruits are eaten and are believed to cure stomach disorders (Bhimaya *et al.*, 1961). .Root paste is applied on eye for conjunctivitis in animals (Sikarwar, 1996).

***Citrullus colocynthis* (L.) Shard. (Cucurbitaceae)**

Local names: Tumba, Indrayan

This creeping under-shrub occurs in sandy plains and sand dunes. This cucurbit species possesses exceptional soil binding and drought resistance capacity has multiple uses. Fruits are used as purgative and root in jaundice and urinary diseases. It is commonly used ethnoveterinary medicinal plant in western Rajasthan.

***Clerodendrum phlomidis* L. f. (Verbenaceae)**

Local names: Arni, Inni, Bharangi

This shrub is grown along the boundaries of cultivated fields. Root is given in convalescence of measles. Leaf juice is given in neglected syphilitic complaints. The leaves are applied locally against guinea-worm (Kirtikar and Basu, 1935). The leaf used in prolonged body ache, constipation and dropsy in Andhra Pradesh (Venkata Raju, 1996). Seed oil used as hair tonic by Garasias (Singh and Pandey, 1998). Also used in arthritis, sciatica and in ringworm (Kumar *et al.*, 2005). Leaves are fed to animals as vermifuse at many places.

***Commiphora wightii* (Arn.) Bhandari (Burseraceae)**

Local name: Guggul

This much branched spinous shrub or small tree naturally occurs on open dry hills and other rocky habitats. Presently it is a threatened species due to its over exploitation for its gum-resin. Its gum resin is used as an astringent and an antiseptic in old wounds and bleeding gums; internally it act as a bitter, stomachic and carminative, stimulating the appetite and improving digestion. The resin is used in the form of lotion for indolent ulcers and as a gargle in pyorrhea, chronic tonsillitis and pharyngitis.

***Cordia gharaf* (Forsk.) Ehrenb. & Aschers. (Boraginaceae)**

Local names: Goondi, Guindi

This shrub or small tree occurs in forests and often cultivated for its edible fruits. Bark decoction is used for gargles and has astringent properties (Kirtikar and Basu, 1935). There is also the domestic demand of this species by local Ayurvedic practitioners (Singh and Kumar, 2005).

***Ephedra foliata* Boiss. & Kotschy ex Boiss. (Gnetaceae)**

Local names: Andho khimp, Sui phogaro,

This much-branched climbing shrub occurs on sandy to gravelly or even in rocky plains on native woody perennials like *Prosopis cineraria, Maytenus emarginata,* and *Euphorbia caducifolia.* It is the only Gymnoperm species of hot arid zone and needs attention for its conservation. Aerial parts are used in asthma bronchitis and severe cough (Sinha and Sinha, 2001).

***Grewia tenax* (Forsk.) Fiori (Tiliaceae)**

Local names: Gangerun, Gangan

This straggling shrub occurs naturally on buried pediments, hill-slopes, wastelands and boundaries of fields. The fruits are given for colds. The wood decoction is given for curing coughs and pains in the body (Caius, 1989). Leaves are used for stone problems and urticaria (Kumar *et al.*, 2005). Leaf used in gripe (Diallo *et al.*, 1996) in Africa.

***Haloxylon recurvum* (Moq.) Bunge ex Boiss. (Chenopodiaceae)**

Local names: Khar, Khara lana

This succulent halophyte shrub is strongly xeromorphic in structure occurs in saline depressions of western Rajasthan. The plant ash is given in water against internal ulcers (Bhandari, 1990). Recently, Recursterols A and B the new C-24 alkylated sterols, have been isolated from *H. recurvum* in Pakistan (Hussain *et al*, 2006).

***Haloxylon salicornicum* (Moq.) Bunge ex Boiss. (Chenopodiaceae)**

Local name: Lana

This much-branched shrub occurs in sandy undulating hummocky plains, dunes, interdunes and the former river courses of the ancient river Saraswati. Plant ash is applied on boils and to cure skin diseases. Plant ash is also applied on the body of sheep and goats to kill lice and other external parasites. The seeds are said to be used in asthma by local *Vaids*. A new pyranone-5-hydroxy-3 methoxy-4H-pyran-4one was isolated from the aerial parts of *H. salicornicum* (Gibbons *et al.*, 2000).

***Indigofera oblongifolia* Forsk. (Leguminosae)**

Local names: Goilia, Jhil, Bekar, Raktpala

This erect shrub is found in open dry places. It is considered as an antidote to all kinds of poisons. Boiled root is used as a purgative and stem decoction as a gargle in mercurial salivation and for washing teeth (Caius, 1989). It is also employed for curing stomachache. Roots are used for tooth brushes. Lodha *et al.* (1990) reported ten compounds in it; four of these have been characterized as psyllostearyl alcohol, triacontanol, β-sitosterol and β- sitosterol- β-D glucoside.

***Lycium barbarum* L. (Solanaceae)**

Local name: Morali

This much-branched spinous shrub is common on sandy scrub lands. The leaves pounded and mixed with ghee are applied to abscesses. The berries are bitter, emmenagogue, enriches the blood; useful in bleeding piles, scabies, toothache; also used as an aphrodisiac. In Yunani system, the leaves improve the eyesight. (Kirtikar and Basu, 1935). Also used for cold and skin irritatuiin (Kumar *et al.*, 2005). The bark powder used against bronchitis in horses (Bhandari, 1990).

***Maytenus emarginata* (Willd.) Ding Hou (Celastraceae)**

Local name: Kankero

This large spinous shrub or small tree traditionally used as biofence. The leaf juice taken to cure spermatorrhoea (Maheshwari and Singh, 1988). Leaf paste is used to heal sores. The fruits used to purify blood (Bhandari, 1990). In Maharashtra bark and leaves are used to cure stomachache, cough and as tonic (Kumbhojkar *et al.*, 1999).

***Salsola baryosma* (Roem. & Schult.) Dandy (Chenopodiaceae)**

Local name: Lani

This much-branched pale hoary shrub is found in saline depressions in western Rajasthan. The plant is used as a vermifuge and the plant ash is applied to itch (Kirtikar and Basu 1935).

***Salvadora oleoides* Decne. (Salvadoraceae)**

Local name: Pilu

This much branched evergreen shrub or small tree occurs on medium heavy to heavy saline soils of alluvial plains. It tolerates both aridity and salinity and thrives well even in 100 mm rainfall. Root bark is used as a vesicant and it helps in regulating the menses in women. Fruits are employed in treatment of enlarged spleen, rheumatism and low fever (Jindal and Singh 2005). Leaves used to relieve cough, and also given to horses as purgative (Singh *et al*, 1990).

***Salvadora persica* L. (Salvadoraceae)**

Local name: Kharo jal

This much branched evergreen shrub or small tree is found on saline soils of alluvial plains. Root bark is applied on blisters. Fruits are used to overcome heat strokes. The oil is used in skin diseases, snakebites and also in joints pain. Root paste is applied as substitute for mustard plaster and decoction is used against gonorrhoea and vesical catarrh. It is widely used in the toothpaste preparations (Jindal and Singh, 2005).

***Sarcostemma acidum* (Roxb.) Voigt (Asclepiadaceae)**

Local names: Khir khimp, Khursani tanto, Arr thor, Somlata

This is a leafless, straggling jointed climbing shrub. In Ayurveda the plant is used to cure biliousness and thirst (Kirtikar and Basu, 1935). Root paste applied to snake bite and taken an infusion in dog-bite (Bhandari, 1990). It is said that the plant has been used in Soma of the Veda (Pal and Jain, 1998).

***Suaeda fruticosa* (L.) Forsk. (Chenopodiaceae)**

Local names: Lunaki, Lunak ,

This much-branched shrub is found on sandy saline depressions in western Rajasthan. The leaf paste is applied as a poultice to opthalmia and also used as emetic (Kirtikar and Basu, 1935). Leaves used as vegetable to cure indigestion and flatulence. Its tender shoots and leaves

are also used as vegetable in the Salsette Island in Maharashtra and also sold in the market (Shah, 1984). Whole plant sap is applied on sores on back of camel (Singh and Pandey, 1998).

***Tinospora cordifolia* (Willd.) Miers. (Menispermaceae)**
Local names: Guruch, Giloy, Guduchi

This glabrous shrub is found climbing on trees and bushes. It is used in more than 88 pharmaceutical preparations in India (Kapur and Mitra, 1979). Dried stem with bark is used to cure all kinds of fever and for urinary diseases, dyspepsia and flatulence. Roots and leaves are used for lowering blood pressure (Sinha and Sinha, 2001). It has approximate Rs. 20-30 million domestic sale (Rawat and Garg, 2005).

The other native woody shrubs/trees viz., Khejri (*Prosopis cineraria* (L.) Druce), Rohida (*Tecomella undulata* (Smith) Seem), Kheep (*Leptadenia pyrotechnica* (Forsk.) Decne.), Bordi (*Ziziphus nummularia* (Burm.f.) Wight and Arn.), Bui (*Aerva pseudotomentosa* Blatt. and Hall.), Safed Aak (*Calotropis gigantea* Ait), Aak (*Calotropis procera* (Ait.)R. Br.), Jinjni (*Mimosa hamata* Willd.), Sinia (*Crotalaria burhia* Buch.-Ham ex Benth.), Gangeti (*Grewia villosa* Willd.), Pilwan (*Cocculus pendulus* Diels.) Nagphani (*Opuntia elatior* Mill.), Thor (*Euphorbia caducifolia* Haines), Jhau (*Tamarix troupii* Hole) etc. are also having medicinal properties. The other semi arid woody species like Neem (*Azadirachta indica* A. Juss.), Ardu (*Ailanthus excelsa* Roxb.), and Sahajan (*Moringa oleifera* Lamk.) have medicinal value and planted in the arid region.

Life Support System:

Most of these indigenous woody species of arid ecosystem provide variety of products of economic importance along with ecological and social services (Table 1) and essential component of life support system. Livestock has vital role in agrarian economy of arid region and fodder scarcity is major handicap for its sustainable development. Therefore integration of the species, which have fodder and medicinal value, need greater attention as they can supply fodder along with materials for pharmaceuticals. These species of medicinal importance also show impact on quality and quantity of milk. Traditionally, some of the plants fed to animals to increase the quality of milk like fruits of Pilu (*S. oleoides*) and Phog (*C. polygonoides*). In ancient Indian literature the *Agnipuran* instructs to give the cow morsels composed of several sticks of Ashwagandha (*W. somnifera*) and sesame (Anonymous, 1964). The leaves and shoots of Giloy (*T. cordifolia*), Pilwan (*C. pendulus*) also supposed to increase milk yield in livestock. There is need to evaluate some of these species to observe the effect on quality of milk as well as health of livestock. The species like Tumba (*C. colocynthis*), Aak (*C. procera*), Guarpatha (*A. barbadensis*) etc. are the common species used in ethno veterinary medicine in western Rajasthan. Likewise some of these species produces products that have industrial demand viz. *Saji* and gum, and their integration can broaden the economic base of farmers. Some of these species provide raw materials for small scale cottage industries which are life line of rural economy, and by the integration of such species the livelihood security of rural inhabitants can be ensured to a great extent. Besides economic importance all these species have great ecological significance by arresting wind erosion and conserving biodiversity of fragile arid ecosystem.

Table 1: Significance of indigenous perennial plants of arid regions.

Product/ service	Plant species
Human Food	
Leaves/ shoots	Luni (*S. fruticosa*), Guarpatha (*A. barbadensis*)
Flower buds	Phog (*C. polygonoides*), Kair (*C. decidua*)
Unripe fruits	Kheep (*L. pyrotechnica*), Kair (*C. decidua*),
Ripe fruits/ seeds	Goondi (*C. gharaf*), Kair (*C. decidua*), Gangeran (*G. tenax*), Pilu (*S. oleoides*), Lana (*H. salicornicum*)
Gum	Bawli (*A. jacquemontii*), Kumut (*A. senegal*)
Food Additives/ Saji	
Shoots	Khara lana (*H. recurvum*), Luni (*S. fruticosa*), Lani (*S. baryosma*)
Feed for Livestock	
Leaves / shoots	Khejri (*P. cineraria*), Phog (*C. polygonoides*), Bawli (*A. jacquemontii*), Bordi (*Z. nummularia*), Lana (*H. salicornicum*), Kair (*C. decidua*), Arni (*C. phlomidis*), Pilwan (*C. pendulus*), Giloi (*T. cordifolia*), Andhokheep (*E. foliata*)
Flowers/ fruits	Phog (*C. polygonoides*), Pilu (*S. oleoides*), Tumba (*C. colocynthis*)
Food for Bees and other invertebrates	
Flowers	Bawli (*A. jacquemontii*)
Leaves/shoots	Phog (*C. polygonoides*)
Fuel	
Shoots & roots	Phog (*C. polygonoides*), Bawli (*A. jacquemontii*), Kair (*C. decidua*), Khejari (*P. cineraria*), Lnni (*S. fruticosa*), Bordi (*Z. nummularia*), Aak (*C. procera*)
Thatching Materials	
Shoots	Phog (*C. polygonoides*), Kheep (*L. pyrotechnica*), Sinia

	(*C. burhia*), Aak (*C. procera*), Khejari (*P. cineraria*), Arni (*C. phlomidis*)
Fibres	
Stem	Sinia (*C. burhia*), Kheep (*I. pyrotechnica*), Aak (*C. procera*), Goondi (*C. gharaf*)
Environmental Uses	
Arresting soil erosion	Tumba (*C. colocynthis*), Phog (*C. polygonoides*), Khara lana (*H. recurvum*), Lana (*H. salicornicum*)
Shade & Shelter	Kair (*C. decidua*), Pilu (*S. oleoides*)
Live fence	Bawli (*A. jacquemontii*), Kumat (*A. senegal*), Arni, (*C. phlomidis*), Gangeran (*G. tenax*), Mural (*L. barbarum*), Kankera (*M. emarginata*)
Saline soils	Khara lana (*H. recurvum*), Lani (*S. baryosma*), Luni (*S. fruticosa*), Khara jal (*S. persica*)
Social & Ethical Uses	
Ritual/ religious significance	Safed Aak (*C. gigantea*), Kair (*C. decidua*), Khejari (*P. cineraria*), Phog (*C. polygonoides*)
Cosmetics	Goondi (*C. gharaf*)
Detergent	Hingot (*B. aegyptiaca*), Khara lana (*H. recurvum*)
Weather Forecast	Phog (*C. polygonoides*)

Integration of Woody Perennials in Production Systems

Sole cultivation of these perennials are neither practically feasible nor economic viable. They need integration with crop-based production system for sustained economic gains. System based production systems having diverse type of plants is a time tested strategy which provides stability in production along with catering diverse needs of farmers. Earlier experience shows that the selection of system-based production should be in accordance with prevailing agro ecological and socioeconomic milieu. Therefore these plants can be integrated in various production system viz. agri-horti, agri-silvi, boundary plantations in farming system prespective. Certain possible avenues for integrating them are outlined in Table 2. In arid region woody perennials have a great promise and socio-economic role to play for rehabilitation of degraded lands (Singh *et al.*, 2004) by strip plantation of shrub/trees in village common lands, field boundary, sand dunes, canal banks, road sides etc. The wastelands and other areas lying unused around the villages can be utilized for planting woody species having medicinal value. The saline wastelands unsuitable for crop cultivation can be utilized for planting halophyte shrubs which are adapted to saline conditions. A number of species can be used as live fence along the border of agricultural fields to demarcate boundaries and to protect home yards, agricultural crops from livestock and wild animals. They can also used as shelterbelts/wind breaks and creates favorable microclimate for crops. The climbing shrubs like Giloy (*T. cordifolia*), Pilwan (*C. pendulus*), Andhokheep (*E. foliata*) etc. can be very well planted in the Agri-silvi system by utilizing their suitable shrub/tree species as support system.

Table 2. Suitable woody medicinal species for different Alternate Land Use Systems/Habitats.

Systems/ Habitats	Plant species
Agri-Horti System	Kair (*C. decidua*), Gondi (*C.gharaf*), Bordi (*Z. nummularia*), Pilu (*S. oleoides*)
Agri-silvi System	Phog (*C. polygonoides*), Bordi (*Z. nummularia*), Khejari (*P. cineraria*), Neem (*A. indica*), Ardu (*A. excelsa*) Climbers: Giloy (*T. cordifolia*), Andhokheep (*E. foliata*), Pilwan (*C. pendulus*)
Sand dune stabilization	Bawli (*A. jacquemontii*), Phog (*C. polygonoides*), Kumat (*A.senegal*), Lana (*H. salicornicum*), Tumba (*C. colocynthis*)
Bio-fence/Boundary Plantation	Bawli (*A. jacquemontii*), Phog (*C. polygonoides*), Kumat (*A. senegal*), Arni (*C. phlomidis*), Gangeran (*G .tenax*), Mural (*L. barbarum*), Kankera (*M. emarginata*), Thor (*E. caducifolia*)
Salt affected areas	Khara lana (*H. recurvum*), Lani (*S. baryosma*), Luni (*S. fruticosa*), Kharo Jal (*S. persica*), Jhau (*T. troupii*)
Rocky	Gugal (*C. wightii*), Goondi (*C. gharaf*)

Conclusion

Indigenous medicinal plants of arid region are under stress due to their indiscriminate collection from wild sources, destruction of natural habitats coupled with frequent drought. Integration of drought resistant under-utilized woody perennials having medicinal value in various production systems have a great role in economic development as well as maintaining the ecological balance of the arid environment. These species can supply the raw material even in the times of drought and low rainfall

condition. Moreover the species having fodder value can be very well utilized at the time of drought as an emergency fodder. There is urgent need to create awareness amongst the farmers regarding the significance of these indigenous plant species. Increased and sustainable supply of raw herbal material by integrating medicinal plants will boost pharmaceutical sector in arid region and *inter alia* income and living standard of the peasantry. The crop diversification through medicinal plants in the farming system perspective can reduce pressure on wild sources as well as strength to the conservation of available medicinal plant diversity in the arid ecosystem. Paris and Dillemann (1960) rightly remarked that "The xerophile medicinal plants can play a part in the economic reclamation of the arid zones". Thus, genotypes of woody medicinal species must be conserved *in situ* and *ex situ* clones for genetic improvement programme.

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Evaluation of pomegranate germplasm under arid conditions

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Abstract

Thirty-eight pomegranate genotypes were evaluated to assess the components of genetic variability with respect to growth, fruit yield and quality traits. Considerable variability was observed in these characters. Number of fruits and fruit yield per plant and fruit weight were observed to be highly heritable traits which also showed large magnitude of genetic advance. Thus these characters should respond favourably to simple selection procedures in cultivar improvement attempts. Out of nine popular pomegranate varieties, Jalore Seedless, G 137 and Ganesh were observed to be superior with regards to fruit yield and Mridula excelled in fruit quality, indicates promise for cultivation. However, all the nine commercial types were prone to fruit cracking (30 – 90 %). This study suggest for systematic improvement in pomegranate not only for high quality fruit yield but also free from fruit cracking under hot arid environment.

Key words: *Arid environment, genetic variability, Pomegranate, Punica granatum*

Introduction

Pomegranate (*Punica granatum* L.) is grown in arid and semi-arid tropics for its acid-sweet fruits. In India, it is mainly cultivated in Maharashtra, Rajasthan, Andhra Pradesh, Karnataka, Gujarat, Haryana and Punjab. Collections of pomegranate gremplasm have been made at the centers of All India Co-ordinated Research Project on Arid Zone Fruits (AICRP on AZF) mainly at MPKV, Rahuri and IIHR, Banglore in collaboration with NBPGR. This enabled evaluation of the germplasm under different agroclimatic regions of the country resulting in selection of genotypes suited to these regions. After establishment of National Research centre for Arid Horticulture (NRCAH) at Bikaner in 1993 and later on upgraded to the status of Central Institute for Arid Horticulture (CIAH) in September, 2000, pomegranate germplasm was assembled for evaluation and genetic improvement under hot arid environment.

To boost pomegranate production in India both for domestic and export, development of improved varieties/ hybrids is required which bear fruits having attractive rind and bold and soft grains with dark red and sweet aril (Pareek and Samadia, 1999). Assessment of variability is the basic requirement in any breeding strategy. Since most of the plant characters are governed by a group of genes and are highly influenced by environmental conditions, it is difficult to judge whether the observed variability is heritable. This necessitates assigning heritable and non-heritable components of phenotypic variation. An attempt was therefore, made to estimate the genetic variability components in the pomegranate germplasm and identify promising types on the basis of their performance under hot arid agro-climatic conditions.

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Materials and Methods

Work was initiated in 1994 to build up pomegranate repository at CIAH, Bikaner under hot arid conditions by collection of germplasm from different centers of AICRP on AZF and NBPGR stations. Field planting was initiated in 1995 and by December 1996, more than 65 collections of pomegranate including some duplicates were established. The assemblage included commercial cultivars, popular types, advanced selections and early introduced material under AICRP on AZF and NBPGR centers. Four to 5 year old 38 genotypes were included in this study. Three trees per accession were maintained in the field gene bank of which each tree served as a replication. Observations for characterization of the genotypes were started from 1997. To analyze the components of genetic variability, data recorded on 38 genotypes in the year 1999 were used. Observations on 6 trees planted in two sets of each of the commercial cultivars (nine) were recorded during 1999 and

Table 1: Plant growth and fruit quality traits of pomegranate genotypes.

Genotype	Plant growth behaviour	Fruit weight (g)	Aril taste	Mellowness of seed	Aril colour
Achikdana	D	152.5	Sour	Hard	Red
Agah	D	132.8	Sour	Hard	Whitish pink
A.K.Anar	D	185.0	Sour	Hard	Light pink
Alah	D	62.5	Sour	Hard	Pink
Bassein Seedless	D	175.2	Slightly sweet	Hard	Whitish pink
Bedana Suri	E	221.5	Slightly sweet	Hard	Whitish pink
Bedana Thin Skin	E	186.4	Slightly sweet	Hard	Whitish pink
Boseka Link	D	75.4	Sour	Hard	Whitish pink
Coimbatore White	E	187.5	Slightly sweet	Hard	Whitish pink
Dholka	E	252.5	Sweet	Hard	Whitish pink
Dorseta Malus	D	169.8	Sour	Hard	Light pink
G 137	E	245.1	Sweet	Soft	Light pink
Ganesh	E	229.1	Sweet	Soft	Light pink
GKVK 1	E	210.5	Sweet	Soft	Light pink
Gul-e-Shah	D	121.2	Sour	Hard	Red
Gul-e-Shah Red	D	85.6	Sour	Hard	Pink
Gul-e-Shah Rose Pink	D	152.4	Sour	Hard	Dark red
Jalore Seedless	E	265.4	Sweet	Soft	Pink
Jodhpur Red	E	196.5	Sweet	Hard	Pink
Jyoti	E	225.7	Sweet	Soft	Light pink
Kabul	E	154.1	Sweet	Very hard	Whitish pink
Kabul IIHR	E	165.5	Sweet	Hard	Whitish pink
Kajaki Anar	D	98.5	Sour	Hard	Light pink
Khog	D	132.5	Sour	Hard	Pink
Mridula	E	102.7	Sweet	Soft	Dark red
Musket	E	221.5	Sweet	Medium hard	Whitish pink
P 13	E	231.1	Sweet	Medium hard	Whitish pink
P 23	E	237.5	Sweet	Slightly hard	Light pink
P 26	E	245.1	Sweet	Slightly hard	Light pink
Patna 5	E	175.2	Sweet	Hard	Light pink
Siah Sirin	D	137.5	Sour	Hard	Pink
Sirin Anar	D	129.1	Sour	Hard	Red
Speen Danedar	D	137.5	Sour	Hard	Pink
Speen Sacarin	D	170.5	Sour	Hard	Red
Surkh Anar	D	122.1	Sour	Hard	Whitish pink
Sur Sukker	D	85.9	Sour	Hard	Whitish pink
Tebest	D	90.1	Sour	Hard	Red
Yarcaud HRS	E	195.2	Sweet	Hard	Whitish pink
CD (P=0.05)*	-	16.6	-	-	-
CV (%)	-	6.1	-		-

*— Significant, D—Deciduous, E—Evergreen.

2000. Pooled data for these two years were used in statistical analysis for varietal performance. The fruits of *mrig bahar* flowering (July- August) were retained and harvested during December - January. Physico-chemical characteristics were recorded on five randomly selected fruits from each replication. Data were subjected to analysis for ANOVA and biometrical components adopting standard statistical procedures suggested by Panse and Sukhatme (1985), Burton (1952) and Johnson *et al.* (1955).

Results and Discussion:

Genetic variability

The analysis of variance revealed that the genotypes differed significantly with respect to height and spread of plant, TSS, weight, length and breadth of fruit and number and yield of fruits per tree. The data on fruit quality traits such as aril taste and colour and mellowness of grains and plant growth behaviour of the genotypes presented in Table 1 show wide variation. It is evident that only a few genotypes viz., Jalore Seedless, Ganesh, G 137, Mridula, P 23, P 26, GKVK 1, Jyoti and Musket possess the desirable traits such as sweet taste, soft to less hard seed and pink to red aril colour and could be used for table purpose. The Russian, Iranian, and other introduced genotypes from Central Asia did not produce desirable fruit quality under the hot arid environment. However, the colour of fruit rind and aril in cultivars Gul-e-Shah Rose Pink, Gul-e-Shah Red, Khog, Kabul, Sirin Anar, etc. were attractive and could be used in breeding programme to infuse these traits in the popular cultivars.

The data on genotypic means, range and biometrical estimates of variability presented in Table 2 indicate wide variability in fruit weight (60.1-340.1 g), number of fruits per plant (4.13-44.98), fruit yield per plant (0.489-10.905 kg), fruit length (4.81-9.89 cm), fruit breadth (4.81-8.19 cm), TSS (12.3-17.6 °Brix), plant height (131.2-245.5 cm) and plant spread (99.2-249.5 cm). In general, the estimates of phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) but the closer correspondence between PCV and GCV for all the quantitative traits revealed that genotypic effects were important in the expression of the characters. Both PCV and GCV were high for fruit yield per plant (76.01 and 73.84), number of fruits per plant (57.96 and 57.92) and fruit weight (34.11 and 33.56), indicating better scope of phenotypic selection to enhance the fruit yield in pomegranate. Similar findings have been reported earlier by Manohar *et al.* (1981) for aril weight, rind weight, fruit weight, number of fruit/tree, fruit yield/tree and acidity in pomegranate.

The magnitude of heritability indicates the extent of reliability in identifying the genotypes on the basis of phenotypic expression. In the present studies, high heritability was observed for all the economical quantitative traits. The broad sense heritability ranged from 90.5 to 99.86 per cent. This high estimate of heritability is helpful to base the selection programme on phenotypic performance in pomegranate. The expected genetic advance as percentage of mean (genetic gain) ranged from 16.32 to 147.22 per cent. This was very high for fruit yield per plant (147.22), number of fruits per plant (119.23), and fruit weight (68.03). This indicates that the level of improvement could be considerable in these traits. The lower genetic gain recorded in TSS (16.32), fruit size and plant growth characters indicates that these traits could not be improved to the desire level as such.

Heritability estimates in conjunction with genetic advance are helpful in predicting its resultant effects for selecting the best individuals (Johnson *et. al*, 1955). Selection based on high heritability and high genetic advance is more helpful than on the basis of low genetic gain. Heritability mainly due to additive gene effects would be associated with high genetic gain and that due to non-additive gene effects with low genetic gain. In the present investigation high heritability along with high genetic advance was recorded in the characters, *viz.* number of fruits per plant, fruit yield per plant and fruit weight. Besides high estimates of GCV was also recorded. This shows that these characters could be considered reliable tools for selection and opens up the possibility of improvement in these characters in pomegranate. These finding are in conformity with the results of Manohar *et al.* (1981).

Performance of popular cultivars in arid environment

Pooled statistical analysis revealed highly significant differences in the existing pomegranate cultivars in all the characters (Table 3). In growth performance the cultivars Jalore Seedless, Jodhpur Red, G 137, P 23 and P 26 proved better under hot arid conditions. Pareek (1978) reported that pomegranate cultivars showed vigorous, semi-vigorous and dwarf vegetative growth characters. The varietal variations in plant growth characters under arid conditions were also reported by Prasad and Bankar (2000). The minimum plant height (162.6 cm) and spread (168.6 cm, mean of north-south + east-west) was recorded in cultivar Mridula. The highest number of 47.24 fruits per plant was recorded in Mridula followed by 40.5 in Jalore Seedless and the lowest (11.6) in Dholka. The heaviest fruit (250.15 g) was produced in the cultivar Jalore Seedless followed by Jodhpur Red (235.3 g). The fruit weight in other varieties *viz.*, Ganesh, G 137, P 23 and P 26 were ranged between 194.75 to 212.48 g. However, Mridula cultivar produced the smallest 105.7 g fruits. Fruit length and breadth ranged from 5.38 to 7.77 cm and 5.46 to 8.01 cm, respectively. The highest fruit yield per plant was recorded in Jalore Seedless (9.78 kg). The cultivars Jodhpur Red, Ganesh and G 137 were *at par* with a moderate fruit load of about 6.5 kg. The fruit yield in Mridula was only 4.94 kg in spite the highest number of fruits per tree. This was obviously because of the small sized fruits (105.7 g) in that cultivar. The variation

Table 2 : Components of genetic variability in pomegranate germplasm.

Characters	Range	Mean	CD (5%)	CV (%)	GCV (%)	PCV (%)	h^2 (broad sense)	GA	Genetic gain (%)
Plant height (cm)	131.2 - 245.5	199.63	7.14	2.2	11.04	11.26	96.19	44.55	22.31
Plant spread (cm)	99.2 – 249.5	192.65	6.04	1.9	15.02	15.15	98.38	59.13	30.69
Fruit weight (g)	60.1 – 340.1	168.48	16.67	6.1	33.56	34.11	96.81	114.63	68.03
Fruit length (cm)	4.81 – 9.89	6.48	0.45	4.3	13.19	13.86	90.50	1.79	27.58
Fruit breadth (cm)	4.81 – 8.19	6.41	0.24	2.4	12.34	12.56	96.45	1.60	24.96
Number of fruits/plant	4.13 – 44.98	17.42	0.60	2.1	57.92	57.96	99.86	20.77	119.23
Fruit yield/plant (kg)	0.49 – 10.90	3.20	0.93	18.0	73.84	76.01	94.40	4.72	147.22
TSS (°Brix)	12.3 – 17.6	15.13	0.23	1.0	7.99	8.05	98.58	2.47	16.32

Table 3 : Growth and fruit yield characters of commercial pomegranate genotypes

Genotype	Plant height (cm)	Plant spread (cm)	Fruits /plant	Fruit yield /plant (kg)	Fruit weight (g)	Weight of 100 aril (g)	TSS° (Brix)	Juice (%)	Seed waste (%)
Jalore Seedless	211.2	192.0	40.5	9.78	250.15	21.47	17.38	54.55	9.85
Jodhpur Red	209.6	243.1	29.1	6.61	235.30	19.74	15.60	42.52	24.28
Ganesh	190.6	222.3	32.3	6.06	194.75	20.78	16.03	47.25	11.77
G 137	220.0	248.2	33.1	6.83	211.56	19.73	15.14	50.60	11.95
Mridula	162.6	168.6	47.2	4.94	105.77	13.57	14.31	58.80	10.05
P 23	227.6	253.7	20.6	4.34	212.48	16.56	16.91	50.57	13.46
P 26	218.6	198.3	22.5	4.53	210.29	18.74	16.93	50.97	12.93
Dholka	205.7	241.3	11.6	2.20	201.20	13.75	15.68	49.32	13.13
GKVK 1	190.0	193.3	22.6	4.54	207.52	17.62	16.59	42.55	14.43
Mean	207.5	218.9	27.4	5.25	200.90	17.85	15.88	48.58	13.84
Sd	22.19	28.52	10.75	2.12	37.74	2.65	1.07	5.89	4.04
CD (P=0.05)*	14.05	8.46	2.27	0.17	8.18	0.09	0.39	1.91	0.71

in fruit weight and size seems to be genotypic as also reported by Prasad and Bankar (2000). The boldness of aril is an important quality trait. The cultivar Jalore Seedless produced the largest aril size (0.22 g) followed by Ganesh (0.21 g) and G 137 (0.20 g). Cultivar Mridula produced the smallest aril (0.14 g). However, the juice content was significantly higher in Mridula (58.8 %) followed by Jalore Seedless (54.55 %) and G 137 (50.60 %). Thus, cultivars differed significantly in juice and seed content, mellowness of seeds and boldness of aril as also reported by Mali and Prasad (1999) and Prasad and Bankar (2000). Desai *et al.* (1992) observed positive and significant correlation between plant spread and fruit yield. Similarly, the fruit number and fruit weight with yield. Thus, the cultivars producing large number of fruits also have genetical potential for bigger fruits. The cultivars producing big sized fruits also had bolder arils. On the basis of varietal performance it is concluded that the cultivars Jalore Seedless, G 137, Ganesh and Mridula are potential under hot arid conditions The cultivars Jalore Seedless, G 137 and Ganesh are high yielding and better in fruit quality except aril colour. It is also found that the fruit quality of Mridula excelled the above three cultivars. However, it is disappointing that all these varieties are prone to fruit cracking. Moreover, this problem is very serious in Jodhpur, Red, Jalore Seedless, G 137 and Ganesh under hyper hot arid conditions. This suggest for systematic improvement in the Jalore Seedless, a locally adapted superior genotype to evolve dark red, soft and bold seeded types.

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Crop diversification under fruit based cropping system in arid zone of western Rajasthan

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Abstract

The experiment conducted at farmers field in Bikaner district on sandy soil during *Kharif* season of 2003 and 2004 under canal command area for crop diversification in different fruit based cropping systems revealed that the maximum plant height of mothbean and groundnut was recorded under the intercropping with Bael where as clusterbean maximum plant height (49.8 cm) was recorded maxium with Ber. Mothbean intercropping with Bael produced 14.61 and 27.24 per cent higher total dry matter (26.99 q/ha) and grain yield (10.40 q/ha), respectively than its intercropping with Ber (23.77 and 8.98 q/ha). Among the entire intercrop highest mean root dry matter addition (2.49 q/ha) to soil after crop harvest was observed in groundnut intercropping, which was significantly higher over the intercropping of mothbean and clusterbean. However, the mean highest system productivity (8.71 q/ha) was observed under the intercropping of groundnut with the fruit trees which was 15.09 and 9.82 per cent higher over intercropping of mothbean and clusterbean, respectively. Highest total income (Rs. 35,172 /ha), net profit (Rs.30,162/ha) and cost: Benefit ratio (6.02) was observed under the intercropping systems of Bael + mothbean.

Key words: *Fruit trees + crops intercropping, crop diversification, arid zone, cropping system*

Introduction

The Low and erratic rainfall with high variability in its quantity and occurrence, high temperature during summers (as high as 48°c) and low in winters (up to –3 °c). High wind velocity (10-13 km /hr) and high annual evapo-transpiration (1527 mm /year) hinders arable cropping in this region. The introduction of canal in the area, opened new vistas thus allowing the choice for more number of crops which can be included in cropping system. The major canal network in the region is IGNP passing through Ganganagar, Bikaner and Jaisalmer districts in which water availability is @ 5.24 m /ha from 1982-86. The flow values of main canal varies from 1.727 x 10^6 M^3 to 2.961 x 10^6 M^3 in different season (Khan, 1996). However, the untimely and irregular availability of canal water along with reduced quantity again put a question to think for inclusion of low water requiring, perennial crops and fruit trees in the cropping system for its sustainability even under adverse condition. Inter cropping of legumes with Ber produced higher grain yield of intercrops by 5-20 per cent over their sole cropping (Singh et al., 2003). Thus, intercropping of annual crops with the perennial trees provided the extra income to the farmer when fruit trees are in their juvenile phase along with the assured production from the system. Keeping the above points in view an experiment was conducted to find out the productivity of different crops intercropped with different fruit trees under canal-irrigated condition.

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Materials and Methods

The experiment was conducted at farmers field in Pugal tehsil of Bikaner district in sandy soil during Kharif season of 2003 and 2004 under canal command area.

The experimental site is characterized as hyper arid with highest mean monthly temperature of 39.7°c in month of July during 2004 with a minimum of 11.6°c in month of November 2003. The highest wind velocity was 10.06 km/hr in month of July during the crop season, which increased the evaporation of water loss during the study period which had impact on the period for water availability to the plant after the irrigation, which seems to be very less.

The soil situation of the experimental site was loamy sand in texture, calcareous alkaline in reaction with normal EC (0.21dsm^{-1}) low in organic carbon with very low in

nitrogen, phosphorus and good in potassium amounting 43.16.3 and 162.4 kg/ha. respectively.

Three crops viz., Mothbean (*Vigna acontifolia*), clusterbean (*Cyamopsis tetragonoloba*) and groundnut (*Arachis hypogea*) were intercropped in interspace of three year-old Ber (*Zyziphus mauritiana*), Bael (*Aegle marmelos*) and Kinnow (*Citrus spp*) orchards under factorial randomized block design with three replications. The canal water was used for irrigating the plants to all the crops at same time through flood system. All other cultural practices were adopted as recommended for individual crops separately. During the cropping season an amount of 178.6 mm and 91.9 mm rainfall was received during 2003 and 2004 respectively. The system productivity was calculated mathematically by using the following formula.

System productivity (SP)= (Intercrop productivity (q/ha) x Area sown in system per ha (m^2)/ ha (m^2) + Fruit trees yield in terms of crop yield equivalent(q/ha).

Results and discussion

Plant height (cm)

The plant height of different crops was not affected significantly under intercropping with different fruit trees. The highest plant height of mothbean and groundnut was recorded under the intercropping with Bael where as clusterbean gave highest plant height (49.8 cm) in intercropping with Ber. The plants were only 3 years old and have no adverse effect on growth and development of intercrops.

Yield of intercrops

The two year pooled data presented in Table 1 showed that the highest dry matter and Grain yield of all the intercrops were recorded under the intercropping with Bael which was significantly higher in mothbean and clusterbean but was at par in groundnut. The same trend was observed with straw yield also. Mothbean intercropping with Bael produced 14.61 and 27.24 per cent higher total dry matter and grain yield, respectively than it's intercropping with Ber. This was due to the fact that at the initial stage of fruit trees there are no adverse effect on the yield of intercrops. Patil *et al.*, 2005, also reported similar findings where no adverse impact of fruit trees was noticed on intercrops at early stages of tree growth.

Root dry matter addition to soil

Significant differences have been observed in root dry matter addition by different intercrops. Highest root dry matter (2.76 q/ha) was added in the treatment when groundnut was intercropped with kinnow plantations followed by Bael. Mothbean root dry matter addition was lower under intercropping with all the trees, which was due to the harvesting system of mothbean in which the plants are normally uprooted at the time of harvesting along with

Table 1. Yield of intercrops grown with different trees under intercropping system (Pool of two years).

Fruit Trees	Yield of intercrops			
	Mothbean	Clusterbean	Groundnut	Mean
		Total dry matter yield (q/ha)		
Ber	16.90	27.24	27.17	23.77
Bael	19.37	32.63	28.97	26.99
Kinnow	18.10	26.97	27.69	24.25
Mean	18.12	28.94	27.94	
C.D. at5%	Crops=1.20	Trees=5.36	Crop x trees=NS	
		Grain yield (q/ha)		
Ber	6.13	9.36	11.47	8.98
Bael	7.80	10.97	12.43	10.40
Kinnow	6.16	8.37	11.12	8.55
Mean	6.70	9.57	11.67	
C.D. at5%	Crops= 1.13	Trees= NS	Crop x tree=NS	
		Straw yield (q/ha)		
Ber	10.78	17.40	15.75	14.64
Bael	11.57	22.18	16.49	16.75
Kinnow	11.95	19.07	16.32	15.78
Mean	11.43	19.55	16.18	
C.D. at5%	Crop=0.15	Tree= NS	Crop x tree=0.18	

thin roots as compared to the clusterbean and groundnut. The highest root dry matter addition of 1.95 q/ha was recorded under Ber + mothbean intercropping followed by Kinnow+mothbean intercropping (Table2). Among the entire intercrop highest mean root dry matter addition (2.49 q/ha) was observed in groundnut intercropping, which was significantly higher over the intercropping of mothbean and clusterbean. The intercropping of groundnut with Bael produced highest root dry matter addition (2.76 q/ha). This was due to the better growth and development of groundnut plants as well as more root dry matter yields per plant in comparison to other crops in the system.

System productivity (SP)

The different crops under intercropping with the fruit trees significantly affected the system productivity, which was lower over the intercrop productivity because the fruit trees were not in bearing. However, the highest system productivity was 8.71 q/ha under the intercropping of groundnut with the fruit trees which was 15.09 and 9.82 per cent higher over mothbean and clusterbean intercropping (Table 3). Over all mean of the crops indicated that intercropping of crops with the Bael produced highest mean system productivity (9.63 q/ha), which was significantly higher over intercropping with Ber and Kinnow.

Table 2. Root dry matter addition in different intercropping systems (Pool of two years).

Fruit Trees (3 years old)	Intercrops			Mean
	Mothbean	Clusterbean	Groundnut	
Ber	1.95	2.07	1.97	2.00
Bael	1.7	2.35	2.73	2.26
Kinnow	1.9	2.03	2.76	2.23
Mean	1.85	2.15	2.49	
C.D. at 5%	Crops=0.47	Trees=0.47	Crop x tree= 0.82	

Table 3. System productivity (q/ha) with the intercropping of crops with trees (Pool of two years).

Fruit Trees*	Intercrops			Mean
	Mothbean	Clusterbean	Groundnut	
Ber	5.40	8.29	8.32	7.34
Bael	9.43	9.62	9.84	9.63
Kinnow	7.88	5.97	7.97	7.27
Mean	7.57	7.96	8.71	
CD at 5%	Crops=1.07	Trees=1.06	Crop x tree= 1.84	

* Fruit tree were not in production.

Economics

Highest total income (Rs. 29,729 /ha) and net profit (Rs.21,799/ha) was observed under the Bael + groundnut intercropping followed by Ber +Groundnut and kinnow +groundnut (Table4). This was due higher yield of groundnut with reasonable market price. The highest cost: Benefit ratio (3.02) was recorded with Bael + clusterbean intercropping followed by Bael+ Mothbean (2.86). The lowest was with Ber+ mothbean (2.06). The results confirms the findings of Patil *et al.* (2005) in which the highest net profit was recorded with the Sapota+ Groundnut intercropping.

Table 4. Economics of different treatments under intercropping system (Pool of two years).

Treatments	Economic (Rs /ha)			
	Total Income	Cost of cultivation	Net profit	Cost : Benefit ratio
Ber + Mothbean	16124	5270	10854	2.06
Ber+ Clusterbean	18540	5570	12970	2.33
Ber + Groundnut	28709	8330	20379	2.45
Bael + Mothbean	19320	5010	14310	2.86
Bael+ Clusterbean	21364	5310	16054	3.02
Bael + Groundnut	29729	7930	21799	2.75
Kinnow + Mothbean	16025	5010	11015	2.20
Kinnow+ Clusterbean	16432	5310	11122	2.10
Kinnow+ Groundnut	27760	7930	19830	2.50

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Nutritional studies in kinnow

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Abstract

The study on "Nutritional studies conducted in Kinnow "at Agriculture Research Station, Sri Ganganagar during 1993-1997 revealed that the nitrogen doses at 60g, 120g, 180g, 300g and 500g from Ist, 2nd, 3rd, 4th and 5th year, respectively in three split doses in February, April and August-September gave significantly better effect on the growth parameters viz., plant height, plant spread, root stock and scion growth and quality parameters of Kinnow fruit as compared to state recommendation.

Key words : *Growth parameters , nitrogen levels, nutritional*

Introduction

Kinnow (*Citrus nobilis* x *Citrus deliciosa*) is a highly preferred mandarin hybrid in Northern India for its precocity in bearing and good quality juice. Sri Ganganagar district of North Western Rajasthan is one of the potentially rich area for Kinnow cultivation in arid irrigated canal region. Previously, no nutritional study was undertaken for Kinnow crop in the region. The present study was therefore undertaken at Agriculture Research Station (Rajasthan Agriculture University), Sri Ganganagar (Rajasthan) on a newly established Kinnow orchard during 1992 to determine the effect of nitrogen levels on single tree basis in Kinnow for first five years.

Materials and methods

An experiment on "Nutritional trial in Kinnow plants budded on Jatti Khatti (*Citrus jambhiri*) at a pre bearing stage was laid out in square system and the planting distance was 6 x 6 m. The doses of nitrogen applied were 30g, 60g, 90g in the first year; 60g, 120g, 180g in the second year; 90g, 180g, 270g in the third year; 150g, 300g, 450g in the 4th year and 250g, 500g, 750g in the 5th year on a single tree basis. In the first set, nitrogen was given in two splits i.e. ½ in February + ½ in April while in other set 1/3rd was given in February + 1/3rd in April + 1/3rd in August. Four replications and four trees per replications were taken for study. The experimental soil was analyzed for its physico-chemical characteristics up to the depth of 1.5 m and the profile soil samples were taken at a depth interval of 0-15, 15-30, 30-60, 60-90, 90-120 and 120-150 cm at four sites in trial. These samples were analyzed for pH, organic carbon and calcium carbonate. The pH, organic carbon and calcium carbonate varied from 8.20 to 8.35, 0.08 to 0.36% and 2.00 to 5.50%. For recording physico-chemical characteristics four fruits per tree were taken from all the four directions of the tree. The experiment was laid out in randomised block design.

Observations were recorded for cumulative plant growth, rootstock and scion girth, number of fruits per tree, fruit weight, fruit size, juice percentage, rag percentage, total soluble solids and titratable acidity of juice. The per cent acidity was determined by titrating the juice against 0.1 N NaOH using phenolphthalein as indicator and has been expressed in terms of citric acid (A.O.A.C., 1970).

Results and discussion

The data pertaining to effect of different levels of nitrogen on cumulative growth parameters of Kinnow mandarin in the first five years of growth in the prebearing stage are presented in Table 1. The results clearly indicated that application of different nitrogen doses (N_3 to N_7) caused a marked increase in the plant height as compared to state recommendation. Likewise, plant spread (East-West) and (North-South) was also statistically significant in N_6 and N_7 levels, respectively. The rootstock girth of N_2 to N_7 levels and scion girth of N_3 to N_7 was also found statistically significant as compared to recommendation made by the state. In general, tree girth came to be a better

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index of plant growth. Similar findings were confirmed by Katyal (1977) who reported that application of N at 200 to 600 g/plant caused a marked increase in growth of mandarin trees in Darjeeling district.

The data on effect of different levels of nitrogen on the quantity and quality parameters of Kinnow fruits during first three years of fruiting are given in Table 2. Maximum number of fruits per tree were found statistically significant from N_3 (183.6) to N_7 (247.6) levels against state recommendation. These results are in close conformity to

Table 1. Effect of different levels of nitrogen on the cumulative growth parameters of Citrus deliciosa during Pre-bearing Stage

Nitrogen Levels	Plant Height (cm)	Plant Spread (E-W) (cm)	Plant Spread (N-S) (cm)	Rootstock Girth (cm)	Scion Girth (cm)
Control	273.3	260.7	261.7	43.5	38.1
N_1*	293.0	309.0	283.7	44.3	41.2
N_2	294.0	290.3	290.0	45.0	40.7
N_3	307.7	308.0	286.3	47.0	43.6
N_4	317.3	309.3	306.0	47.5	44.3
N_5	287.3	301.7	300.7	48.1	43.6
N_6	311.7	321.7	315.3	49.0	46.1
N_7	312.7	322.3	314.3	49.2	46.2
CD(5%)	8.9	11.9	9.2	1.1	0.9

the findings of Singh and Aggarwal (1960) who reported that in trials at Butwal, Nagpur and Srinagar with hill cultivars of mandarin improved fruit yield by nitrogen levels.

Average fruit weight was observed to be statistically significant in N_3, N_4, N_5 and N_6 levels of nitrogen compared to state recommendation which might be due to the fact that flower production and initial fruit set was highest in N_7 treatment but fruit weight remained maximum with N_4 level (166.3g). These results are in accordance with the findings of Carranca *et al.* (1992) who reported that flower production and initial fruit set in mandarins were the highest with the highest level of N but total fruit weight was maximum with medium nitrogen level.

The Kinnow fruit length was found to be statistically higher with higher nitrogen levels (i.e. from N_3 to N_7) as compared to state recommendation. Per cent juice content was found maximum and statistically significant (49.75%) in the N_5 treatment i.e. low nitrogen application favours high juice content. Similar findings were reported by Carranca *et al.* (1992) who reported an increased juice content with low nitrogen.

Rag percentage was found minimum (50.2%) in the N_5 treatment i.e. low doses of nitrogen favours to reduce rag percentage whereas at higher doses i.e. N_4 and N_7, the rag percentages are comparatively higher.

The total soluble solids was found statistically significant from N$_2$ to N$_7$ levels being maximum (13.36° brix) in the N_6 level i.e. three split doses of 60,120,180,300 and 500g from 1993 to 1997 gave better on results. Likewise, Singh and Aggarwal (1960) in trials at Butwal, Nagpur and Srinagar with hill cultivars of mandarin showed that fruit quality improved by N levels.

The titratable acidity varied from maximum (1.21%) in

Table-2. Effect of Different Levels of Nitrogen on the Quality Parameters of Fruits of Citrus deliciosa in the three years of fruiting (1995-1997)

Nitrogen Levels	Average no. of Fruits/tree	Average Fruits Weight (g)	Fruits Length (cm)	Fruits Diameter (cm)	Per cent Juice	Per cent Rag	TSS (°Brix)	Per cent Acidity
N_0 (Control)	112.7	115.7	6.18	7.09	48.37	51.6	12.37	1.14
*N_1	158.3	143.0	6.26	7.21	48.29	50.7	12.83	1.21
N_2	151.0	142.0	6.24	7.13	47.68	52.3	12.73	1.17
N_3	183.6	163.7	6.38	7.37	44.40	55.6	12.33	1.07
N_4	183.0	166.3	6.40	7.39	39.20	60.8	12.97	1.10
N_5	191.3	149.3	6.24	7.25	49.75	50.2	13.20	1.16
N_6	244.0	153.3	6.36	7.39	49.40	50.6	13.36	1.19
N_7	247.6	151.7	6.36	7.37	46.00	54.0	12.83	1.14
CD (5%)	12.3	6.8	0.08	NS	1.19	0.95	0.06	NS

*N_1 = State Recommendation

the N_1 level (state recommendation) to minimum (1.07%) in the N_3 level which shows that the percentage acidity was found maximum with the state recommendation and minimum with the N_3 level of two split doses.

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Effect of integrated nutrient management on yield and yield attributing characters in okra and its residual effect on succeeding crop radish

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Abstract

A field experiment to study the effect of integrated nutrient management on okra (*Abelmoschus esculentus (L.) Moench*) and its residual effect on succeeding crop radish (*Raphanus sativus L.*) was conducted during kharif, 2004 and winter season 2004-05, respectively at the Deparment of Horticulture, College of Agriculture, Bikaner. The results revealed that application of inorganic fertilizers @ 60:30:30 kg N,P,K q ha^{-1} and vermicompost @ 6 t ha^{-1} significantly increased the number of pickings, fruit weight, length and diameter of fruit, fruit yield/ plot and fruit yield (q ha^{-1}) in okra, while root length, width of root, weight of root and root yield q ha^{-1} in succeeding crop radish.

Key words : *Okra, radish, nutrition, crop sequence*

Introduction

Okra (*Abelmoschus esculentus (L.) Moench*) is one of the important summer and rainy season vegetable crop of Rajasthan. It is rich in its nutritive value and has medicinal importance. Okra is specially valued for its tender fruits. It is rich in vitamin, calcium and potassium and other minerals. It has been reported to have an average nutritive value (ANV) of 3.21, which is higher than tomato, and most of the cucurbits except bitter gourd (Grubben, 1977).

Okra- radish crop sequence can be beneficial for the vegetable growers under arid irrigated condition of Bikaner. Radish growing on residual effect of applied Vermicompost and fertilizers to okra can add more benefit to the vegetable growers. Both the crops are highly responsive to applications of essential plant nutrients viz., N, P and K. The yield potential of high yielding varieties of crops can be obtained only with optimal nutrient supply and other input management. These are applied through inorganic fertilizers to meet crop nutrients requirements.

Now a days, organically produced vegetables are fetching good market price and people are aware regarding adverse effects of excessive use of inorganic fertilizers and pesticides, which are causing health hazards. In view of above, there is urgent need to find out the effect of application of nutrients through organic source on growth, yield and quality and also on integrated nutrient management for minimizing the requirement of inorganic fertilizers. Vermicompost is becoming very promising source of nutrients of organic origin. Keeping the above considerations in view, an experiment was carried out to find out the effect of integrated nutrient management on okra and its residual effect on succeeding crop of radish.

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Materials and Methods

The experiment was conducted at Research farm, College of Agriculture, Bikaner during *kharif* season, 2004 and residual crop of radish during *rabi* season 2004 - 2005. The varieties of okra and radish were VRO-6 and Japanese white, respectively. The experiment was carried out with four levels of inorganic fertilizers viz., control (F_0), 30:15:15 (F_1), 60:30:30 (F_2) and 90:45:45 kg N, P and K per hectare (F_3) and four levels of Vermicompost viz., 0 (V_0), 3(V_1), 6(V_2) and 9(V_3) tonnes per hectare using randomized block design with three replications. Sowing of okra was done on August 18, 2004 in well prepared field in plots size of 3m x 3m. The soil of the experimental field was loamy sand in texture and slightly alkaline in reaction. The soil was poor in organic carbon (0.08%) and low in available nitrogen (63.24 kg ha^{-1}), phosphorus (9.60 kg ha^{-1}) and medium in available potassium (148.62 kg ha^{-1}). The field was fertilized to supply

nitrogen (urea) according to treatments in two split doses one at the time of sowing and another at 30 days after sowing. Phosphorus, potassium and Vermicompost were applied at the time of sowing of the crop. The observations on number of pickings, fruit weight, length of fruit at first picking, fruit diameter at first picking, fruit yield per plot and fruit yield per hectare were recorded. The yield of fruit per plant was recorded at each picking and subsequently pooled to work out total yield of okra. In *rabi* season, in same field, radish was grown as the residual crop following same layout plan as okra. Sowing of seeds of radish was done on December, 4, 2004 and harvesting of roots of radish was done from February, 10, 2005 to February, 22, 2005. Root length, width and root weight of radish were recorded at the time of harvest.

Results and Discussion

The present investigation revealed that application of fertilizers up to 60:30:30 N, P and K kg ha^{-1} showed significant increase in yield attributes i.e. number of pickings, fruit weight, length of fruit and diameter of fruit (Table 1). The observations are in conformity with findings of Abdul and Aarf (1986) and Chattopadhyay and Sahana (2000) in okra.

Application of different levels of Vermicompost up to 6 t ha^{-1} significantly increased the fruit yield, number of pickings, fruit weight, fruit length, fruit diameter and fruit yield q ha^{-1} in okra. The results are in agreement with the findings of Kalambasa (1996) and Alexive and Rankov (1997) in tomato. On succeeding residual crop, it was observed that application of fertilizers up to 60:30:30 N, P and K kg ha^{-1} to preceding okra significantly increased the root yield of succeeding radish. Similar trend was recorded with increasing levels of Vermicompost. The interactions effects between Vermicompost and fertilizers levels on all parameters under study were found non significant and hence these have not been given. Difference due to levels of N, P and K were found in yield and its attributing characters could be due to over all improvement in plant growth which might be due to increased availability of nutrients and in turn might have helped in pod formation and ultimately increased the yield. Similar findings have been reported by Rao and Subramaniam (1991) in okra.

Net return and B : C ratio of okra significantly differed with 60:30:30 kg N, P and K ha^{-1} compared to control and 30:15:15 and remained at par with 90:30:30 kg N, P and K ha^{-1}. Application of increasing levels of Vermicompost up to 6 t ha^{-1} significantly increased length and width of the fruits, number of pickings in okra and it was statistically at par with 9 t ha^{-1}. In radish, fertilizer application up to 60:30:30 kg N, P and K ha^{-1} significantly increased net return and B:C ratio whereas Vermicompost application up to 6 t ha^{-1} applied to okra significantly increased net return and B : C

Table 1. Effect of integrated nutrient management on yield and yield attribiutes of okra and radish (q ha^{-1})

Treatments	Okra								Radish					
	NOP	FW (g)	FL (cm)	FD (cm)	FY/ Plot	FY/ q ha^{-1}	NR Rs.	BC	RL (cm)	RW (cm)	RW (g)	RY q ha^{-1}	NR Rs	B:C
V_0	7.2	6.6	6.59	0.95	6.14	68.26	46594	2.14	17.30	3.47	111.76	161.86	37734	3.49
V_1	7.9	8.3	8.27	1.17	7.69	85.49	59323	2.25	18.93	3.79	139.30	189.47	46016	4.25
V_2	8.4	9.1	9.12	1.31	8.45	93.92	63252	2.06	20.05	3..95	158.72	208.88	51840	4.79
V_3	8.6	9.4	9.44	1.35	8.78	97.50	62342	1.77	20.14	4.03	162.01	212.35	52882	4.89
SEm±	0.19	0.18	0.18	0.02	0.17	1.93	5543.9	0.20	0.38	0.07	5.35	5.53	4762.19	0.43
CDat5%	0.55	0.54	0.54	0.06	0.50	5.58	5586.90	0.21	1.09	0.22	15.47	15.99	4799.04	0.44
F_0	6.9	6.8	6.82	0.97	6.35	70.50	43217	1.59	17.82	3.55	111.57	166.51	39127.0	3.61
F_1	7.8	7.8	7.81	1.13	7.25	80.56	52461	1.88	19.05	3.80	139.94	189.93	46155.0	4.26
F_2	8.6	9.2	9.19	1.30	8.54	94.87	66077	2.33	19.72	3.92	154.31	204.31	50469.0	4.66
F_3	8.8	9.6	9.61	1.36	8.93	99.29	69755	2.41	19.84	3.96	160.97	211.81	52719.0	4.87
Sem±	0.19	0.18	0.18	0.02	0.17	1.93	5543.90	0.20	0.38	0.07	5.35	5.53	4762.19	0.43
CD at 5%	0.55	0.54	0.54	0.06	0.50	5.58	5586.90	0.21	1.09	0.22	15.47	15.99	4799.04	0.44

NOP = Number of picking, FW= Fruit weight, FL= Fruit length, FD= Fruit diameter, FY= Fruit yield, NR= Net return, BCR= Benefit cost ratio, RL= Root length, RW= Root width, RY= Root yield

ratio of succeeding radish and okra radish crop sequence. The increase in the yield with the application of Vermicompost might be due to the fact that Vermicompost application significantly increased the total number of fruits and increased weight of fruit. Vermicompost provide adequate supply of macro and micronutrients to the metabolic activities of plants. Indirectly it increases the photosynthetic activities of plants and ultimately number of picking increased which improved the yield of okra. These findings are in agreement to those reported by Senthil and Sekar (1998) in okra and Kalambasa et al. (1998) in radish.

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Variation in physiological parameters of some ber (*Ziziphus maurtiana* var. *rotundifolia*) cultivars

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Abstract

The gene pool of the ber (*Ziziphus maurtiana*) cultivars available in the National repository at Central Institute for Arid Horticulture, Bikaner was evaluated for the variation in the photosynthetic rate and associated parameters. It was observed that the ber cultivars showed a marked variation on the basis of photosynthetic rate and can be grouped into two groups viz. i) showing mid day depression and ii) those which do not show mid day depression. The results on relative water content of leaves demonstrated that leaves of group (i) maintains high RWC as compared to that in group (ii).

Key words : *Ber (Ziziphus maurtiana), photosynthetic rate, mid day depression*

Introduction

Ziziphus mauritiana (Indian jujube) is an important fruit crop of arid region. It is drought hardy and bears nutritious fruits, which provide nutritional and income security to the inhabitants of this region. The species exhibit a rich variability in bio diversity (Vashishtha, 2001; Pareek, 2001), possess varying fruit maturity time which make the availability of fruit for a longer period of time. As a result of extensive survey and collection programme taken up at CIAH, a rich gene pool of ber cultivars is being maintained in the National repository at this Institute. Evaluation of these cultivars revealed that cultivars demonstrated a wide spectrum of phenotypic variability as well as in yield. Despite the existence of rich variability in this species, no physiological analysis has been taken up to evaluate the cultivars on the basis of physiological parameters. Accordingly, the present study was designed to assess the germplasm lines, available in National repository on the basis of photosynthetic efficiency and diurnal variation in photosynthetic rate using four cultivars of ber. The results thus obtained constitute the text of the present communication.

Material and Methods

Four cultivars of ber viz., Kali, ZG3, Jogia and Tikadi constituted the material for present study. These cultivars were selected because the leaves of Jogia and Tikadi are light green in colour whereas Kali and ZG3 have dark green colour leaves. Observation on photosynthetic rate, transpiration, RWC were measured from well developed plants maintained at National Repository of ber at CIAH, Bikaner during fruiting stage. The photosynthetic rate was estimated using Infra Red Gas Analyzer (LICOR-6200).

Relative water content in leaves was estimated using the method of Barrs and Weatherley (1962). The chlorophyl was extracted after the method of Hiscox and Isrelstam (1979) and chl. a, chl. b and total chlorophyll were calculated using the Arnons formula (Arnon, 1949). The yield and pruned wood weight was recorded from the well-grown trees of respective varieties.

Results and Discussion

Changes in Relative water content in leaves

The changes in relative water content in leaves at 1100, 1300 and 1500 hrs are presented in Table 1. Perusal of table reveals that RWC in leaves varied from 68.16 to 90.90%. The diurnal variation in RWC of leaves of ber cultivars under study demonstrated that in cultivars such as ZG3 and Jogia the variation is very less. This is illustrated by the fact that in cv. ZG3 the RWC of leaves was 78.16, 75.88 and 75.58 at 1100, 1300 and 1500 hrs, respectively. However, the other two cultivars (Kali and Tikadi) under study showed a marked variation in the RWC. For instance in cv. Kali the RWC was 74.86, 68.69 and 70.57 at 1100, 1300 and 1500 hrs, respectively. Similar trend was also observed in cv Tikadi. The results thus obtained suggest that marked variation exist with respect to the diurnal variation in RWC of leaves in ber cultivars. This may be on account of the

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Table 1. Relative water content (%) in leaves of ber cultivars

Cultivars	Time		
	1100 hrs	1300 hrs	1500 hrs
Kali	74.86±9.99	68.69 ±10.38	70.57 ± 4.97
Tikadi	90.90±6.82	68.16 ± 6.70	78.76 ± 1.009
ZG3	78.16±8.78	75.88 ± 7.49	75.58 ± 9.87
Jogia	84.62±4.04	82.16 ± 7.31	75.10 ±13.80

fact that some cultivars have inherent mechanism to control water loss and maintain turgour even in the mid day whereas others lack such mechanisms.

Chlorophyll content

The chlorophyll content in the leaves was estimated using dimethyl sulphoxide (DMSO) and the data is presented in Fig. 1. Perusal of data reveals that total

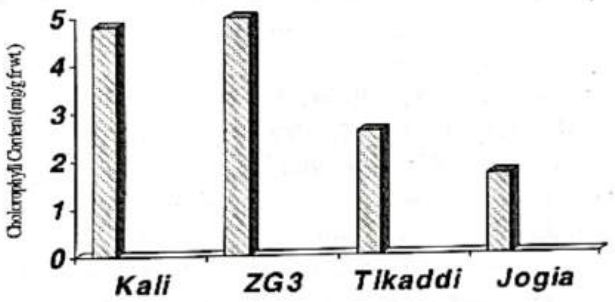

Fig. 1 Cholorophyll content in diffrent ber Cultivars

chlorophyll content in Kali and ZG3 was maximum 4.80 and 4.99 mg/g fresh weight of leaves, respectively. Whereas Tikadi ranked next with 2.60 mg/g fresh weight of leaves followed by Jogia 1.69 mg/g fresh weight of leaves.

Table 2. Photosynthetic rate (mg CO_2 $m^{-2}s^{-1}$) in selected ber cultivars

Cultivars	Time		
	1100 hrs	1300 hrs	1500 hrs
Kali	1.609	0.957	0.930
Tikadi	0.898	0.638	0.622
ZG3	1.144	1.166	1.129
Jogia	0.498	0.436	0.588

Photosynthetic rate

The diurnal pattern in photosynthetic rate recorded in four cultivars under investigation is presented in Table 2. Perusal of data reveals that at 1100 hrs Jogia is having a very low photosynthetic rate (0.498 mg CO_2 $m^{-2}s^{-1}$) whereas, Kali had the highest rate of photosynthesis (1.609 mg CO_2 $m^{-2}s^{-1}$). The other two cultivars lies in between with Tikadi displaying 0.898 mg CO_2 $m^{-2}s^{-1}$ and ZG3 1.144 mg CO_2 $m^{-2}s^{-1}$.

The data at 1300 hrs in cultivar Kali and Tikadi showed a marked reduction in rate of photosynthesis. This is illustrated by the fact that photosynthesis rate dropped from 1.609 at 1100 hrs to 0.957 mg CO_2 $m^{-2}s^{-1}$ at 1300 hrs. Similarly, in Tikadi the photosynthetic rate dropped from 0.898 mg CO_2 $m^{-2}s^{-1}$ at 1100 hrs to 0.638 mg CO_2 $m^{-2}s^{-1}$ at 1300 hrs. On the contrary, the photosynthetic rate remained fairly constant in other two cultivars. This is illustrated by the fact that in ZG3 the rate was 1.144 mg CO_2 $m^{-2}s^{-1}$ and 1.166 mg CO_2 $m^{-2}s^{-1}$ at 1000 hrs and 1300 hrs, respectively.

Perusal of photosynthesis rate at 1500 hrs reveals that the magnitude remained nearly same as that at 1300 hrs (Table 2). This is illustrated by the fact that values were 0.930 mg CO_2 $m^{-2}s^{-1}$ in Kali, 0.622 mg CO_2 $m^{-2}s^{-1}$ in Tikadi, 1.129 mg CO_2 $m^{-2}s^{-1}$ in ZG3 and 0.588 mg CO_2 $m^{-2}s^{-1}$ in Jogia.

Critical analysis of the spectrum further reveals that the ber cultivars demonstrates two typical patterns with respect to photosynthetic rates i) there is reduction in rate of photosynthesis during mid day (showing mid day depression) and ii) there is no reduction in rate of photosynthesis during mid day (do not show mid day depression). The former is typical for cultivars Kali and Tikadi. For instance in Kali the rate of photosynthesis at 1100 hrs, 1300 hrs and 1500 hrs are 1.609, 0.957 and 0.930 mg CO_2 $m^{-2}s^{-1}$, respectively. Identical pattern was also observed in cv. Tikadi showing thereby that the photosynthetic rate declined during midday.

In contrast to this cvs. ZG3 and Jogia demonstrate no reduction in photosynthetic rate during midday. This is illustrated by the fact that rate of photosynthesis was 1.144, 1.166 and 1.129 mg CO_2 $m^{-2}s^{-1}$ at 1100 hrs, 1300 hrs and 1500 hrs, respectively in ZG3. Although, cv. Jogia had very low rate of photosynthesis but is maintained throughout the day.

Table 3. Fruit yield and pruned wood weight of ber cultivars

Cultivars	Pruned wood weight (g/ tree)	Fruit Yield (kg/ tree)
Kali	15.0	17.0
Tikadi	09.0	08.0
ZG3	18.0	20.0
Jogia	17.0	16.0

Fruit yield and Pruned wood weight

The yield of four cultivars were recorded for two years and the mean data is presented in Table 3. Perusal of table reveals that fruit yield was recorded maximum in ZG3 (20.0 kg/ tree) followed by Kali (17.0 kg/ tree) and Jogia (16.0 kg/

tree). The minimum fruit yield was recorded in germplasm line Tikadi (08.0 Kg/ tree).

Data on pruned wood weight of 4 cultivars under study is presented in Table 3. Perusal of table reveals that maximum pruned wood weight was recorded in ZG3 (18.0 kg/ tree) followed by Jogia (17.0 kg/ tree) and Kali (15.0 kg/ tree). Tikadi recorded lowest pruned wood weight (9.0 kg/ tree).

In the earlier studies on photosynthesis in ber it was pointed out that the assimilation was highest early in the morning, which gradually declined throughout the remainder of the day (Clifford et al., 1997). In our study too, some cultivars demonstrated the trend as depicted by Clifford et al. (1997) but in addition to this, some cultivars showed relatively constant photosynthetic rate through out the day.

The data on yield of cultivars under investigation also reveals that the cultivars which do not show mid day depression are more productive as compared to those which shows mid day depression. This is illustrated by the fact that the yield of ZG3 is higher than that reported for Kali and Tikadi. Similar results were also observed with respect to pruned wood weight. Perusal of data in Table 3 illustrates that pruned wood weight of Kali and Tikadi was much less than those of ZG3 and Jogia. This is illustrated by the fact that the pruned wood weight of ZG3 and Jogia are 18.0 and 17.0 kg per tress whereas that recorded in Kali and Tikadi were 15.0 and 9.0 kg per tress respectively. In addition to above, it was further recorded that cultivars which do not show mid day depression are also able to maintain the turgour of the leaves. Perusal of data in Table 1 reveals that in ZG 3 the RWC of leaves were 78.16, 75.88 and 75.58 at 1100, 1300 and 1500 hrs. However, in Kali the RWC of leaves was 74.86, 68.69 and 70.57 at 1100, 1300 and 1500 hrs, respectively. Thus the maintenance of photosynthetic rate through out the day in cultivars which do not show mid day depression may be on account of fact that these cultivars are able to maintain leaf water potential to a magnitude which allows the photosynthetic activity to continue through out the day.

From the foregoing account it is apparent that apart from phenotypic variability, the ber cultivars also reveals the physiological variability in terms of photosynthetic rate and associated parameters. The ber cultivars can be grouped into two groups viz., those i) showing mid day depression and ii) those which do not show mid day depression. The cultivars which do not show mid day depression also maintains the high relative water content. However, it remains to be identified how the plants of group (ii) maintains fairly constant relative water content.

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Direct organogenesis in single bud explant of lasoda (*Cordia myxa* Roxb.)

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Abstract

Organogenesis of shoot and root in single bud explant taken from mature tree of Lasoda (*Cordia myxa* Roxb) has been achieved. Organogenesis was obtained by placing nodal explant on shoot induction medium and subsequently on rooting medium. More than 90% culture were responsive for *in-vitro* axillary shoot proliferation on MS media supplemented with BA 2.0 mg and NAA 0.1 mg per litre. After culture period of 6-8 week, the nodal explants with microshoot were rooted on the MS media supplemented with 3g activated charcoal and different level of NAA (0, 1, 3 and 6 mg/ litre). The season and position of explant on the mother plant was also shown to influence *in-vitro* performance of the regeneration in terms of establishment of aseptic culture, percentage of responsive explants and intensity of leaching of growth inhibitory phenolics.

Key words : *Cordia myxa, tissue culture, organogenesis*

Introduction

Lasoda (*Cordia myxa* Roxb) belongs to the family Boraginaceae and is one of the important arid fruit tree having characteristics of better adaptation to arid and semi arid conditions of tropical and subtropical climates and diverse economic and nutritional utility in culinary processing, preservation and value addition of pickles product alone or in combination with others fruits and vegetables. The plant is a small and medium size tree with a short and crooked trunk. Moreover, the fruits have medicinal value and considered as anthilmintic, diuretic, demulcent and expectorant (Chundawat, 1990). Looking into the importance of this hardy fruit tree, the Central Institute for Arid Horticulture, Bikaner has started collection, conservation and characterization of its germplasm for systematic and economic orcharding. The existing plantation of this fruit is heterozygous with great variability in fruit quality and tree morphology because of propagation by seeds and inefficient conventional vegetative methods. Therefore, growers face problems of poor quality of fruits with low productivity and income. Recently some high yielding genotypes with big size fruits have been identified (Anon., 2002). For rapid and large scale clonal propagation of superior genotypes of tree species the regeneration of plantlets from pre existing meristems through shoot and node culture is the most reliable and widely used procedure however, the need for multiple subcultures on different media makes shoot and node culture extremely labour intensive (Kane, 2000). Total labourers cost ranging from 50 to 70% of production cost, limit expansion of the micropropagation industries (Aitken-Christie *et al*, 1995). Therefore, current application of the technology is restricted to the high value ornamental crops. Expansion of this Industry to include fruit tree species depend on development of efficient micropropogation system. Cost reduction strategies including elimination of the production steps and development of low cost hardening facility will facilitate this expansion in developing countries. Recently, Chitra and Padmaya (2005) made an attempt to study direct organogenesis in leaf explant of mulberry fruit tree for successful plantlet production. Looking into these aspects, a study was conducted to explore direct organogenesis from single node explant of superior genotype of *lasoda* (*Cordia myxa*).

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Materials and Methods

Preparation of mother plant and collection of explant

Selected tree of *Cordia myxa* were irrigated and fertilized as per general recommendation. In order to induce juvenility in stock plant and maximize lateral branching for

obtaining explants, the mother plants were pruned during the month of October. Actively growing lateral shoots were collected and subdivided into single node segments for culture initiation.

Explant preparation and sterilization

The lateral shoot of 10 to 15 cm long collected from mother plants were subjected to washing in running tap water. Leaf blades were trimmed from each node leaving only the petiole bases. Shoots were further divided into single nodal explant and rinsed in mild concentration of detergents (1%) followed by rinsing in tap water. Thereafter explants were treated with 0.1% $HgCl_2$ for 6 minutes. The surface sterilized explant were thoroughly washed several times with sterile water and trimmed to a size of 2 to 2.5 cm before inoculation.

Culture media and Conditions for shoot induction

Surface sterilized explants were inoculated vertically in conical flask of 250 ml size containing MS medium (Murashige and Skoog, 1962) supplemented with 30g sucrose, 8.0g agar and various concentration of BA (0,1,2, and 4mg/l) alone or in combination of NAA 0.1mg/l. The pH of the medium was adjusted to 5.7 and sterilized by autoclaving at 121° C and 15 psi for 15 minutes. The culture were incubated at 26 ± 2° C, and 16 hrs photoperiod provided by cool fluorescent tube with 2000 lux light intensity at bench level.

Culture media for rooting

After culture period of 4 to 5 week the nodal explants with microshoots were transferred to MS medium supplemented with 30 g of sucrose, 8.0g agar, 3g activated charcoal and varied levels of NAA (0,1,3 or 6 mg/l) for rooting of explants.

Hardening of in-vitro produced plantlets

For hardening of the plantlets in arid agro ecosystem, a low cost plant hardening facility was devised involving three step hardening procedure such as (i) transfer of plantlets to acclimatization hood inside the culture room (ii) transfer of plantlets in evaporative cool chamber (iii) for further growth and development in poly house or shade house equipped with intermittent fogging device. Different combinations of potting mixture such as cocopeat, vermicompost and vermiculite, were tried for survival and acclimatization of plantlets to pots. The data of experiments was statistically analyzed using WINDOSTAT (INDOSTAT) software. The analysis was performed using one factor ANOVA and CD thus obtained was used to compare the mean values.

Results and Discussion

Morphogenic responsive culture

In the present study nodal explants were assessed for *in-vitro* morphogenic response, both factors such as position of explant on the stock plant (Table 1) and season of explantation greatly influenced the responsive explant in terms of induction of axillary shoots and phenolic leaching or media browning. The highest percentage (92%) of responsive explants were observed from mid portion of the lateral shoots as compared to apical and basal portion being observed, 32% and 20% respectively. The phenolic leaching from the explant and subsequent browning of the media was maximum during winter season (December-January) however, newly emerged lateral shoots during the period of spring summer (March-April) and rainy season (July-August) were found completely free from leaching of phenolic compounds. Similar observations on the effect of season and source on the morphogenic competences of mature trees have been noticed by several other workers (Deora and Sekhawat 1995, Purohit and Kukda 2004, Rathore *et al.*, 2004 and Read, 1988) with important fruit tree species.

Table 1: Percentage of responsive culture as influenced by position of explant on lateral shoot on the stock plant.

Position of explant	% Responsive explants in terms of induction of shoots
Explant taken from apical portion of lateral shoots	32
Explant taken from mid portion	92
Explant taken from basal portion of lateral shoots	20

Induction of axillary shoot and callus in nodal explants

Morphogenic response in terms of single axillary shoot induction and formation of callus at the base of nodal explant was observed in all concentration of BA in combination of NAA (Table 2). The maximum mean length of shoots (26 mm was recorded with 2mg / litre BA in combination of 0.1mg/litre NAA. At this stage we have completely eliminated the need of repeated sub culturing which is generally adopted by several workers for multiple shoot induction and only two or three microshoots were obtained particularly with tree species. It is well established research finding that the ratio of cytokinin and auxin controls the various morphogenic responses *in-vitro* culture and relatively low ratio of cytokinin to auxin may induce both shoot and callus or rooting in the culture. The higher concentration of BA at 4.0 mg/litre found to induce callus at the base at explant. However, the induction and

Table 2: Effect of BA and NAA on the growth and development of callus and axillary shoot induction in nodal explant

MS + growth regulators (mg/litre)		Formation of callus at the basal end of explant	Induction of axillary shoot (length in mm)
BA	NAA		
			(±SD)
0	0	No Callus	0 ± 0.00
1.0	0	No Callus	8 ± 1.15
2.0	0	No Callus	16 ± 1.58
4.0	0	Callus	5 ± 0..94
0	0.1	Callus	0 ± 0.00
1.0	0.1	Callus	21 ± 0.88
2.0	0.1	Callus	26 ± 0.81
4.0	0.1	Callus	6 ± 0.81
CD at 5%	—	—	0. 84

growth of axillary shoots was very poor. The studies conducted by the workers (Deora, and Sekhawat 1995, Purohit and Kukda, 2004 and Rathore *etal.*, 2004) also favours with tree species either cytokinin alone or in combination of very low concentration of NAA for only shoot organogenesis.

Rooting of the explants

The in-vitro cultured original explants having single axillary microshoot and callus at their base were directly used for root induction experiment. At this stage we have eliminated the step of excision of micro shoot and subsequent culturing in rooting media. Under different concentration of NAA treatments rooting response in

Table 3: Root induction in original nodal explant of *Cordia myxa* on MS medium + 30g sucrose +8g agar + 3g activated charcoal and different concentration of NAA after culture period of 6 to 8 weeks

Concentration of NAA (mg/litre)	Rooting response (%)	Average No. of roots (±SD)	Average root length (cm) (±SD)
0	00	0.0 ±0.00	0.0 ±0.00
1	20	2.1 ±0.56	5.4 ±0.41
3	60	2.7 ±o.48	4.6 ±0.40
6	00	0.0 ±0.00	0.0±0.00
CD 5%		0.34	0.24

explants was found to be significant (Table 3). The maximum 60% explants with roots were noticed in the media composition MS + 30g sucrose + 8.0g agar + 3.0g activated charcoal and 3.0mg NAA/litre. The medium without NAA or at higher concentration of NAA (6.0 mg) failed to induce root. The few cultures i.e. 20% rooted at the concentration of NAA 1.0mg/litre. The higher concentration of NAA found to be induced excessive callusing in the explant.

Hardening of plantlets

Under hot arid agro-ecosystem, hardening and acclimatization of plantlets is very challenging component of micropropagation. In the present study a three step hardening facility (Table 4) was devised and maximum percentage (70%) of plantlets were acclimatized successfully as compared to low survival rate (40%) under the two step procedure. This could be achieved probably due to integration of evaporative cool chamber as one of the important hardening steps which favourably supported the process and facilitated desired temperature and humidity parameters suited to hardening i.e. 80 to 90% relative humidity and 25 to 30° C temperature under hot

Table 4: Influence of hardening steps on survival percentage of plant lets

Hardening step	Survival % of plantlets	
	Cocopeat Vermiculite (3:2)	Vermicompost: Vermiculite (3:2)
Two step procedure: Primary hardening in acclimatization hood kept in culture room for 7-10 days and subsequent transfer in shade house equipped with intermittent fogging.	40	30
Three step procedure: Primary hardening in acclimatization hood kept in culture room for 7-10 days and subsequent transfer to evaporative cool chamber for 7-10 days, thereafter to shade house equipped with intermittent fogging	70	60

and dry weather condition. Similarly, Preece and Sutter (1991) also emphasized certain environmental condition necessary for acclimatization of plantlets using controlled environmental facilities and Singh *et al.* (2005) obtained conducive environmental conditions under three step hardening technique for acclimatization of in vitro raised plantlets of *Capparis deciduas* and cactus pear under hot arid agro ecosystem.

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Effect of post harvest treatments on the quality and shelf life of custard apple (*Annona squamosa* L.) local cultivar during storage.

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Abstract

Custard apple is a climacteric fruit and highly perishable in nature as well as mostly utilized for fresh market. It has very short shelf life that makes the marketability difficult. Therefore, in the period of glut it has to be sold at unremunerative prices. Increasing shelf life of fruit is the only remedy for getting the remunerative profit from them. An investigation with bavistin, calcium carbide, Dithane M-45, oil emulsion (mustard oil, groundnut oil) and paraffin wax treatments were carried out. The application of Paraffin wax was found to be significantly better in physiological loss in weight (PLW), acidity, total soluble solids, reducing sugar and ripening of custard apple during storage.

Key Words : *Custard apple, storage, shelf life*

Introduction

Horticultural crops are good revenue generators but are highly perishable too. In India post harvest handling of fruits and vegetables accounts for 20 to 40 per cent of the losses at the different stages of storage, grading, packing, transport and marketing of fresh produce or processed product. Such an enormous loss is a great handicap in exploiting the full potential of these crops in increasing production, which is one of the constraints in improving the rural income, employment opportunity and nutrition of the masses. Custard apple is mostly used as a desert fruit for its delicious taste and nutritive value. It is a hardy crop, which can be grown on marginal lands with minimum inputs. Due to its climateric nature, it ripens fast and gets spoiled easily. Therefore, increasing the shelf life of its fruits is the only remedy for getting the remunerative profit from it. Thus, the present study was carried out to compare the effects of different chemicals viz., fungicides and oil emulsion on physico chemical characteristics of custard apple during storage.

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Material and Methods

The experiment was carried out in the Department of Horticulture, Indira Gandhi Agricultural University, Raipur during 2004-05. It was laid out in split plot under completely randomized design. The physiologically matured fruits of custard apple having uniform size and shape were procured from local market and cleaned with moist cloth. Fruits were treated with Bavistin (500ppm), calcium carbide (2.0%) mustard oil, Groundnut oil, paraffin wax, Dithane M-45 (1%), control and then dried in shade for 20-30 minutes. Later, they were kept for 0, 3, 6 and 9 days under ambient storage condition. The fruits were analyzed at regular intervals for physiological loss in weight (PLW), ripening percentage and other physico-chemical characteristics. The total soluble solids (TSS) were recorded with hand refractometer at 20°C. The ascorbic acid content was determined by using 2, 6 Dichlorophenol-indophenol dye (Ranganna, 1986). The per cent acidity was analyzed by titrating the fruit juice pulp with N/10 NaOH using phenolphathalein as an indicator. The reducing sugar was determined by standard methods (AOAC, 1970).

Results and discussion

The observations on physiological weight loss Table 1 revealed that there was a uniform increase in loss of

Table 1: Effect of post harvest treatments on physiological weight loss (percentage) in custard apple

Treatments	Days of Storage			Mean
	D2 (3 days)	D3 (6 days)	D4 (9 days)	
T1: Bavistin 500 ppm	*15.36 b (7.00)	22.62 b (14.80)	30.52 d (25.80)	22.83 bc (15.10)
T2: Calcium carbide @ 2%	25.32 d (18.30)	30.93 d (26.40)	34.38 e (31.90)	30 d.21 (25.30)
T3: Mustard oil	17.09 b (8.60)	23.25 b (15.60)	23.38 b (15.70)	21.2 b4 (13.10)
T4: Groundnut oil	17.78 bc (9.30)	23.98 bc (16.50)	24.63 bc (17.39)	22.13 bc (14.20)
T5: Paraffin wax	7.97 a (1.90)	12.20 a (4.48)	14.75 a (6.50)	11 a.64 (4.10)
T6: Dithane M-45 @ 1%	19.45 c (11.10)	26.66 c (20.10)	27.32 c (21.03)	24.4 c7 (17.10)
T7: Control	16.55 b (8.10)	24.49 bc (17.20)	24.89 bc (17.07)	21.98 bc (14.00)
Mean	17.07 a (8.60)	23.43 b (15.80)	25.70 c (18.80)	
	SEm±	CD at 5%		
Treatments (T)	1.05	3.21		
Days (D)	0.25	1.02		
T X D	0.94	2.74		

* Arc sine transformed values, corresponding to original per cent data Figures in parenthesis indicate per cent value corresponding to arrange arc- sine transformed value

Table 2: Effect of post harvest treatments on ripening percentage in custard apple

Treatments	Days of Storage			Mean
	D2 (3 days)	D3 (6 days)	D4 (9 days)	
T1: Bavistin 500 ppm	26.90 (20.48)	30.00 (25.00)	35.17 (33.19)	30.69 b (26.03)
T2: Calcium carbide @ 2%	35.17 (33.29)	45.00 (50.00)	63.10 (79.50)	47.75 d (54.80)
T3: Mustard oil	23.00 (16.29)	30.00 (25.00)	35.17 (33.19)	29.65 b (24.48)
T4: Groundnut oil	23.80 (16.29)	27.97 (22.00)	40.17 (41.60)	30.64 b (25.08)
T5: Paraffin wax	0.00 (0.00)	13.80 (5.70)	26.90 (20.49)	13.56 a (5.50)
T6: Dithane M-45 @ 1%	20.00 (1.70)	35.17 (33.19)	42.58 (45.80)	32.58 bc (29.00)
T7: Control	32.58 (29.00)	37.76 (37.50)	49.89 (58.36)	40.05 c (41.40)
Mean	23.18 a (15.49)	31.38 b (27.11)	41.84 c (44.50)	
	SEm ±	CD at 5%		
Treatments (T)	2.46	7.49		
Days (D)	1.23	3.59		
T X D	-	NS		

* Arc sine transformed values, corresponding to original per cent data Figures in parenthesis indicate per cent value corresponding to arrange arc- sine transformed value

weight with the increase in storage period under all treatments. The interaction effect of post harvest treatments with storage period was found to be significant in case of physiological weight loss (Table 1) and acidity percentage (Table 4). Therefore, the treatment effects on these characters have been compared for different storage periods under study, while in case of ripening percentage (Table 2), TSS percentage (Table 3) and reducing sugar percentage (Table 5), this interaction is not significant so in such cases only the average effects of treatments over storage period have been compared. On comparison of the effects of post harvest treatments on physiological weight loss it was found that paraffin wax caused significantly lowest (1.90, 4.48 and 6.50) weight loss for 3 days, 6 days, as well as 9 days of storage periods. Similarly, the highest (18.30, 26.40 and 31.90) weight loss was attributable to the calcium carbide treatment across all the storage period under study, which was also having significantly different effect compared to all other treatments. For 3 and 6 days of storage period the treatments bavistin, mustard oil and ground nut oil were having at par effect as that of control on the physiological weight loss i.e., these treatments showed same impact on physiological weight loss as in case of control. However, for the storage period of 9 days only mustard oil and ground nut oil were having at par effect with the control. These losses in weight were caused due to reduction in respiration, transpiration and ethylene production by the application of respective treatments.

The observation in ripening percentage is presented in Table 2. Due to non significance of interaction effects the average effects of storage period over treatments as well as the average effects of the treatments over storage periods have been discussed. The ripening percentage significantly increased from 3 to 9 days of storage period. At each level of storage period the ripening was significantly different from the others. On comparison of the average effects of the treatments, minimum (5.50) ripening was observed in paraffin wax while maximum (54.80) ripening was in case of calcium carbide, both of which were having significantly different impact on ripening

compared to other treatments. However, the treatments bavistin, mustard oil, ground nut oil and Dithane-M45 were having at par effect on ripening.

The observation on TSS are given in Table 3, the perusal of which indicates that there was no significant effect of either the treatments or their interaction with the storage period on the TSS contents of custard apple. The different levels of storage period however had significant impact on the TSS content especially between 0, 3 and 6 days. Beyond 6 days upto 9 days the TSS contents were almost at par. The general increase in TSS may be due to hydrolysis of starch and other polysaccharides to soluble form and concentration of juice as a result of dehydration. Similar results were reported by Deol (1985) in mango, Singh *et al.* (1978) in Kinnow. The effect of post harvest treatments on acidity are presented in Table 4. The perusal of the table reveals that there was a significant effects on acidity due to the interaction between the treatments and storage days. Therefore, it suffices to discuss the interaction effects only. There was general decrease in acidity on increase of storage period across all the levels of storage. The decrease in acidity due to storage, might be attributed to the increase in activity of enzymes invertase which is responsible for conversion of acid into sugar and secondary due to utilization of acid in metabolism. Similar results were reported by Singh *et al.* (1978) in Kinnow and Sahni and Khurdiya (1989) in mango. The maximum (0.25) acidity was obtained in case of paraffin wax treatments across all the storage periods which was significantly different from those of all other treatments except that at 6 days of storage ground nut oil and paraffin wax were having at par effect. Similarly, the minimum (0.20) acidity was obtained in case of calcium carbide which was having at par acidity with that of the control from 0 day to 6 days only this was however not the case of 9 days of storage.

So far as other treatments at different levels of storage are concerned, other treatments were having significantly different impacts compared to others except that in case of 0 day storage bavistin, ground nut oil and Dithane M-45 which were having at par effect on acidity; at 3 days of

Table 3: Effect of post harvest treatments on total soluble solids (percentage) in custard apple

Treatments	Days of Storage				Mean
	D1 (0)	D2 (3)	D3 (6)	D4 (9)	
T1: Bavistin 500 ppm	26.68 (20.16)	27.46 (21.28)	23.22 (22.32)	29.35 (24.02)	27.23 (21.92)
T2: Calcium carbide @ 2%	26.40 (19.79)	26.44 (19.83)	29.29 (23.90)	30.50 (25.73)	28.16 (22.20)
T3: Mustard oil	26.49 (19.90)	27.78 (21.70)	29.17 (23.78)	29.44 (24.13)	28.22 (22.36)
T4: Groundnut oil	26.26 (19.60)	26.54 (19.97)	28.13 (22.26)	29.69 (24.49)	27.65 (21.57)
T5: Paraffin wax	25.99 (19.20)	26.84 (20.40)	28.97 (23.45)	29.21 (23.81)	27.75 (21.70)
T6: Dithane M-45 @ 1%	26.29 (19.60)	28.52 (22.80)	28.83 (23.27)	29.84 (24.78)	28.37 (22.60)
T7: Control	26.56 (20.00)	28.92 (23.40)	29.91 (24.87)	29.95 (24.89)	28.83 (23.28)
Mean	26.38 a (19.60)	27.50 b (21.28)	28.93 c (23.40)	29.64 c (24.40)	

	SEm±	CD at 5%
Treatments (T)	-	NS
Days (D)	0.26	0.72
T X D	-	NS

* Arc sine transformed values, corresponding to original per cent data
Figures in parenthesis indicate per cent value corresponding to arrange arc- sine transformed value

Table 4: Effect of post harvest treatments on acidity (percentage) in custard apple

Treatments	Days of Storage				Mean
	D1 (0)	D2 (3)	D3 (6)	D4 (9)	
T1: Bavistin 500 ppm	2.82 c (0.24)	2.78 cd (0.23)	2.76 c (0.29)	2.70 d (0.22)	2.77 bc (0.23)
T2: Calcium carbide @ 2%	2.76 ab (0.23)	2.66 a (0.21)	2.58 a (0.20)	2.29 a (0.16)	2.57 a (0.20)
T3: Mustard oil	2.82 c (0.24)	2.81 d (0.24)	2.79 cd (0.23)	2.71 d (0.22)	2.78 bc (0.23)
T4: Groundnut oil	2.81 bc (0.24)	2.77 cd (0.23)	2.77 cd (0.23)	2.73 d (0.22)	2.77 bc (0.23)
T5: Paraffin wax	2.90 d (0.25)	2.90 e (0.25)	2.82 d (0.24)	2.80 e (0.24)	2.86 c (0.25)
T6: Dithane M-45 @ 1%	2.78 abc (0.23)	2.73 bc (1.22)	2.67 b (0.21)	2.60 c (0.20)	2.69 abc (0.22)
T7: Control	2.75 a (0.23)	2.69 ab (0.22)	2.61 a (0.20)	2.51 b (0.18)	2.64 ab (0.21)
Mean	2.81 d (0.24)	2.76 c (0.23)	2.71 b (0.22)	2.62 a (0.21)	

	SEm±	CD at 5%
Treatments (T)	0.05	0.17
Days (D)	0.007	0.02
T X D	0.19	0.05

* Arc sine transformed values, corresponding to original per cent data
Figures in parenthesis indicate per cent value corresponding to arrange arc- sine transformed value

storage bavistin, mustard oil, ground nut oil and Dithane M-45. At 6 days of storage bavistin, mustard oil and ground nut oil were having at par effect and similarly at 9 days of storage also bavistin, mustard oil, and ground nut oil were have at par effect on acidity. Thus in general bavistin, mustard oil and ground nut oil were found to be have uniformly at par effect on acidity across all the storage period under study.

Table 5: Effect of post harvest treatments on reducing sugar (percentage) in custard apple

Treatments	Days of Storage				Mean
	D1 (0)	D2 (3)	D3 (6)	D4 (9)	
T1: Bavistin 500 ppm	22.08 (14.10)	23.44 (15.80)	23.83 (16.31)	24.30 (16.95)	23.41 a (15.80)
T2: Calcium carbide @ 2%	22.21 (14.50)	25.22 (18.14)	25.46 (18.48)	26.58 (20.02)	24.87 b (17.70)
T3: Mustard oil	22.70 (14.91)	23.44 (15.81)	23.83 (16.30)	23.99 (16.50)	23.42 a (15.90)
T4: Groundnut oil	21.90 (13.90)	23.60 (16.01)	24.12 (16.70)	24.35 (17.00)	23.49 a (15.90)
T5: Paraffin wax	21.74 (13.70)	23.28 (15.62)	23.94 (16.43)	24.24 (16.85)	23.30 a (15.61)
T6: Dithane M-45 @ 1%	22.81 (15.01)	23.52 (15.91)	24.06 (16.62)	24.29 (16.94)	23.67 a (16.11)
T7: Control	21.70 (13.40)	23.33 (15.70)	25.01 (17.90)	25.88 (19.03)	23.98 a (16.44)
Mean	22.16 a (14.20)	23.69 b (16.12)	24.32 c (16.97)	24.86 d (17.60)	

	SEm±	CD at 5%
Treatments (T)	0.23	0.70
Days (D)	0.15	0.44
T X D	-	NS

* Arc sine transformed values, corresponding to original per cent data Figures in parenthesis indicate per cent value corresponding to arrange arc- sine transformed value

The effect of post harvest treatments on reducing sugar of custard apple is presented in Table 5. The effects due to interaction of treatment and storage period has been found to be non significant on the reducing sugar. Therefore, the average effects of treatment across storage period as well as the average effects of storage periods across treatments have been discussed. The perusal of Table 5 shows that the treatments except calcium carbide were having at par effect on the reducing sugar compared to control. Thus it is an evident that calcium carbide is not able to maintain the reducing sugar compared to rest of the other treatments. As far as the effect of storage period is concerned, significant increase in reducing sugar levels on increase of each level of storage period was observed.

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Effect of emulsions and carbendazim on storability of kinnow (*Citrus deliciosa* Tenore x *C. nobilis* Lour)

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Abstract

The individual effect of wax emulsion, oil emulsion and carbendazim were found significant in prolonging the post harvest life and standard quality of kinnow fruits.The treatment of wax emulsion and carbendazim under zero energy cool chamber gave better results. At the end of storage period (28th day), the minimum PLW (7.70 %), minimum TSS (11.07 %), and maximum acidity (0.83 %) were observed in the treatment of wax emulsion 12 % + carbendazim 500 ppm under zero energy cool chamber. At ambient conditions, the fruits were not much matching in quality to that of zero energy cool chamber stored fruits.

Key words: *Carbendazim, emulsion, kinnow, shelf life, ambient conditions.*

Introduction

Kinnow, a mandarin hybrid belongs to the family Rutaceae. In view of its heavy bearing character coupled with relative tolerance to diseases and pests, it has been popularized in irrigated areas of Rajasthan, Haryana, Punjab, Himachal Pradesh, Uttar Pradesh, Karnataka, Kerala and Tamil Nadu. However, the fruits on storage loose their quality. Therefore, an attempt was made for prolonging post harvest storage life and to study the effect of emulsions and fungicide under cool chamber and at ambient storage conditions on kinnow.

Materials and Methods

The experiment was conducted during the year 2001-02 under laboratory conditions, Depatment of Horticulture, College of Agriculture, Rajasthan Agricultural University, Bikaner. For conducting the study, uniform and healthy fresh fruits were picked up randomly and washed with tap water. The fruits were then treated with wax, oil emulsions and carbendazim and placed under zero energy cool chamber as well as at ambient storage condition. For the treatment oil emulsion at 0,1and 2 % and wax emulsion at 0, 4, 8 and 12 % concentrations were used. Two concentrations of carbendazim (0 and 500 ppm) were also taken for studying its effect on storability of kinnow fruits under zero energy cool chamber as well as at ambient storage conditions. Individual effect of these treatments and their combinations on storability of kinnow was studied. The temperature and relative humidity under storage conditions were recorded.

The observations were recorded on physiological loss in weight (PLW), TSS and acidity. The PLW in weight was determined by substracting final weight from initial weight followed by dividing by initial weight and expressed in percentage. The TSS content of the fruits was directly measured by the hand refractometer. Acidity was determined by titrating the juice against standard N/10 NaOH using phenolphthalein indicator and expressed on percentage basis. Five fruits were taken as an unit to record the observations under context. Each unit of fruits was replicated thrice to record the data. The data so recorded were subjected to statistical analysis using CRD and treatments effects were adjudged at 5% level of significance.

Results and Discussion

Data on PLW are presented in Table 1. The PLW increased continuously till the end of storage period irrespective of the treatments and storage conditions. The treatment showed highly significant effect on PLW throughout the storage period. However, mean maximum PLW was observed in control (20.95 %) followed by carbendazim 500 ppm (18.14 %) and mean minimum PLW was recorded in wax emulsion 12 % + carbendazim 500 ppm (13.19 %) preceded by wax emulsion 8 per cent + carbendazim 500 ppm (13.97 %) on 28th day of storage.

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The fruits stored in zero energy cool chamber exhibited minimum PLW of 4.00, 5.82, 7.95 and 10.42 % and that at ambient condition 5.39, 10.87, 16.59 and 22.17 % at 7th, 14th, 21th and 28th days of observations, respectively. Interactions between treatments and storage conditions were significant on all the days of storage. Maximum (27.52%) PLW was observed in control at ambient temperature and minimum (7.30%) in wax emulsion 12 per cent + carbendazim 500 ppm stored in zero energy cool chamber on 28th day of storage (Table 1).

It is evident from the study that the substantial increase in loss in weight increased with the advancement of storage period. Similar results have also been observed in different citrus spp. like lime (Garg and Ram,1972), and Coorg mandarin (Dalal, *et al.*,1962). The reduction in weight was possibly due to loss of moisture through transpiration and utilization of reserve food materials in process of respiration (Meyer *et al.*,1966).

The TSS content of the fruits affected by the treatments are presented in Table 2. As the storage period progressed, the TSS content of the fruits increased irrespective of the treatments. The mean maximum (12.70%) TSS content was found in control followed by 12.66 per cent in fruits treated with carbendazim 500 ppm on 28th day of storage. At the end of storage, mean minimum TSS (11.43%) was observed in the fruits treated with 12 % wax

Table 1. Effect of post harvest treatments and storage conditions on PLW of kinnow fruits *(%)*

S.No. Treatment /	Storage period (days) 7 days ZECC	AC	Mean	14 days ZECC	AC	Mean	21 days ZECC	AC	Mean	28 days ZECC	AC	Mean
1. Control	6.97	8.66	7.81	8.79	14.87	11.83	11.15	20.88	16.01	14.39	27.52	20.95
2.WE 4%	3.74	5.08	4.41	5.48	11.53	8.50	17.71	15.85	11.78	09.62	21.20	15.40
3. WE. 8%	3.39	4.73	4.06	4.15	10.66	07.90	01.26	15.19	11.22	09.03	20.52	14.77
4. WE 12%	3.04	4.28	3.66	4.72	09.42	07.07	16.80	14.31	10.55	08.39	19.88	14.13
5. Sesame Oil 1%	4.15	5.63	4.89	5.95	11.19	08.57	08.27	17.43	12.85	11.29	23.07	17.18
6. Sesame Oil 2%	3.86	5.30	4.58	5.63	10.72	08.17	07.86	16.99	12.42	10.80	22.57	16.69
7. Linseed Oil 1%	4.45	5.97	5.20	6.29	11.57	08.93	08.59	17.92	13.25	11.58	23.51	17.54
8. Linseed Oil 2%	4.29	5.81	5.05	6.10	11.28	08.69	08.38	17.66	13.02	11.30	23.23	17.26
9. Carbendazim 500 ppm	5.27	7.00	6.13	7.12	13.46	10.29	09.40	19.38	14.39	11.40	24.88	18.14
10. W E. 4 % + Carbendazim 500 ppm	3.36	4.58	3.97	6.09	09.88	07.98	07.23	15.00	11.11	08.94	20.32	14.63
I I. W E. 8 % + Carbendazim 500 ppm	3.04	4.18	3.61	4.72	09.03	06.87	06.67	14.10	10.38	08.33	19.60	13.97
12. W. E. 12 % + Carbendazim 500 ppm	2.66	3.75	3.20	4.33	08.25	06.29	06.03	13.35	09.69	07.70	18.67	13.19
13. Sesame Oil 1% + Carbendazim 500 ppm	3.92	5.25	4.58	5.60	10.42	08.01	07.91	16.77	12.34	10.90	22.36	16.63
14. Sesame Oil 2% + Carbendazim 500 rpm	3.59	4.91	4.25	5.30	10.03	07.66	07.56	16.19	11.87	10.44	21.66	16.05
15. Linseed Oil 1% + Carbendazim 500 ppm	4.28	5.67	4.97	6.01	11.02	08.52	08.31	17.50	12.90	11.35	23.00	17.17
16. Linseed Oil 2% + Carbendazitn 500 ppm	4.07	5.50	4.78	5.80	10.65	08.22	08.10	17.03	12.65	11.08	22.60	16.84
Storage condition mean	4.00	5 39		5.82	10.87		7.95	16.59		10.42	22.17	
	SED	CD 5%		SED	CD 5%		SED	CD 5%		SED	CD 5%	
Treatment (T)	0.02	0.04		0.06	0.12		0.02	0.04		0.02	0.05	
Storage condition (S)	0.00	0.01		0.02	0.04		0.00	0.01		0.00	0.01	
TXS Interaction	0.03	0.07		0.08	0.17		0.03	0.07		0.03	0.07	

W. E.= means Wax Emulsion, NS = Non Significant, ZECC= Zero Energy Cool Chamber, AC= Ambient Conditions

Table 2. Effect of post harvest treatments and storage conditions on TSS content of kinnow fruits (%)

S.No.	Treatment	Storage period: 7 days			14 days			21 days			28 days		
		ZECC	AC	Mean	ZECC	AC	Mean	ZECC	AC	Mean	ZECC	AC	Mean
1.	Control	11.0	11.50	10.25	11.47	12.13	11.80	11.93	12.57	12.25	12.30	13.10	12.70
2.	WE 4%	10.5	11.03	10.76	10.70	11.47	11.08	11.2	11.83	11.51	11.57	12.47	12.01
3.	WE. 8%	10.33	11.87	10.60	10.60	11.20	10.90	11.00	11.67	11.33	11.37	12.10	11.73
4.	WE 12%	10.17	11.70	10.43	10.43	11.03	10.73	10.80	11.47	11.13	11.17	11.87	11.52
5.	Sesame Oil 1 %	10.67	11.23	10.95	11.00	11.60	11.30	11.50	12.17	11.84	11.90	12.63	12.26
6.	Sesame Oil 2 %	10.50	11.10	10.80	10.80	11.50	11.15	11.37	12.03	11.70	11.73	12.50	12.11
7.	Linseed Oil 1%	10.83	11.40	11.11	11.17	11.90	11.53	11.77	12.50	12.13	12.20	13.00	12.60
8.	Linseed Oil 2 %	10.70	11.23	10.96	11.03	11.73	11.38	11.63	12.40	12.01	12.07	12.87	12.47
9.	Carbendazim 500 ppm	10.93	11.43	11.18	11.33	11.03	11.68	11.80	12.53	12.16	12.26	13.07	12.66
10.	W E. 4 % + Carbendazim 500 ppm	10.36	11.00	10.68	10.70	11.30	11.00	11.13	11.73	11.43	11.50	12.23	11.86
II.	W E. 8 % + Carbendazim 500 ppm	10.30	11.80	10.95	10.47	11.17	11.82	10.90	11.57	11.23	11.30	12.03	11.66
12.	W. E. 12 % + Carbendazim 500 ppm	10.10	11.60	10.35	10.27	11.93	11.60	10.80	11.37	11.08	11.07	11.80	11.43
13.	Sesame Oil 1 % + Carbendazim 500 ppm	10.60	11.20	10.90	10.90	11.57	11.23	11.40	12.10	11.75	11.83	12.60	12.21
14.	Sesame Oil 2 % + Carbendazim 500 rpm	10.47	11.10	10.78	10.73	11.40	11.69	11.23	12.00	11.61	11.07	12.43	12.05
15.	Linseed Oil 1 % + Carbendazim 500 ppm	10.70	11.33	10.01	10.07	11.87	11.47	11.70	12.47	12.08	12.03	12.97	12.50
16.	Linseed Oil 2 % + Carbendazitn 500 ppm	10.60	11.20	10.90	10.93	11.93	11.33	11.57	12.33	11.95	11.90	12.83	12.36
	Storage condition mean	10.54	11.10		10.85	11.55		11.37	12.04		11.73	12.53	
		SE D	CD 5%		SE D	CD 5%		SE D	CD 5%		SE D	CD 5%	
	Treatment (T)	0.10	0.203		0.12	0.251		0.158	0.31		0.17	0.35	
	Storage condition (S)	0.03	0.07		0.04	0.08		0.05	0.11		0.06	0.12	
	TXS Interaction	0.14	NS		0.17	NS		0.22	0.44		0.25	0.50	

W. E.= means Wax Emulsion, NS = Non Significant, ZECC= Zero Energy Cool Chamber, AC= Ambient Conditions

emulsion + 500 ppm carbendazim followed by the fruits which were treated with wax emulsion 12 % alone. Storage conditions had a significant effect on TSS content of fruits throughout the storage. Zero energy cool chamber stored fruits showed minimum increase in TSS while fruits which were stored at ambient condition exhibited fastest increase in TSS. Gupta *et al.* (1980) reported increase in TSS content of kinnow fruits and Singhrot *et al.* (1987) in lemon. The increase in TSS must be accounted to the moisture loss and hydrolysis of polysaccharides as also discussed by Jwanda *et al.* (1978) in mandarin. TSS content of the fruits was significantly affected by wax, oil emulsions and carbendazim treatment. The increase in TSS content was appreciably higher under control as compared to wax and oil emulsions treated fruits. High TSS content in control treatment fruits may be due to high rate of transpiration as compared to wax and oil emulsions treated fruits. Carbendazim treated fruits showed slower rate of increase in TSS as compared to control. This might be due to lower PLW in these fruits. Similar observations have been observed by Sandhu *et al.* (1989) in Kinnow and Verma (1997) in Kagzi lime.

The data presented in Table 3 shows that the acidity of stored fruits decreased with the advancement of storage period. The mean maximum acidity (0.81%) on 28th day was found in the fruits treated with 12% wax emulsion + carbendazim 500 ppm closely followed by 8 % wax emulsion + carbendazim 500 ppm treated fruits (0.79%). Fruits placed

Table3. Effect of post harvest treatments and storage conditions on acidity of kinnow fruits (%)

S.No. Treatment	Storage period (days) 7 days			14 days			21 days			28 days		
	ZECC	AC	Mean	ZECC	AC	Mean	ZECC	AC	Mean	ZECC	AC	Mean
1. Control	0.77	0.74	0. 75	0.76	0.72	0.74	0.75	0.70	0.72	0.73	0.68	0.70
2. WE 4%	0..83	0.79	0. 81	0.82	0.78	0.80	0.81	0.77	0.79	0.79	0.75	0.77
3. WE. 8%	0.83	0.80	0.81	0.82	0.78	0.80	0.81	0.76	0.78	0.79	0.75	0.77
4. WE 12%	0.84	0.80	0.82	0.83	0.79	0.81	0.82	0.78	0.80	0.80	0.77	078
5. Sesame Oil I%	0.80	0.77	0.78	0.78	0.75	0.76	0.77	0.73	0.75	0.75	0.71	073
6. Sesame Oil 2%	0.82	0.78	0.80	0.81	0.77	0.79	0.80	0.76	0.78	0.79	0.75	0.77
7. Linseed Oil %	0.79	0.76	0.77	0.78	0.74	0.76	0.77	0.72	0.74	0.75	0.70	0.72
8. Linseed Oil 2%	0.80	0.77	0.77	0.79	0.75	0.77	0.78	0.73	0.75	0.77	0.71	0.74
9. Carbendazim 500 ppm	0.77	0.74	0.75	0.76	0.72	0.74	0.75	0.70	0.72	0.73	0.68	0.70
10. W E. 4 % + Carbendazim 500 ppm	0.83	0.80	0..81	0.82	0.78	0.80	0.81	0.76	0.78	0.78	0.75	0.76
I I. W E. 8 % + Carbendazim 500 ppm	0.84	0.80	0.82	0.83	0.79	0.81	0.82	0.78	0.80	0.81	0.77	0.79
12. W. E. 12 % + Carbendazim 500 ppm	0.86	0.82	0.84	0.85	0.81	0.83	0.84	0.80	0.82	0.83	0.79	0.81
13. Sesame Oil I% + Carbendazim 500 ppm	0.80	0.77	0.78	0.79	0.75	0.77	0.78	0.73	0.75	0.76	0.71	0.73
14. Sesame Oil 2% + Carbendazim 500 rpm	0.83	0.79	0.81	0.82	0.78	0.80	0.81	0.77	0.79	0.80	0.75	0.77
15. Linseed Oil I% + Cairbendazim 500 ppm	0.80	0.76.	0.78	0.78	0.74	0.76	0.77	0.72	0.74	0.75	0.70	0.72
16. Linseed Oil 2% + Carbendazitn 500 ppm	0.80	0.78	0.79	0.79	0.76	0.775	0.78	0.75	0.16	0.77	0.72	0.74
Storage condition mean	0.81	0.77	0.80	0.16	0.78	0.74	0.78	0.73				

	SE D	CD 5%	SE D	CD 5%	SE D	CD 5%	SE D	CD 5%
Treatment (T)	0.20	0.014	0.024	0.048	0.026	.051	0.024	0.048
Storage condition (S)	0.07	0.040	0.008	0.017	0.009	.0]8	0.008	0.017
TXS interaction	0.28	NS	0.034	NS	0.036	NS	0.034	NS

W. E.= means Wax Emulsion, NS = Non Significant, ZECC= Zero Energy Cool Chamber, AC= Ambient Conditions

under zero energy cool chamber exhibited the high acid content (0.81%) on 7th day and had the same trend throughout the storage period. Room temperature stored fruits showed the minimum acid content throughout the storage period. As regards to storage condition, maximum acidity content (0.83%) was recorded in fruits treated with wax emulsion 12 % + carbendazim 500 ppm and placed under zero energy cool chamber. Minimum acidity content (0.68%) was noted in control as well as carbendazim 500ppm treated fruits kept at ambient condition on 28th day of storage. Gradual decline in total acidity content of the fruits during storage period, irrespective of the treatments may be due to utilization of acid in the respiration process. These results are in conformity to the findings of Bhullar *et al.* (1981). The acid content of the fruits was significantly affected by all the treatments containing wax and oil emulsions over control. It may be due to lesser availability of oxygen in wax and oil treated fruits. It appears that organic acid which participates in the respiratory process did not oxidize, therefore, their level remained high (Singh *et al.*, 1978). Meena (1997) ascribed similar reason in ber and Khan (1995) in Nagpur mandarin.

Carbendazim was found effective in retaining the acidity of fruits during storage. Jwanda *et al.* (1978) reported application of fungicidal wax quite effective in retention of acidity during storage. Zero energy cool chamber lowered the acid decline as compared to ambient condition. This might be due to the delay in ripening and slower degradation of organic acids as a result of low temperature and high humidity prevalent in srorage. Similar findings have also been reported by Naik (1985) and Singh (1987) in mango.

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Screening of aonla cultivars for making squash

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Abstract

An experiment was conducted at IGKV, Raipur to assess the suitability of aonla cultivar viz. Banarsi, Chakaiya, Francis, Kanchan, Krishna, NA-10, NA-6 and NA-7 for preparation of squash and their shelf life. A recipe of 40 per cent pulp, 60 per cent total soluble solids and 0.75 per cent acidity was found most ideal to prepare squash from Aonla. Among all the eight cultivars of aonla "Chakaiya" was found most suitable cultivar for preparation of squash. This squash remained acceptable up to period of six months during storage at room temperature. The total soluble solid, acidity, reducing sugar and total sugar of the squash increased continuously during storage while the ascorbic acid in contrast decreased.

Key words : *Aonla squash, oragnoleptic quality*

Introduction

Aonla (*Emblica officinalis*) a member of family Euphorbiaceae drop their leaves during February-March and goes under dormant condition and fruit starts growth during rainy season. This character makes aonla remunerative for wasteland and rainfed areas. As aonla is not consumable in fresh form or in raw state or even in the form of juice due to its highly astringent taste, its juice needs to be converted in the form of beverage to dilute its astringency. An attempt was therefore, made to utilize this fruit as beverage in the form of squash because the quality of the processed products can be maintained from good quality of raw materials only. Therefore, the present experiment was planned to screen the aonla cultivars for making squash.

Materials and methods

Studies were performed on eight cultivars of aonla viz Banarasi, Chakaiya, Francis, Kanchan, Krishna, NA-10, NA-6 and NA-7. The fruits were obtained from Horticulture farm, I.G.A.U., Raipur. Harvesting of fruits and preparation of squash was done in the month of December. The squash of following recipes were prepared. R_1 40 per cent pulp adjusted to 40 per cent TSS and 0.75 per cent acidity, R_2 40 per cent pulp adjusted to 50 per cent TSS and 0.75 per cent acidity, R_3 40 per cent pulp adjusted to 60 per cent TSS and 0.75 per cent acidity. For formulation of recipe the total soluble solids and total acidity present in the pulp were first determined and then remaining amount of sugar and citric acid were added. One litre of squash of each recipe was prepared by mixing the calculated amount of pulp, sugar, citric acid and water in different recipes. First sugar syrup was prepared by heating the mixture of sugar, water and citric acid and then it was blended with fruit pulp. Organoleptic quality of the recipes for aonla squash was evaluated by a panel of five judges who scored on a 9-point Hedonic scale (Ranganna, 1997). The trial was conducted under the set up of randomized block design with the judges acting as blocks. The recipe, found ideal for aonla squash, was used for screening suitable cultivar for squash. The bottles of aonla squash were stored (from December to July) at room temperature to study the physico-chemical changes during storage. The physico-chemical study of fresh aonla fruits of different cultivars alongwith the same for stored squash were determined as per the method described by Ranganna (1997). The TSS was measured using a hand refrectometer. The titrable acidity was determined by titrating against N/10 sodium hydroxide solution of thoroughly mixed sample with phenolphthalein indicator. The acidity was expressed in term of per cent citric acid of juice. The ascorbic acid (mg/100g) was determined by titrate known weight of sample with 2,6-dichlorophenol indophenol dye using metaphosphoric acid as a stabilizing agent. The reducing sugar in a sample was estimated by determining the volume of the unknown sugar solution required to completely reduce a measured

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volume of fehlings solution. The total sugar percentage was similarly estimated after acid inversion.

Result and discussion

The fresh fruit was analyzed for TSS, acidity, sugar and ascorbic acid. Results are presented in Table-1. The results of organoleptic evaluation (Table 2) indicates a significant difference between the recipes with respect to

Table-1. Percentage of TSS, Acidity, Sugar and Ascorbic acid (mg/100g pulp) in different cultivars of aonla.

Cultivar	TSS	Acidity	Sugar		Ascorbic acid
			Reducing	Total	
Banarsi	1088	2.07	2.63	3.83	431.4
Chakaiya	7.74	1.87	1.69	3.44	445.7
Francis	8.25	2.2	2.00	3.54	3.80.0
Kanchan	9.66	1.87	2.21	2.83	409.0
Krishna	11.75	1.99	2.54	3.85	455.6
NA-10	7.94	1.85	2.09	3.83	3.87.6
NA-6	9.28	1.76	2.01	3.39	420.6
NA-7	9.97	2.04	2.70	3.77	381.5

acceptability of aonla squash. A significantly highest score of 7.6 was recorded for acceptability of aonla squash in Recipe R-3 having 40 per cent aonla pulp, 60 per cent total soluble solids and 0.75 per cent acidity followed by Recipe R-1 with score 6.4. The least organoleptic score 6.2 was recorded in case of Recipe R-2. The data recorded on organoleptic quality of squash prepared from different

Table-2 : Average organoleptic score for recipe standardization of squash of aonla.

Recipe	Average score
40% pulp adjusted to 40% TSS and 0.75% acidity	6.4^{b}
40% pulp adjusted to 50% TSS and 0.75% acidity	6.2^{b}
40% pulp adjusted to 60% TSS and 0.75% acidity	7.6^{a}
SE (m) ±	0.32
CD (5%)	1.06

The superscripts indicate the treatment means with same letter are at par at 5% level of significance while the means with different letters are significantly different at 5% level. These letters have been affixed based on CD-value comparisons of treatment means.

cultivars of aonla are presented in Table-3. The squash prepared from the Chakaiya cultivar recorded significantly highest organoleptic score 8.4. The Chakaiya has also been reported to be suitable for preparation of beverages by Singh and Pathak (1987), Singh and Kumar (1995) and Nath

Table-3 : Screening of aonla cultivars for preparation of squash

Cultivars	Average organoleptic score
Banarasi	7.0^{b}
Chakaiya	8.4^{a}
Francis	6.0^{d}
Kanchan	6.2^{cd}
Krishna	6.4^{bcd}
NA-10	6.8^{bc}
NA-6	6.0^{d}
NA-7	6.6^{bcd}
SE(m)±	0.23
CD (5%)	0.67

and Sharma (1998). The squash prepared from Banarsi stood second highest within acceptable limit of score 7.0, however, it was statistically at par with those of Krishna, NA-10 and NA-7 at 5 per cent significant level. Both the cultivars NA-6 and Francis recorded least organoleptic scores of 6.0 for aonla squash, which was statistically at par with cultivars Kanchan, Krishna and NA-7.

A gradual change was recorded upto 6 months in the physico-chemical composition of aonla squash of Chakaiya cultivar during storage as evidenced by the organoleptic scores presented in Table 4. After 6 months the deterioration in composition of squash was rapid which brought down the scores below 7 and the product became unacceptable for consumption. Further, the perusal of Table 4 indicates that the TSS, titrable acidity, reducing and total sugar of Chakaiya squash increased continuously during storage. The significant changes were observed almost every month for TSS and Acidity. However, the changes in reducing and total sugar were slow. Ascorbic acid of the squash decreased continuously during storage. An increase in TSS during storage may possibly be due to the conversion of polysaccharides into sugar. The degradation of pectin substances of pulp into soluble solids might have contributed towards an increase in acidity of aonla beverage. The reason for rise in reducing sugar might be ascribed to the conversion of non-reducing sugar to reducing sugar due to the process of hydrolysis. Similarly the increase in total sugar might be due to partial hydrolysis

Table-4 : Physico-chemical changes in aonla squash of Chakaiya cultivar during storage.

Month	Average organoleptic score	TSS (%)	Acidity (%)	Reducing sugar (%)	Total Sugar	Ascorbic acid (mg/100g)
0	8.6[a]	60.07[a]	*4.95[a] (0.74)	37.60[a] (37.22)	45.45[a] (50.79)	393.0[a]
1	8.0[ab]	60.57[b]	5.17[b] (0.81)	37.93[b] (37.78)	45.69[b] (51.20)	376.6[b]
2	7.6[bc]	60.80[c]	5.29[c] (0.85)	38.25[c] (38.05)	45.83[c] (51.44)	363.0[c]
3	7.2[c]	60.97[d]	5.37[c] (0.87)	38.52[d] (38.78)	45.99[d] (51.72)	344.3[d]
4	7.2[c]	61.00[de]	5.62[d] (0.96)	38.58[d] (38.89)	46.31[e] (52.22)	330.0[e]
5	7.0[c]	61.07[e]	5.71[e] (0.99)	38.60[d] (38.92)	46.33[e] (52.32)	318.6[f]
6	7.0[c]	61.27[f]	5.83[f] (1.03)	39.06[e] (39.70)	46.44[f] (52.52)	297.0[g]
7	5.2[d]	61.43[g]	5.90[g] (1.06)	39.21[e] (39.96)	46.75[f] (53.06)	269.5[h]
SE (m) ±	0.20	0.02	0.02	0.08	0.02	2.71
CD (5%)	0.61	0.08	0.08	0.24	0.07	8.13

* Mean arcsine transformed value.

Figure in parenthesis are inverse transformed valued of the corresponding mean arcsine transformed values

Superscripts letters indicate the treatment means with same letter are at par at 5% level of significance while the means with different letters are significantly different at 5% level. (Superscript affixed on CDvalue comparisons of treatment means).

of complex carbohydrates. And the hydrolysis must have been accelerated due to high temperature and acidity. The reduction in ascorbic acid may be due to oxidation by trapped oxygen in glass bottle resulting in the formation of dehydroascorbic acid. These chemical changes in beverages of aonla juice during storage have been reported by Mehta and Rahotre (1976); in squash of litchi by Singh and Singh (1994); in squash of pomegranate by Prasad and Mali (2000).

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Review on ber (*Ziziphus mauritiana* Lamk) diseases and their management

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Abstract

Ber (*Ziziphus mauritiana* Lamk) is an ancient and poor man fruit crop grown in semiarid and arid regions of India and other few countries. Ber fruits from commercial varieties like Gola, Umran, Seb, Mundia, Chomu local are considered as supplementary source of nutrition to the poor people of arid region. However, the yield and quality of ber fruits are adversely affected by various abiotic and biotic factors. Out of different biotic factors, fruit fly infestation and powdery mildew incidence pose much problems in attaining economic yield and consumers preference of these commercial varieties. Being an under utilized fruit crop, much attention has not been given on documentation of the production constraints mainly the biotic factors. Unless there is a comprehensive information available about the symptoms, life cycle and epidemiology of particular disease, suitable management practices can not be worked out. In this review, all possible efforts have been critically evaluated and only the relevant information from different sources, the working experience and publications available with the authors are presented. Emphasis was given on almost all the diseases based on the economical significance of particular disease in ber growing areas of the country preferably Western parts of Gujarat and Rajasthan. Disease like powdery mildew, fruit rots and post harvest diseases are elaborated with suitable literatures and management practices including some of the resistant varieties. This review could be more useful to formulate integrated management strategies for managing ber diseases at present and in future.

Key words : *Ber, diseases, fungicides, pathogens, symptoms and resistant varieties*

Introduction

Ber (*Ziziphus mauritiana* Lamk) is a major fruit crop cultivated all over the water deficit areas of arid and semiarid regions of the Indian subcontinent. Ber orchards are relatively free from diseases wherein the dry and hot weather conditions coupled with very less relative humidity prevails. However some diseases like powdery mildew and leaf spots in humid region, fruit rots in arid conditions and post harvest diseases in all locations are economically important and concern with yield and quality. Complete loss of ber fruits due to havoc nature of ber powdery mildew being experienced in semi arid and humid regions every year. Successful management practices depend upon the proper diagnosis and distinction of symptomotlogy of different diseases in ber. However, there is no comprehensive information about major diseases and their management and therefore, this review will be immensely useful for the researchers, extension personals and ber growers.

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1. Powdery Mildew

Powdery mildew is a major disease concern with low productivity and quality of ber fruits. Being an obligate parasite, recurrent incidence results in heavy loss on susceptible cultivars grown in humid region every year. Ber powdery mildew caused by *Oidium erysiphoides* f.sp. *ziziphi* was first reported from Allahabad (Mitter and Tandan, 1930). Kumar *et al.* (1978) noted the occurrence of powdery mildew of ber (*Ziziphus* spp.) in Indian arid zone. However, complete life cycle of this major disease is yet to be investigated.

Symptoms: Initial symptoms appear on tender or young fruits at pea stage. White specks may occur on any parts of immature fruits at this stage. In severe incidence, floral parts, whole fruits; pedicel, tender branches and leaves would appear with powdery mass of conidia of the fungus. Severe dropping of such fruits can be seen under the tree canopy. The spots change into light to dark brown discolourations. Both upper and under surfaces of tender leaves are also affected and the colonized area are slightly raised and rough in appearance causing shrink and defoliation. Stunted growth of new branches, less fruit

setting and mummified fruits are the later symptoms of same tree already infected in severe form. Under severe incidence, whole tree would appear with very less number of fruit setting and malformed fruits. The matured fruits appear with brown rusty patches over the surface and such fruits are tasteless resulting complete loss on yield and quality. Ber orchards are devastated completely when the powdery mildew is in severe form at flowering and fruit setting stages.

Epidemiology: The cloudy, humid and moderate temperature coupled with few rainy days favour powdery mildew occurrence in moderate to severe form in ber orchards. Disease intensity may vary in different cultivars grown under various environmental conditions. In North India, infections appear from October and reached peak by December. Maximum severity of 100% could occur at maximum temperature of 21.9°C, 88% morning relative humidity, 59% evening relative humidity and 9.6hrs sunshine per day. In Southern states, disease intensity increase steadily from 38th meteorological week having 45.3% disease intensity and reached maximum of 90.7% disease intensity by 50th meteorological week. In Western parts of Gujarat, it appears in the month of September and persists up to January. Maximum temperature of 23.9 to 32.6°C, minimum temperature of 3.8 to 18.4°C coupled with morning relative humidity of 67-83% and evening relative humidity of 17-59% were found favourable for the disease development (Anonymous, 2002b).

Pathogen: According to Mitter and Tandan, (1930), the casual organism of ber powdery mildew has been reported to be *Oidium erysiphoides* f.sp. *ziziphi*. Other literatures reveal involvement of *Microspherea alphiditoides* f.sp.*ziziphi*. These belong to Ascomycotina, order Plectoycetes. The conidiophores are simple, erect measuring 75.8-139.8 x 12.6 ìm in size. Conida are cylindrical, one celled and hyaline measuring 25.2- 37.8 x 16.8-21ìm. Recently, CIAH, Bikaner has studied the basic aspects of this pathogen by collecting different isolates of powdery mildew from various locations of the country. Variability on morphogenesis of conidia and conidiophores was observed in all isolates (Anonymous, 2002a). Investigations on the molecular basis on ber powdery mildew resistance revealed that the phenolics, oxidative enzymes and calcium ion content could be considered as biochemical markers in demarcation of ber cultivars with regard to powdery mildew resistance (Nallathambi and Umamaheswari, 2002).

Perpetuation: Powdery mildew pathogen can survive in the absence of vulnerable growth stages of ber plants and subsequently infect under favourable conditions. However, limited works were carried on this particular aspect resulting different opinions about survival of this pathogen. It can survive on bud woods of the host plants during the non-flowering period. Prakash and Jhoooty (1987) reported that the pathogen can survive as normal and active mycelium on the leaves of ber plants growing under shade. Pathogen may also over winter or over summer and survive in the form of dormant mycelia in bark tissues. Laboratory studies revealed the persistence of dormant mycelia even in 6 months old leaves and fruits of susceptible cultivars like Gola, Umran and Seb (Anonymous, 2002). This pathogen may also survive on some of the collateral hosts viz., *Acanthospermum hispidum*, Haldi grass, *Xanthium xanthocarpum*, *Agrotum*, *Phyllanthus miuri*, *Tridax procumbus* and *Cenchrus biflorus* (Anonymous, 2002b).

Management practices

Cultural practices: Successful management is easily achieved through integrated methods and maximum inoculum could be destroyed by cultural practices. During off season, wild species of ber viz., *Z.nummularia* and *Z.routantifolia* have been found to harbor the pathogen. Therefore, orchards must be free from such wild species. Some of the collateral hosts viz., *Acanthospermum hispidum*, Haldi grass, *Xanthium xanthocarpum*, *Agrotum*, *Phyllanthus miuri*, *Tridax procumbus* and *Cenchrus biflorus* have to be removed from ber orchards. Summer plouging of orchard help in desiccation of soil borne cleistothecia of pathogen. Regular monitoring of orchards is required particularly after flowering and fruit setting. As soon as white powdery specks appear on immature fruits at pea stage, such fruits should be removed and destroyed.

Resistant varieties: Plantation of resistant cultivars is an appropriate method for reducing intensity of this disease for a reasonable period of time. Jayarajan and Cheema (1972) reported some of the ber cultivars (Chhuhara, Safeda selected, Nazuk, Glory, Sanur-2, ZG-2, ZG-3 and Chinese), resistant to powdery mildew. Subsequently, these varieties also broke down their resistance and at present all the commercial varieties are susceptible. Kapoor *et al.* (1975) have tested 37 varieties and found that Sanaur 1 to 4, Bahadurgarthi, Noki and Chinese were tolerant. Genotype viz., Desi Alwar, Dharkhi, Desi, Sukhwani, Gulli, Villaiti and Seedless have also showed filed tolerance. Lodha *et al.* (1984) have screened 66 cultivars and of which 31 showed no symptoms of *Oidium erysiphoides* f.sp.*ziziphi* and 20 were moderately resistant under arid conditions. Some of the resistant tyeps (Chinese, Jogia and Vikas) identified by AICRP on Arid Zone Fruits may have potential genes of resistance for varietal improvement either through hybridization or by other means of breeding programmes.

Chemical control: The control efficacy of various fungicides for the management of ber powdery mildew has been worked out by many workers. Kapoor *et al.* (1975) have reported that out of 9 fungicides, the best was benlate giving 92.1% control followed by afugan, both at 0.07%.

Spraying of 0.2% karathane and morestan (quinomethionate) @ 0.07% could result up to 97 per cent control of this disease (Gupta *et al.*, 1978). Subsequently, Singh and Sindhu (1985) found the best control of this disease could be achieved by 2 sprays of bavistin at a 25 days intervals starting fruits at pea stage, followed by karathane (0.1% dinocap) at 10-15 days.. Karathane at 0.1% was the most effective fungicide tested against *Oidium* sp on ber (Yadav and Singh, 1985). Commonly available fungicides have been tested for their efficacy and concluded that the acaricide i.e., karathane (Dinocap) is one of the best fungicides for the management of this disease. It can be recommended that spraying of 0.1% karathane immediately after pruning, will control the existing inoculums from the previous crop. Later on the spray schedule should be started at 15 days intervals from the time of full foliage to fruit maturity stage if, the areas under endemic location and expecting high intensity otherwise, number of sprays should be reduced to one or two based on the necessity at fruit setting stage.

Biological control: The biocontrol method of powdery mildew management is very limited in most of the crop plants. 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. However, CIAH, Bikaner has initiated work on exploitation of native isolates of both bacterial and fungal antagonists. The field experiments on management of powdery mildew were carried out under powdery mildew endemic location. The native isolates of *Trichoderma* (CIAH-240) and *Pseudomonas fluorescens* (CIAH-196) along with 50% less than recommended dose of fungicide (karathane) were sprayed at monthly intervals on susceptible cultivars (Gola and Umran). The overall results depicted that the maximum (90.66) per cent disease control has been achieved by spraying 5% culture filtrate of *Trichoderma* (CIAH-240) followed by conidial suspension of *Trichoderma* (5 and 10%) spray resulting 82.19 and 83.2% respectively. In case of cv.Gola. per cent control efficacy of 95.81 could be achieved by combined application of *P.fluorescens* and 0.05% karathane. Bacterial antagonist alone was moderately effective as compared to combination with fungicides (Nallathmbi *et al.*, 2003) Therefore, these bioagnets will have grate importance as an alternative component in formulation of integrated management strategies against powdery mildew.

Fruit Rots : Fruit rots of ber are not a major problem in other parts of the Country. However, in western parts particularly in arid regions of Rajasthan, it is and major disease and economically important as compared to powdery mildew. Nallathambi (2001) studied in details about different kinds of rots due to various fungal pathogens in this region. Different types of fruit rots were recorded in almost all the major varieties of ber. The cumulative analysis of data form two years survey in different locations of arid region revealed that the fruit rot infection index was up to 22.5% with an estimated total yield loss up to 31%. Therefore, the fruit rots can cause major loss of ber fruits in coming years unless suitable management practices are followed.

2. Alternaria Rot

Symptoms: Disease incidence can be seen in immature as well as young and matured fruits. In Gola variety, *Alternaria* infection initiates from pedicel end and subsequently in bottom portion of fruits. Ripened fruits are relatively free from infection. Severe infection on maturing fruits resulted in dark brown blotch and ultimately whole fruit got rotted. Such fruits ultimately fall down resulting severe losses. Some fruits with complete rotting contained concentric rings having plenty of spores of the pathogen. In advanced stage of infection, fruits skin is found to be rough, shrivelled with distorted tissues. Fruits infected at pea and maturing stage also fall down from branches. At times, all the young fruits also fall down by severe infection and ber plants appear with moderate bearing of fruits. When infected fruits at maturity stage cut open, brown pulp in contrast to whitish green in healthy fruits could be seen easily. Seed development in such fruits is arrested or seeds are malformed.

Symptomatology on fruits of Umran variety is slightly different. Pathogen starts infection from pedicel end resulting in dark brown lesion lacking distinct margin on fruits and in some cases, infection can be seen in pedicel also. Dark brown lesions in batches can be observed on entire fruit surface and it is a characteristic symptom in this particular variety. Maturing fruits are mostly affected than young fruits and fruit dropping will be high in such plants. However, some of the fruits do not fall and remain on the branches in dry conditions. Internal symptoms show dark brown tissues with necrosis. Epidermal cells of fruit skin are found disrupted, light to dark brown and rough. However, pulp colour is not changed as much as in case of Gola variety. In premature fruits, seed is affected while in matured fruits under severe infection, seeds turn grey to brown or black as compare to healthy fruits. In case of cv. Seb, young fruits (pea stage) are mostly affected by Alternaria fruit rot. Fruits under maturity and ripening stages are less susceptible. Dropping of fruits is relatively less even under severe infection. Brown lesions from pedicel end enlarged rapidly and covered the whole fruits. Seed necrosis within light brown pulp tissues the internal symptoms. Fruits of Chomu local under maturity and ripening stage are mostly free from Alternaria infection. However, young berries are completely rotten and dropping

could be seen under the trees. Dark browning and shrivelled skin are the main symptoms due to this pathogen. Such fruits are hard to open. Internal symptoms can be seen as distortion of seed having pathogen growth on its surface. Pulp tissues are fibrous and interlocked with dark brown mycelium of the fungus.

Pathogen: Pathogenic fungi responsible for this disease has been identified as *Alternaria alternata* (Fr.) (Perfect state : *Pleospora infectoria*). This pathogen expressed variation in its growth characters. Mycelia were olive green in the initial growth and later on turned to blackish green. Brown mycelia with frequent concentric rings and dark brown mycelia lacking concentric rings can be observed. *A. alternata* is widely present in almost all host plant either as parasite or saprophyte on dead organic matter and therefore, it can easily survive during over winter and summer season. In addition, the dormant mycelia can be observed at inter and intracellular spaces of infected dead tissue and these can serve as primary inoculum for fresh infection under favourable conditions.

3. Black Rot or Aureobasidim Rot

Nallathambi *et al.* (2001) have studied in detail about disease for the first time in ber fruits (var. Gola). External symptoms of this disease are different from other fruit rots. Black lesions from pedicel region progressed rapidly on entire fruit. Infact, it is the only fruit rot showing black lesions on fruits and hence, this disease was named as black rot of ber berries. Infected fruits are not easily detachable from branches since pedicel of such fruits appears green and healthy. The casual organism of black rot has been identified as *Aureobasidium pullutans* (de Bary) G. Arnaud. (*Dematium pullulans*, *Pullularia pullulans* (de Bary)-Berkhout Microscopic observation can show dark grey to black, thick walls and frequent septation in mycelium. Conidia have borne on dark brown structures called denticles directly from the hyphae. Primary conidia are dark brown, thick wall with cylinderical shape. In 15 days old culture, budding from the primaries exhibits formation of secondary conidia by budding from the primaries. Secondary conidia are smaller (7-10 x 3-4.5 µm) than primary conidia, not adhering to each other, hyaline or light brown with smooth walls.

4. Cladosporium Rot

It is caused by *Cladosporium oxysporum* and found to occur in all the major varieties grown in the arid zone of Rajasthan. Infection appears predominantly on young and maturing fruits of Gola and Umran. Light brown lesions or blotches of browning on fruits surface are observed. Greenish mycelium of the pathogen can be also seen on fruit surface. Mycelial colonies of this pathogen are constricted and slow in growth on PDA medium. Initially colonies are olive green, slightly wringled or dark green and conidiophores are long, light brown, sparsely and irregularly branched.

5. Colletotrichum Rot

This disease is caused by *Colletotrichum gloeosporioides* on young and maturing fruits. Initial symptoms appear as water soaked, light brown lesions on fruit surface. Young berries also exhibit such symptoms. Whereas infection in ripening fruits is characterised with depressed, reddish brown lesions. Advanced infection show mass of acervuli on fruit surface. In Umran variety, reddish brown spots enlarged and coalesced forming bigger lesions. However, dropping of fruits is not severe as in case of Alternaria fruit rot. The pathogen *Colletotrichum gloeosporioides* (Penz.) sacc., Teleomorph *Glomerella cingulata* (Stomenason) Spould. and Schrenk. was found in association with fruit rot. Mycelial growth was grey on PDA medium. Acervuli production in the initial stage of mycelial growth is not common but plenty of conidia and setae are produced in 15 days old culture. Ber fruit rot symptoms of *Alternaria* and *Colletotrichum* are easily distinguishable in irrespective of varieties they infect, e.g. *A. alternata* produces browning with clear margin or brown batches in Kaitha variety while *Colletotrichum gloeosporioides* express water soaked lesions in Mirchia variety. Both pathogens also coexisted in same variety producing their characteristic symptoms.

6. Epicoccum Rot

Nallathambi *et al.* (2002) recorded for the first time under field conditions. During surveys undertaken in arid region of Rajasthan, this fruit rot was encountered in cv.Gola. Infection on maturing fruits appeared as a brown strips progressing downwards in one side of fruit where yellowing on other side. In severe infection, depression of fruit surface as well as hardening and malformation of such fruits can be observed. In some fruits with severe infection, small pinhead like growth of the pathogen having clusters of dark conidia were found. Internal symptoms showed fibrous nature of pulp tissues with necrotic seeds. Pathogen of this fruit rot has been identified as *Epicoccum nigrum* Link. It is a hyphomycetes fungus, commonly appears as saprophyte or secondary invader. However it has been found to cause fruit rot on ber fruits. The pathogen produced numerous large sized, spherical, irregularly septate conidia, borne on rapidly growing mycelium. Conidia appear in clusters, black, borne solitarily on short conidiophores, measuring 15-25 µm diameters with rough walls obscuring many septa.

7. Phytophthora Rot

Jee Hyeong Jin *et al.* (1990) have studied in details about the fruit rot due to *Phytophthora citricola* on *Zizyphus sativa* fruit. Symptoms consisted of brownish to reddish rot on fruits resulting in early drop or mummification. The causal fungus isolated from infected fruits and adjacent leaf stalks was identified as *P. citricola*. The fungus was highly pathogenic to *Z. sativa* and other fruit crops like apple, pear, orange, persimmon and aubergine and relatively weak to citron, tomato, capsicum and cucumber. Phytophthora rot will be severe and major problem if, rain occurs during the harvesting period. Pathogen can also infect at storage and causes losses during transit and in the market (Lin,1984).

8. Trichothecium Rot

This disease can be observed in later stages of fruit development, which are maturing and ripening during the months of January and February (Nallathambi, 2001). Fruits at ripening stage are more susceptible than young and maturing stages. Initially, reddish sunken spots on fruit surfaces were seen and in advanced stage of infection, few spots coalesce and cover a larger area. Dropping of fruits was not common in orchards. In some fruits, pathogen also colonized on surface. *Trichothecium roseum* (Pers.) Link is associated with this fruit rot. Mycelial colonies of this pathogen on PDA medium are orange pink with powdery mass of conidia. Microscopic observations revealed the profuse branching of mycelium, which are hyaline and septate. Conidiophores are long, erect, simple or aseptate, unbranched, hyaline and swollen at apex bearing conidia at the tips successively, each formed as a blown out cell below the previous, sometimes adhering loosely in chain. Conidia are hyaline, almost ellipsoidal to puriform with a single septa with the size of 16-20 x 8-10 µm. Conidia are having thin and smooth wall.

Management practices

Cultural practices: Management of fruit rots is essentially required to get better yield and quality fruits of ber. In ber, *A. alternata* causes a major proportion of loss. This particular pathogen has many alternate hosts and it can survive as saprophyte in any kind of organic matter. Therefore, removal and destruction of infected fruits and other host plants in ber orchards can reduce the inoculum level. The use of fungicides is imperative to save not only the crops from avoidable losses but also for increasing productivity and ensuring stability and security because they play an integral role crops for better yields. Fungicidal sprays at fortnight intervals (0.2% mancozeb or copper oxychloride or chlorothalonil) can minimize the level of incidence if, the fruit rot incidence is more. Since *A. alternata* is also causes leaf and fruit spot disease in pomegranate, all the precaution measures followed in ber orchards have to be adopted in case of pomegranate orchards also so that the fruit rot incidence of ber can be minimized indirectly by arresting the inoculum from pomegranate plants to ber.

Chemical control: Evaluation of some of the non-systemic fungicides at different concentrations against *A. alternata* resulted that out of 7 fungicides including a biofungicide. dinocap (Karathane) inhibited the growth of the pathogen 100% at all concentrations. Mancozeb and copper oxychloride are also significantly effective to check the growth. However, captan showed moderate efficacy upto 250 ppm and higher concentrations (500 and 1000 ppm) of this fungicide resulted 72.28% and 82.75% inhibition respectively. Wettable sulphur and alcidine are not effective to the test pathogen. Systemic fungicides act systemically in plant after application either in soil or as foliar sprays. Propiconazole and tridemorph completely inhibited the mycelial growth of test pathogen followed by triademefon with an inhibition range of 72.52 to 98.63% at 50 to 1000 ppm active ingredients. The least efficacy was expressed by carbendazim (3.5 to 15%) followed by metalaxyl+ mancozeb and thiophenate methyl (Nallathambi and Thakore, 2003)

Biological control: It is gaining importance for management of crop diseases (Backer and Cook, 1974). Diseases caused by *Alternaria* species have also been successfully managed by biocontrol agents like *Trichoderma harzianum* and *Bacillus* sp (Mercer and Papadopolous, 1990) and Fluorescent pseudomonads (Silva *et al.*, 1998; Prasad and Kulshresthra, 1999). Native isolates of *Trichoderma* were evaluated for *in vitro* inhibition of *A. alternata*. (Nallathambi and Thakore, 2002a). Out of 16 isolates, 9 isolates could check more than 50% growth of pathogen. Native isolate CIAH-240 was significantly superior than rest of the isolates. Isolates viz., CIAH-142, CIAH-150, CIAH-161, CIAH-165a, CIAH-259 and SBI-33 showed less than 50% check ((Nallathambi and Thakore,2002b). Least inhibition (26.41%) was expressed by CIAH-150. Different native isolates of *Trichoderma* inhibited the pathogen by different mechanisms. The superior isolate CIAH-240 was mycoparasitic as well as secreted toxic metabolites. Weakening, lysis and distorted mycelium of pathogen results in response to *Trichoderma* colonization. Isolates CIAH-142 and 165a can be used as mycoparasitic while rest of isolates are merely competitive. Out of 14 native isolates of *P.fluorescens* tested, CIAH-196 inhibited the maximum mycelial growth. Interestingly, sporulation of test pathogen was suppressed by some of the native isolates (Nallathambi and Thakore, 2002b). However, practical applications have to be evaluated.

Management of Alternaria rot at post harvest stage

Generally post harvest infection due to microbial organisms results into severe losses particularly in fruits due to high perishability. Fruits are enriched with high carbohydrates which are ready-made food with other nutrients thereby utilization is easy for fungal colonization. In order to find some post harvest treatments for combating *A. alternata* infection which was found to spoil fruits in transit and storage (Nallathambi and Thakore, 2004) have screened to select an effective bioagents under laboratory conditions using biocontrol agents, fungicides and combination of these two methods to reduce the infection. Bacterial antagonists are also useful for post harvest treatments for the control of fruits diseases (Pusey and Wilson, 1984). Nallathambi (2001) has identified some of the effective isolates of *P. fluorescens* under *in vivo*. All native isolates of *P. fluorescens* were effective with more than 60% control efficiency after 7 days of treatment. In addition, physical properties like texture and colour of ber fruits were better in bacteria treated fruits. Isolates of bioagents i.e. CIAH-240 (*Trichoderma*) and CIAH-196 (*P. fluorescens*) are better than rest of the biocontrol agents tested and therefore, these two effective isolates have been taken for further experiments. Fungicides treatment showed that dinocap and copper oxychloride at 50 ppm are effective and resulted in more than 50% control. Whereas, at 100 ppm concentration, except mancozeb, wettable sulphur and dinocap were found to control more than 60%. Copper oxychloride has given 67.7% control. Dinocap also expressed some scorching effect on treated fruits and smell of treated fruits was also bad. Some of the systemic fungicides except carbendazim have resulted more than 50% control at both concentrations tested. Moreover, propiconazole and tridemorph can injure the fruits resulting in scorching or necrotic spots on fruits just after treatment.

Integration of more than one component can result better efficacy on management of post harvest pathogens. Effective fungicides as well as bioagents were combined for the control of fruit rot of ber so that maximum loss is reduced with minimum use of fungicides. Effective isolate of *Trichoderma* (CIAH-240) and *P. fluorescens* (CIAH-196) were chosen for combined treatment with fungicides. Mixing of *Trichoderma* certainly improved the efficiency of the treatment, as there was marked increase in disease control. More than 70% efficiency can be realized when thiophenate methyl, mancozeb and alcidine at 50 ppm whereas more than 80% PEDC was obtained when 100 ppm of thiophenate methyl, chlorothalonil, mancozeb and alcidine were mixed with *Trichoderma* isolate (CIAH-240).

In other case, per cent control efficiency was more than 60% when *P. fluorescens* isolate (CIAH-196) was mixed with thiophenate methyl, captan and alcidine at 50 ppm. Similarly mixing of *P. fluorescens* with thiophenate methyl, captan, and alcidine cay be effective to control the Alternaria rot of ber. Fungicides solution mixed in *Trichoderma* (isolate, CIAH-240) solution first, then with bacterial cells suspension and then pathogen inoculated fruits were treated in this mixture. Lower concentration of fungicides (50 ppm a.i.) mancozeb + metalaxyl, triademefon, thiophenate methyl, captan, chlorothalonil, copper oxychloride, mancozeb and alcidine gave more than 50% PEDC. Nevertheless, mancozeb, thiophanate methyl and alcidine were significantly controlled the disease at 50 ppm with both the bioagents. In order to ascertain the actual resistance level, some of the genotypes were evaluated under laboratory conditions using its toxin. Genotypes viz., Chhuhara, Bagwadi, Khura B. Bawandi, Reshmi and Ponda showed immune response to fruit rot pathogen.

9. Black leaf spot

Symptoms : Gupta *et al.* (1977) have reported this disease for the first time from Haryana. It is common in Southern and Northern parts of the Country. Cloudy weather with moderate temperature during October-November is favourable conditions for the development of this disease. Black spots, which are sooty, tuft like circular to irregular black spots develop on leaf surface. During advanced stage, the lower surface of leaves also covered in larger area and corresponding upper surfaces show brown discolouration. Microscopic examination indicated that hyphae penetrated the lower epidermal cells, disintegrated them together with the spongy parenchyma and rapidly colonized between the palisade and spongy parenchyma cells to penetrate the upper epidermis causing necrosis and browning.

Pathogen: This disease is caused by *Isariopsis indica* var.*zizyphi*. The fungus as primary inoculum survives in plant debris and soil for subsequent infection. Plenty of spores produced from each spots serve as secondary spread through wind. An isolate of *I. indica* var. *zizyphi* from *Ziziphus mauritiana* grew and sporulated best at 20°C. which was the most prevalent temperature during January, when the disease was most severe under natural conditions. The fungus can survive up to 6 months on infected leaves after dropping on the ground or sticking to crotches of branches and cracks in the bark.

Management:

Cultural practices: The infected leaves and twigs are to be removed and destroyed as soon appearance of disease is seen. Ber orchards should be maintained free of weeds and ber plants should be properly pruned with optimum canopy density so that humidity may not develop and the available inoculum will not proliferate for fresh infection. However, this pathogen also infects other plants like mulberry trees used as wind brakes around the plantations and the common weeds *Cynodon dactylon* and *Bidens pilosa* (Verma *et al.*, 1984). Therefore, such plants have to

be avoided in the vicinity of ber orchards in addition to destruction of all weed hosts.

Resistant varieties: Gupta *et al.* (1980) reported that out of 56 *Ziziphus mauritiana* varieties screened for resistance to *Isariopsis* (*Phaeoisariopsis*) *indica* var. *ziziphi* in the field at Hissar. Some of them were resistant varieties viz., ZG-3, Seo Bahadurgarhia and Safeda Rohtak. Cheema and Dhilon (1981) studied the resistance level of different cultivars and reported that none of the 36 of *Ziziphus mautitiana* was resistant to this disease. Some of the cultivars like ZG-3, Safeda Rohtak, Mundia-Murthera, Sua, Sanour-1, Padami, Jhajjar selection; Seo-Bahadurgarhia and Jhajjar special were reported to be resistant.

Chemical control: Other than cultural practices like removal and destruction of infected leaves, some of the contact fungicides have been found to be effective in control of this disease. Different fungicides have been evaluated to manage the disease. However, spraying of bavistin or difolatan (0.2%) was found effective. It was also reported that this disease was successfully controlled by 4 sprays of carbendazim, copper oxychloride or Bordeaux mixture applied fortnightly from the first week in November and containing a suitable adjuvant (Verma and Cheema, 1983). Of 6 fungicides applied as sprays, 0.1% Bavistin was effective in reducing the disease incidence followed by 0.2% Dithane M-45 mancozeb (Sekhar, *et al.*, 1989). Rawal and Saxena (1989) have concluded that *Isariopsis indica* var. *zizyphi* was effectively controlled with treatment of 0.1% Bavistin (carbendazim) followed by Daconil (chlorothalonil) at 0.2% under field trials. A mycoparasite called *Hansfordia pulvinata* (Berk et.Curt) Hughes was growing on diseased spots in nature can also control disease without further damage to the host (Gupta and Madaan, 1979).

10. Alternaria leaf spot

Alternaria leaf spot in ber is commonly noticed in ber orchards. Except in few locations where the environmental conditions are highly conducive for disease development, there will not be much loss in orchards. The disease is characterized by the formation of small, irregular brown spots on upper surface of leaves. Corresponding lower side appears with dark brown to black spots. Under humid conditions, black patches comprising plenty of conida can be seen and which serve as air borne inoculum. As in case of other plants, under severe conditions many spots coalesce to form big patches and later such leaves defoliate from branches. Different authors have reported various species of *Alternaria* species.

This disease development is favoured between 20 to 30°C with an optimum temperature at 25°C. Plant debris serves as potential source of primary infection. High relative humidity coupled with frequent rainy days appears to be more important than temperature in disease development. Madaan and Chand (1986) confirmed that the pathogen survives over the summer in debris of *Ziziphus mauritiana*, providing primary infection and perpetuation in soil and plant debris to provide recurrent infection. In order to manage this disease, plantation of resistant cultivars is recommended. Bahadugarhia, Govindgarh special, Gola-Gurbaon, popular Gola, Seo, ZG-3, Safeda Rohtak, Jhajjar special and Mirchia were reported to be resistant to this particular leaf spot (Jayarajan and Cheema, 1972). However, the disease can be effectively managed by weekly spray of either one of the fungicides like Difolatan, Dithane-Z-78 or 0.2% mancozeb.

11. Red Rust

The algae *Cephaleuros virescens* Kunze causes red rust in ber. However, leaf rust of *Zizyphus mauritiana* caused by *Phakopsora zizyphi-vulgaris* has been reported from Haryana, When it occurs, at first some light green spots appear on the over blade of the leaves, then some yellow powder will appear, that is the summer spores of the pathogen (Quan and Quan, 2002). Gjaerum (1973) has reported *Uromyces anthyllidis* and *Ziziphi vulgaris* on *Ziziphus mauritiana*. Jujube rust disease (*Phakopsora ziziphi - vulgaris* (P. Hean.) Diet.) is an important disease for jujube trees. It usually attacks the leaves and often makes the leaves to fall by 30-40%, so the production will be much reduced. The spots are of 2-5mm diameter. They occur on the upper surface of the leaves as first greenish gray and later they turn into purplish black with central tuft of blight orange. Severely infected twigs are stunted growth and leaves wither from them. Symptoms are severe on old leaves and uncared trees.

This disease can be managed through integrated approaches. Plantation of resistant varieties would be the permanent and effective method of managing this disease. Of 58 cultivars screened under field conditions having natural infection, 7 were resistant against this disease. Fungicidal spray is required when there is moderate to severe incidence. However, prophylatic spray is advisable for checking initiation of incidence. The best control of leaf spot on Z.*mauritiana* was given by 0.1% carbendazim followed by 0.1% thiophanate-methyl (Gupta *et al.*,1989). Spraying Bordeaux mixture, lime sulfur, triadimefon (as amiral) or carboxin effectively managed the *Ziziphus* rust of ber in some locations.

12. Stem Blight

Stem blight of ber has been reported for the first time in ber under arid conditions (Nallathambi and Umamaheswari, 2001). This disease was observed after pruning. Almost 80% of the genotypes in the National germplasm repository were infected and failed to sprout. Initially, black lesions appeared from cut ends of the stem

and progressed downwards. In severe infection half portion of the stems were observed with black lesions. Complete drying of the whole tree was noticed when the blighting progressed below the soil level. When the bark was split open, pinhead like pycnidia interlocked in mycelia mat of the pathogen could be seen. The saprophytic fungus *Torula herbarum* has been identified as casual organism of this disease. This pathogen could survive for long time in the infected stems in the form of dormant mycelium and pycnidia. In order to manage this disease, infected stems or the part the stems, which is not sprouting for long time, have to be removed from the tree and injured portions may be pasted with Bordeaux paste. Pasting and soil drenching of copper fungicide (Bordeaux mixture) are effective in suppression of the disease.

13. Amellophorella Leaf Spot

It is considered as minor disease in ber except some places in central and Southern parts of the India have reported that this leaf spot is serous problem. This disease appears during the months of January and February. Formation of small, irregular, pale or dark grey spots on the leaves are the symptoms. In advanced stage of infection, such spots get enlarge result drying of leaves. This disease is caused by *Amellophorella zoenoplia* and it can be easily managed by spraying 0.2% Difolatan or Dithane M-45 when there is severe infection.

14. Cercospora Leaf Spot

It appears during the months of January and February. This disease is caused by *Cercospora jujubae* Choudury(*Cladosporium ziziphi* Karst). Small, round, gray spots with red margin on both sides of the leaves are the symptoms of this leaf spot. Severely infected leaf areas dries up and fall off showing shot hole symptoms. It is also known as shot hole disease. Some time this particular disease can also produce sooty mould growth having dark brown blotches on the under surface of the leaves. Though it is not a major disease, the contact fungicides like 0.2% mancozeb or copper oxychloride or zineb can control it.

15. Post Harvest Diseases of Ber

Ber fruits are having short period of shelf life and therefore, many fungal pathogens at their saprophytic stage can easily infect few days after the harvest or in other words, after complete ripening of the fruits. The per cent infection of fruit rot due to post harvest pathogens may vary from 5-12 per cent irrespective of the varieties. After 5-7 days of harvest, ber fruits are adversely affected by different saprophytic fungus. Kainsa *et al.* (1978) have studied the surface mycoflora of freshly harvested ber fruits. Inoculating the fruits by pinprick injury and placing them in sterile desiccators for 10 days at room temperatures and studied the relative efficiency of different microorganisms among the surface microflora. In India, post harvest rots of ber is mostly confined with deuteromycetus fungi, whereas, in other countries even lower fungi also cause fruit rots. Gray mold disease on *Z.jujuba* and *Z.marutiana* caused by *Botrytis cinerea* has been reported from Taiwan (Hsieh and Tsai, 1978). Wadia *et al.* (1980) reported three post harvest pathogens viz., *Alternaria alternata, Fusarium decemcellulare* (*Calonectria rigidiuscula*) and *Cladosporium cladosporioides* on *Z.mauritiana* fruits from India. The consolidated reports from different research centers of AICRP revealed the involvement of fungus viz.,*Aspergillus terrens, A. flavus, A. niger, Alternaria alternata, Colletotrichum gloesporioides, Penicillium spp., Phoma spp., Rhizopus stolanifer and Cladosporiun oxysporum.* Sumbali and Mehrotra (1982) have studied the post harvest fungal diseases of ber fruits caused by *Trichothecium roseum, Glomerella cingulata, Cladosporium oxysporum, Alternaria alternata, Geotrichum* sp, *Phoma herbarum* and *Fusarium equiseti.* Maadan and Dasgupta (1983) have surveyed of markets in West Bengal and reported *Aspergillus aculeatus* on *Z.jujuba.* Ullasa and Rawal (1986) have described the post harvest decay caused by *Phytophthora nicotianae, Sclerotium rolfisii* and *Botryodiplodia theobromae* in ber fruits. In several markets of Rajasthan, some new post harvest diseases were observed and the fungi including *Cladosporium tenuissimum, Fusarium pallidoroseum, Pythium aphanedermatum, Phoma nebulosa and Rhizoctonia solani,* which have not been reported as post harvest pathogens of this host (Sharma *et al.*, 1978). A number of fungi causing rotting with an average incidence ranged from 2 to 15.3% of ber fruits have been identified from a regular survey of Chomu, Jaipur and Jobner areas of Rajasthan, wherein the ber cultivation is abundant. The most frequently occurring fungi were *A.alternata, Cladosporium oxysporum, Rhizoctonia solani, Fusarium solani, F.pallidoroseum, Pestalotiopsis palmarum, Phoma hisorensis, Rhizophus stolonifer, Colletotrichum* sp and *Aspergillus* sp (Jat *et al.*, 1997). The most frequently isolated pathogens were *A. flavus, A.niger, Emericella nidulans, A.alternata, Cladosporium oxysporum, Curvularia lunata* (*Cochliobolus lunatus*), *Fusarium sporotrichioides and Penicillium chrysogenum.* The relationship exists between preharvest fungal populations and postharvest fruit rot of *Z. mauritiana.* Among the mycoflora on the surface of jujube (*Ziziphus mauritiana*) fruits, *Aspergillus flavus* was consistently recorded during the entire period of fruit development.

Management

In order to avoid the fruit loss due to these fungal pathogens, ber fruits have to be harvested in right time without injuries on the fruits. Harvested fruits should be

marketed as quickly as possible. Since the ber fruits are directly consumed, it is not advisable to go for chemical treatments for the control above mentioned fungal infection. However, the physical and biological treatments can preserve the fruits somewhat free from the fungal species. Singh and Gupta (1983) evaluated four types of packaging and 2 cushioning materials for their effect on microbial decay during storage of Umran and Kaithli cultivars of ber (*Ziziphus mauritiana*) at room temperature. Gunny bags and wooden boxes were better at reducing spoilage than packing made of bamboo basket or cardboard. Paper cuttings were the best cushioning material for reduction of decay losses due to *Ulocladium chartarum, Phoma hissarensis* and *Botryodiplodia theobromae*. Lal *et al.* (1981) have recommended as fruit dips at 500ppm of Bavistin (carbendazim) and 1000 ppm of Difolatan (captafol) and performed best. Nallathambi *et al.*, (1999) reported that the post harvest infection of ber fruits can be minimized when the fruits treated with calcium nitrate are stored at low temperature (below 10°C). The symptoms of *Colletotrichum gloeosporioides* (*Glomerella cingulata*), *Botryodiplodia theobromae, Rhizopus stolonifer, Phomopsis nastume*, and *Pestalotiopsis palmarum* were described. In order to reduce the incidence of such diseases and improve fruit quality, the correct harvesting period is essential.

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Effect of processing, packaging and storage conditions on bacteria and yeast load of *anardana*

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Abstract

Anardana is mostly used as an acidulent for most of the Indian curries as it impart special taste, flavour and aroma. In traditional Indian system, the pulp-coated arils of pomegranate are dried in the open space and hence dust, dirt and microorganisms deposit over them. The improper packing in gunny bags results in moisture ingress and caking of product causing chemical and microbial colonization in *anardana*. Hence, in present experiment drying and dehydration of Bassein Seedless genotype of pomegranate under different conditions along with selection of suitable packaging material was done to reduce the microbial population and make the product hygienic. Steam blanching (with and without sulphuring) prior to drying, in a cabinet drier gave excellent quality of *anardana* with attractive red colour, firm texture, soft, free flowing with minimum microbial population. Microbial population was not detected in *anardana* exposed to blanching (with and without sulphuring) before drying in a cabinet drier and hence steam blanching before drying was recommended for preparation of *anardana*. From the storage studies, it was found that *anardana* dried under cabinet drier could be safely stored in aluminium pouches and plastic bottles (50% transparent) at low temperature for a period of six months.

Key Words : *anardana, pre-treatments, microbes, drying, packing and storage*

Introduction

The pomegranate (*Punica granatum* L.) has been grown since biblical times for its delicious fruit. It belongs to the family *Punicacea* and is one of the oldest known edible fruits. In India, it is grown as arid and semi-arid fruit crop because it can withstand different soil and climatic stresses. Fruit cracking at maturity stage is one of the major problems in pomegranate leading to huge economic loss. Seeds of these cracked fruits are traditionally utilized by drying to yield a value added by-products known as *anardana*.

Whole pomegranate seeds which are dried and sour are popularly known as *anardana* and used as an acidulant in Indian curries, chutneys etc. in place of tamarind and dried raw mango in North India (Singh and Singh 2003). It is also used in Ayurvedic and Unani system of medicine. The therapeutic properties are reportedly due to presence of betalic acid and usolic acid and different alkaloids i.e. pseudopelletierine, elletierine, isopelletierine and methyl pelletienine and sme other basic compounds (Anonymous, 1969).

In traditional system, the pulp-coated seeds are dried n the open sun and it takes 10 to 15 days for complete rying in addition to contamination and dust deposition. Moreover, the dry product is packed in gunny bags, results in moisture ingress and caking due to high humidity during rainy season. It also results in chemical and microbial degradation of *anardana* (Singh and Sethi, 2003). However much attempts were not made on proper processing of *anardana* and therefore, the present investigation was undertaken to study the effect of processing and storage conditions on microbial population of *anardana*. The selection of suitable packaging material was also undertaken.

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Materials and methods

Pomegranate fruits (variety Bassein seedless) were harvested at the optimum edible stage from horticulture farm of Indian Agriculture Research Institute, New Delhi and transported to laboratory in plastic crates. Pomegranate fruits were taken out at random and peeled, the seeds and remaining portion were stored separately. The entire seeds (aril) were divided into three lots as fresh seeds, steam blanching (5 min) and steam blanching (5 min) followed by sulphuring (5g /kg). These three lots were then divided into two sets. The lots were loaded with pre-standardized tray loads and kept in aluminium trays. One set was exposed to drying under open atmosphere i.e. sun drying and another lot was dried in a cabinet drier (60 ± 5° C). The cross flow cabinet drier (Kilburn make, Model 0248) was used for drying the lot. Airflow of drier was 1.2 - 1.8 m/s. After obtaining required and standard moisture percentage (8 %) in *anardana*, the product from all the six lots was subjected for microbial enumeration. Out of the six lots, the best-processed product viz. *anardana* was packed in different containers viz., P_1= Low density polyethylene (LDPE, 150 gauge), P_2= Polypropylene (PP, 100 gauge), P_3= Bio-oxy polypropylene (BOPP, 150 gauge), P_4= High Molecular Milky (HMM, 150 gauge), P_5 = Aluminum co-extruded pouches (ACEP, 150 gauge), P_6=Plastic bottles (100T, 100% transparent) and P_7= Plastic bottles (50 T, 50% transparent). The *anardana* packed in 7 types of packaging materials was stored for a period of 6 months at room temperature (23±1°C) and cold storage (5±1°C) seperately. At the end of storage period the product in different packing material and under different storage conditions was analyzed for microbial population.

Microbial enumeration

The samples were subjected to microbiological analysis initially and at the end of storage period i.e. 6 months after processing. The samples were analyzed for the population of bacteria and yeast by using Standard Plate count agar (Harrigan and Mc Cance, 1966) Martin Rose Bengal agar (Martin, 1950) and MGYP (Manitose Glucose Yeast Peptone) medium (CMI, 1968) respectively. Appropriate dilutions (10^{-1} and 10^{-2}) were plated on respective media and incubated at 30°C for 24 to 28 hrs. The results were expressed in terms of Colony forming units/gm of sample. First dilution (10^{-1}) was inoculated in BCP (Bromo Cresol Purple) lactose broth tubes and incubated at 37°C for 48 hrs. and observations were taken for acid and gas production. If tubes recorded positive for acid and gas then it was considered positive for presence of *E. coli*. BCP lactose broth media (Seelay and Denmark, 1970) was used for checking the presence of *E. Coli*.

Statistical analysis

The entire experiment was laid out in complete randomized block design with three replications. Data collected for the experiment for the preparation of *anardana* was subjected to statistical analysis by the analysis of variance technique as suggested by Panse and Sukhatme (1989). Whenever variance value (f value) was found significant, the critical difference value at 5% level of probability was compared for making the comparison among the different treatments.

Results

Drying Methods: Total viable cells (TVC) of microorganisms were enumerated for different pretreatments and drying methods (Table 1). Population of bacteria and yeasts were recorded in all samples in different proportion.

Bacteria: Bacterial population varied from 11.0 to 181.5 colony-forming units (cfu/g) in sun drying samples. Population was maximum in the sample dried under sunlight and minimum in the sun dried sample exposed to steam

Table 1. Bacteria and Yeast population in anardana under different drying conditions.

Drying Methods	Pre-treatment	Bacteria*	Yeasts*
Control		181.50	144.0
Sun drying	Steam blanching	33.50	81.5
	Steam blanching + sulphuring	11.00	20.5
Mean		75.33	82.0
Cabinet drying	Control	120.0	73.50
	Steam blanching	ND	ND
	Steam blanching + sulphuring	ND	ND
Mean		40.0	24.5
Drying methods (DM)	SEm ± CD	SEm ± CD	
	1.92 5.49	1.45 4.15	
Treatment (T)	3.33 9.52	2.51 7.18	
DM x T	4.71 13.46	3.55 10.16	

ND = Not detected, * = values are mean of three replications

blanching alongwith sulphuring. Significant differences in mean bacterial count were observed among sun dried ($7.53x10^2$ cfu/g) and cabinet dried samples ($4x10^2$ cfu/g) and it was not detected in the cabinet dried samples pretreated with steam blanching with and without sulphuring . In this case these pretreatments were the best to destroy all microbes. *Esturaetia coli* was not detected in any of the sample. No acid or gas was produced in any of the treatment, which indicates that the samples were free from *Coliforms*.

Yeasts: Yeasts population varied from $14.4x10^2$ cfu/g in sundried samples to $2.05x10^2$ cfu/g in sun-dried arils exposed to steam blanching alongwith sulphuring. Yeast population was not detected in cabinet dried samples exposed to steam blanching either with or without sulphuring. Mean yeast population ($8.2x10^2$ cfu/g) in sun-dried arils showed significant difference ($2.45x10^2$ cfu/g) from that of cabinet dried arils. The steam blanching and steam blanching alongwith sulphuring differed in comparison to untreated arils.

Storage Studies: Results presented in Table 2 represents the population of bacteria and yeasts influenced by packaging material under different storage conditions. The microbial quantity was assessed after 6 months of storage.

Bacteria: Bacterial population in stored *anardana* samples was maximum ($1x10^2$cfu/g) in package P_3 (BOPP) at ambient temperature (25-30°C) and minimum ($1x10^1$ cfu/g) in P_7 (PB 50% transparent) both at ambient and low temperature (0-7°C). Bacterial population was not detected in P_5 (AP) sample at low temperature. Among different packages P_5, P_6 and P_7 samples recorded a minimum population ($1x10^1$ cfu/g) whereas, P_3 recorded maximum population ($1x10^2$ cfu/g) showing significant difference. At ambient temperature bacterial population ($5.42x10^1$ cfu/g) differed significantly when compared to samples stored at low temperature ($2.42x10^1$ cfu/g) indicating low temperature is useful for preservation of *anardana*. *E.coli* was absent in all the packaging materials and samples stored at ambient temperature and low temperature up to 6 months.

Yeasts: In stored *anardana* samples, yeasts population was quiet low in comparison to population of bacteria. It ranged from $5x10^1$cfu/g in P_1 package at ambient temperature in comparison to $1x10^1$ cfu/g in package P_6 stored at ambient temperature and in packages, P_2, P_4, P_6 stored at low temperature. Yeasts were not detected in P_5 and P_7 packages both at ambient and low temperatures. Amongst various packaging materials, P_5 and P_7 packages were considered best, as yeasts could not colonize in *anardana* packed. Out of different storage temperatures, low temperature ($1x10^1$ cfu/g) was best in comparison to ambient temperature ($2.14x10^1$ cfu/g) for the mean values indicating safe for storage of *anardana*.

Discussion

Microbes counts i.e. the total viable count of bacteria, and yeast were minimum for the treated samples (both sulphured and unsulphured) dried under controlled conditions that is, in a cabinet drier. Further samples pre-treated with sulphur di-oxide proved more useful as SO_2 combines with free moisture to form sulphorus acid, which is very effective against mould, yeast and bacteria (Mc bean *et al.*, 1971; Tandan *et al.*; 1983 and Dziezak, 1986).

Cabinet drying proved to be the best for eliminating microflora from *anardana* as drying occurs under controlled conditions of temperature and relative humidity (Singh and Sethi, 2003). The total count were less due to

Table 2. Population of bacteria and yeasts as influenced by packaging material under different storage conditions

Packaging Material	Bacteria (cfu/g) RT	LT	Mean	Yeasts (cfu/g) RT	LT	Mean
P_1	70	40	55	50	20	35
P_2	80	20	50	30	10	20
P_3	130	70	100	20	20	20
P_4	60	20	40	40	10	25
P_5	20	ND	10	ND	ND	ND
P_6	10	10	10	10	10	10
P_7	10	10	10	ND	ND	ND
Mean	54.28	24.28	21.42	10.00		
		SEm ±	CD	SEm ±	CD	
Packaging material (P)		0.81	2.31	0.44	1.26	
Storage temperature (T)		1.51	4.31	0.83	2.37	
P x T		2.13	6.09	1.17	3.35	

ND = Not detected
RT = Room temperature
LT = Low temperature

P_1 = Low density polyethylene
P_2 = Polypropelene
P_3 = Bio-opeque polypropelene
P_5 = Aluminium pouches
P_6 = Plastic bottles (100% transparent)
P_7 = Plastic bottles (50% transparent)

lowering of available water, as reported by Frazier (1967) who indicated that at 0.93 aw bacterial spores can not germinate while the common species of yeasts and moulds are suppressed at aw of 0.85 and 0.80 respectively. Microbial counts were minimum for all the samples (dried in cabinet drier) as compared to sundried samples as the samples are dried by artificially produced heat under controlled conditions for temperature, humidity and airflow. Drying in a cross flow dehydrator yielded better quality *anardana* (Singh and Sethi, 2003), apple rings (Sharma *et al.*, 1996) and guava, papaya and apple cheeses (Rai, 2001) than open sun drying .

Microbial population after six month of storage was more in samples stored at ambient temperature in comparison to the samples stored at low temperature. Plastic bottles proved to be the best for storage both at ambient temperature and low temperature. The results are in accordance with the findings of Pruthi and Saxena (1984) who indicated that 200 gauge polythene bags were best for storage of *anardana* in comparison to tin cans and glass bottles as moisture retention was minimum in polythene bags giving minimum chances for microbes to survive.

The results are also in close proximity with our observations recorded that as in dried guava pulp (Kalra and Rewati, 1981) stored guava pulp (Tandan et. al. 1983) osmo-vac dehydrated apple rings (Sharma, 1996) dehydrated papaya slices (Ahmed and Chaudhary, 1998) and *anardana* (Singh and Sethi, 2003). All these works had concluded that microbial count was minimum at low temperature irrespective of packaging material during storage.

This study concluded that quality of *anardana* can be improved by pre-treatments i.e. steam blanching and sulphuring. Drying under controlled conditions as well as packaging in aluminium pouches and semi-transparent bottles provide additional advantage in maintaining the quality of *anardana* for prolonged period up to six months. However, this technique can be adopted for large-scale process at industry and farmers level after further refinement if, required.

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Management of aonla rust (*Ravenelia emblicae*) using fungicides and biocontrol agents

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Abstract

Studies were conducted to select the effective fungicides and biocontrol agents for the management of Aonla rust. Two spraying of fungicides and biocontrol agents were given at 20 days interval. The results showed that the disease intensity was 18.6% in mancozeb treatment as against 52.4% in the control. This was followed by chlorothalonil (0.2%) and copper oxychloride (0.4%) which recorded 21.4% and 24.3% disease intensity respectively. The second year confirmation trial showed that PDI was low in treatment Chlorothalonil (13.6) followed by Copper oxychloride (17.3), Mancozeb (19.6). In case of bioagents, *T. viride* recorded PDI of 34.7, *Pseudomonas flourescens* (27.7) as compared to untreated plants recording PDI of 41.7.

Key words : *biocontrol agents, fungicides, PDI, aonla*

Introduction

Aonla is an important economic fruit tree which come up very well in vertisols even under rainfed conditions. Rust incited by *Ravenelia emblicae* Syd. is a serious and economically important disease in aonla not only in Tamil Nadu but also in other states like Uttar Paradesh and Rajasthan. It was first observed in Rajasthan by Tyagi (1967). Subsequently, it has been observed in Rehmankhera farm, Lucknow (UP) and Rajgarh area of Pratapgarh by Misra, (1988). In India, Rawal (1993) has observed that this causes considerable loss in major aonla growing tracts of Uttar Paradesh. The leaflets show conspicuous rust pustules. On the fruits, blackspots appear which sometimes cover the entire surface of the fruits. Affected fruits may drop before maturity. Plants with a severe attack on fruits show no symptoms on the leaves and vice-versa (Tyagi, 1967). Sometimes, ring rust appears as circular or semi-circular, reddish solitary or gregarious spots on leaves from the beginning of January month. (Chundawat, 1990). Therefore, there is severe loss in foliage as well as in fruits, which are rusted. Owing to expansion of aonla orchards, working out of management strategies is also equally important to sustain the yield and quality of aonla fruits and hence the present study was conducted with an objective to screen out suitable fungicides and biocontrol agents for the management of aonla rust.

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Materials and methods

The study was conducted for a period of two years at Regional Research Station (RRS), Aruppukottai of Tamil Nadu Agricultural University. Aonla trees available in the horticultural crops block at RRS, APK were frequently examined for rust disease initiation. Field experiment was conducted during 2000-2002 for the management of Aonla rust using fungicides, plant extracts and biocontrol agents (T_1- Mancozeb(0.3%), T_2- Topsin M (0.1%), T_3-Copper oxychloride (0.4%), T_4-Chlorothalonil (0.2%), T_5-Triademefon (0.1%), T_6-Triademorph (0.1%), T_7-Sulphur (0.3%), T_8-*Prosopis julifera* (10%), T-$_9$, *Trichoderma viride* (5g/l) and T_{10}-*Pseudomonas flourescens* (10g/l). Two trees per replication were maintained for each treatment. From each tree, 15 leaves from top, middle and bottom were selected for recording the observations on disease intensity. Modified cobb's scale (1-7grade) was used to record the disease intensity. Two rounds of spraying, one at the initiation of disease and another 20 days after first spraying were given. The disease intensity was recorded 20 days after the last spray. The second year field experiment was conducted during 2002-2003 to confirm the efficacy of treatments. Per cent disease index (PDI) was worked out following 0-7 scale (Pathak, 1984).

Results and discussion

The commercially cultivated cultivars of aonla are susceptible while cvs Kanchan, NA-6 and NA-10 showed moderately susceptible under Jobner of Rajasthan conditions. Rust disease in this crops could be effectively managed when the integrated approaches are followed. Proper sanitation and clean cultivation of aonla are the basic requirements to avoid this disease. However, fungicides play important role for the better management of rust. In present investigation, field valuation of some of the common fungicides and bioagents showed differential response. Results presented in Table I reveal that spraying two times with mancozeb (0.3%) was highly effective in reducing the rust disease intensity. The disease intensity was only 18.6% in this treatment as against 52.4% in unsprayed control. This was followed by chlorothalonil (0.2%) and copper oxychloride (0.4%), which were also recorded 21.4% and 24.3% disease intensity respectively. The use of biocontrol agent viz., *T. viride* at the rate of 5g/l (41.4) and the plant extract viz., *P. julifer* (40.5) at the rate of 10% were effective in reducing the disease. The disease

Table 1. Comparative efficacy of management of aonla rust

Treatment	Mean PDI	
	2001-02	2002-03
Mancozeb (0.3%)	18.6	19.6
Topsin M (0.1%)	26.6	22.5
Copper oxychloride (0.4%)	24.3	17.3
Chlorothalonil (0.2%)	21.1	13.6
Triademefon (0.1%)	31.9	20.6
Trademorph (0.1%)	30.9	25.6
Sulphur (03%)	33.8	26.2
Prosopis julifera (10%)	40.5	36.6
Trichoderma viride (5g/l)	41.4	34.7
Pseudomonas flourescens (10g/l)	33.3	27.7
Control	52.4	41.7
CD (P=0.05%)	2.1	5.1

intensity in this treatment was 41.4 and 40.5% respectively. In the second year experiment (2002-2003) using the same treatments showed that PDI was low in treatment Chlorothalonil (13.6) followed by Copper oxychloride (17.3), Mancozeb (19.6). In case of *T. viride* (34.7), *Pseudomonas flourescens* (27.7) and untreated plot showed (41.7) in table1. Similar results was obtained in Jobner, chlorothalonil (Kavach 75wp) (0.1%) and Triademefon (Bayleton 25 wp) at (0.05%) 10 days interval reduced the Aonla rust in Jaipur on the basis of Cost:Benefit ratio, spraying of chlorothalonil (0.2%) at 15 days interval was found most effective control for aonla rust followed by six sprays of chlorothalonil (0.2%) at 10 days interval. (Jat, 1999).

However, Tyagi and Pathak, (1988) showed that monthly sprays of wettable sulphur (0.5%) or zineb (0.2%) during July-September can be advocated to check further spread of this disease. Subsequently, the most promising results for the control of *R.emblica* var.*pinnulae* and *R.emblicae* var.*fructicolae* on *E.officinalis* (*Phyllanthus emblica*) were given by elosal (sulfur) dust and ultra sulfur. Research works carried out under the AICRP on arid zone fruits revealed that out of nine cultivars of aonla screened under Faizabad (UP) conditions, cultivar NA-6 was found to be resistant. In general, no genotype was found immune against rust. (Anonymous, 2002). In southern India, some of the aonla cultivars showed moderate susceptibility to this disease. However, they are not commercially important so far (Anonymous, 1989). Therefore, such wild species conferring resistance can be explored for the development of rust resistant genotypes through breeding programme in addition to the usage of mancozeb (0.3%) or chlorothalonil (0.2%) as evidenced from present study.

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Role of information and communication technologies for improving input efficiency of horticultural crop production

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Abstract

Indian farming community is passing through a phase of reducing incomes, uncertain and unpredictable markets and weather conditions. They need advance information and intelligence on agricultural commodities and their supply/demand position in the local as well as global markets. They also need advises on the impending climate/weather parameters so as to regulate their choice of crops and farm management and operations. They have to be enabled to face the global competition. For that Information and communication Technologies (ICT) are very use full.

The use of ICT in agriculture in general and rural livelihood security in particular remains restricted in India. Effective utilization of ICT has the potential to make the rural communities in India prosperous. Failure to exploit the benefits of ICT would make them isolated, victims of the vicious cycle of poverty and widen the gap between rich and poor people, thereby affecting social equality and livelihood security. The use of ICT should not be restricted to simply establishing information flow channels, rather we should find a way to integrate it with the various livelihood needs (natural, social, human, physical and financial) of the rural community. The narrow ICT coverage is found to be financially non-viable. Further, no single agency can effectively deliver this critical input. Besides the public sector, the need for a proactive participation by the private sector, NGOs and other civil society organisations is being increasingly felt. For ICT initiatives to be successful and sustainable in the long run, collaborative efforts are indispensable. This digital development in rural areas of India facilitates rural prosperity, rural empowerment, and a warehousing of data for development, increasing input efficiency and productivity, reducing cost of service delivery etc. a step towards digital inclusions to foster rural enterprise in India.

Kew words : *ICT, horticulture, GPS, GIS and precision farming*

Introduction

With the grand success of green revolution in India, agriculture has evolved from subsistence farming into a complex and profit oriented business,which requires accumulation and integration of knowledge and information from diverse sources. An increasing population coupled with mining of natural resources requires application of new technologies to maintain a sustainable food and water supply without environmental degradation. Horticultural crop production is input intensive enterprise. Presently the costs of the planting material/seeds, nutrients, pesticides, water, power and labor are increasing enormously, where as increase in crop productivity is at low pace. Farmers are more concerned about the choice of crops that are appropriate for the changing environmental conditions and more conscious about location-specific crop management so that the input costs are minimal and less risk prone.

It is essential to optimize the various inputs under different edapho-climatic and cropping system. Information and communication technologies (ICT) particularly the Internet, are transforming all human activities dependent on information, including rural development and food security. ICTs play a crucial role in improving the efficiency of inputs as water, nutrient and pesticide use, Ananda Sagar and Vijayanand (2003). Modern tools such as Remote sensing and Geographic Information System (GIS) are helpful to estimate area and production under horticulture and other related crops. Other models such as decision support system, Bio-Informatics, Precision Agriculture, Rural net working etc can be achieved by aligning Information Technology with agriculture. Combining the satellite technology with the tools of ICT farmers in a remote village can demand and get the following information's:

- Land use planning for Horticulture crops for farmers

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fields based on integrated information on soil, water, weather, fertilizer and pest management models.

- How and where to get seeds or good quality nursery plants of horticultural crops
- Interactive exchange of information for planning and day-to day operations by farmers.
- E-procurement

In addition to this farmers can access the information on prevailing prices of farm equipments, agricultural produce, products and series of such set of information, which can lead to high productivity and optimum cost benefit to the farmers.

Information is crucial

The Horticultural sector is facing the challenges of sinking land resources, increasing biotic and abiotic stresses, indications of factor productivity decline, threatened loss of bio-diversity, natural resource shrinkage and degradation, climate change, new IPR regime, intensifying competition (costs and quality) in international trade, widening economic inequality etc., Adiguru and Mruthyunaja (2005). Further, Indian agriculture has come under significant adjustment pressure from market liberalization and globalization.

Recent evidence shows that farmers, including small landholders are gradually shifting their production portfolios in favour of high-value commodities, and are willing to take high risks. But they are confronted with a host of constraints like high transaction costs in acquiring resources, marketing of tiny marketable surplus and inadequate information (Joshi et al. 2003; Ballabh and Sharma, 1989, and Hiremath and Ballabh, 1996). Farmers need reliable and timely information about best practices of production, processing, marketing, input and output prices, financial markets and risk-covering institutions. It is comprehensible that on the one hand Horticulture is becoming highly science driven and knowledge intensive, but on the other hand the existing public extension system, has become outdated and ineffective in spite of the fact that it has been a catalyst in successfully heralding the Green Revolution in the country. This is partly due to an inadequate use of new means of information dissemination and also due to inadequate natural resources, Adhiguru, Mruthyunjaya and Birthal (2003).The public extension system follows a top-down approach and has become less interactive, more time-consuming and costly and fails to meet the expectations of those involved in the agricultural production and other involved in the value chain. Therefore, a new extension system re-oriented to meet the information needs of the farmers should be put in place across the country by using ICT, Adhiguru and Mruthyunjaya (2004).

Some of the main areas where the information technology can work in collaboration with horticulture to increase input efficiency are discussed.

Expert System in Agriculture

An "Expert system" is an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution. These software programs typically suited to the category of decision support tools (Malobika Ghatak, 2002). Decision support programs imitate an expert by involving a client in a problem-solving situation, often providing a recommendation in response to a client's request for help in making a decision. Expert systems help farmers run their business more economically.

Remote sensing

Remote sensing has shown potential for use in horticultural crop management. New companies that provide aircraft-based imagery to meet the resolution and temporal requirements for agricultural management are now emerging in a big way. The promise of commercially available, high-resolution satellite imagery will also provide additional sources of remotely sensed data. Remote sensing imagery can be obtained either through satellite-based sensors. Remote systems vary in spatial resolution, spectral coverage and temporal frequency. The selection of remote systems is dependent on agricultural applications, which are different for different applications. Remote sensing is required to provide with characteristics of low turn around time, low data cost, high spatial temporal and spectral resolutions and delivery of analytical products in simpler formation.

Bioinformatics

Informatics is a very essential component in the biotechnology revolution. Bioinformatics has emerged out of the inputs from several different areas such as biology, biochemistry, biophysics, molecular biology, biostatistics, and computer science. Specially designed algorithms and organized databases is the core of all informatics operations. The requirements for such an activity make heavy and high level demands on both the hardware and software capabilities.

Precision Farming in Horticulture

India has a variety of climates and soils on which nearly 48 fruits and plantation crops, 50 vegetable crops including potato and tuber crops:20 spices ,10 ornamental,70 medicinal and aromatic plants are being grown commercially.

Diversification to horticulture is best option. These crops are adapted to wide range of climates produce higher biomass than field crops per unit area. They have potential for improvement of wasteland through planned strategies. Horticultural crops contribute 28.65% to GDP from merely 8.5% of area and have a high potential for value addition and foreign exchange earnings (Chadha, 2005).

Time bound removal of quantitative curbs on import and other barriers to access to domestic markets under WTO of which India is a signatory, will require Indian horticultural product to be competitive both in domestic and export market. For that Hi-tech and precision Farming technologies are required. Hi-Tech Horticulture as defined are those, which are modern, less-environment dependent, capital intensive and have the capacity to improve the productivity and quality through the use of genetically modified crop varieties, micropropogation, integrated nutrient and water management, integrated pest management, organic farming and hi-tech post-harvest technologies including cold chain

Precision Farming (PF) is one of the most scientific and modern approaches to sustainable Horticulture which has gained popularity in the 21st Century. Precision Farming is defined as the application of the technologies and principles to manage spatial and temporal variability associated with all aspects of agriculture production. Precision Agriculture, which focuses on the positioning of agricultural tools with high degree of accuracy and sophistication for maximizing returns.

It is a comprehensive approach to farm management designed to optimize agriculture production through the use of information technology to bring data from multiple sources to bear decision associated with agriculture production marketing, finance and personnel while taking care of the environment issues. Precision farming has also been termed as Precision Agriculture (PA), Variable Rate Technology (VRT), spatially variable farming (SVF), Global Positioning Systems(GPS) based agriculture, Site Specific Farming (SSF) etc.

Aspects of Precision Farming

In precision Farming the field is broken into "management Zones" also called "grids" based on Soil pH, nutritional status, pest infestation, yield rates and other factors that affect crop production. Management decisions are based on requirements of each zone and PF tools such as Geographical Information System(GIS),GPS etc., Which are used to control inputs.

In contrast, traditional farming methods have used a "whole field" approach where the filed is treated as homogeneous area. Decisions are based on field averages and inputs are applied uniformly across a field.In reality most of the fields are not uniform and there exit a within-field variation in soil characteristics, topography, drainage, microclimate etc, (Shylla; Handa and Sharma, 2004). As such sampling in the traditional system where representative samples of the entire field is used for testing and further recommendations for fertilizer applications are made based on these generalized data may not prove to be very effective, leading to yields below field capacity. But with grid sampling method under precision farming system, it is possible to identify the fertilizer /pesticide requirement of a particular grid and as such necessary applications as per requirements can be made thus reducing the amount of fertilizer/pesticide etc., which may have an impact on the environment leading to ecological degradation.

Precision Agriculture System

Precision farming is combination of several technologies. It involves integration of information technologies with agronomic knowledge hence this is called technology enabled information based and decision focused (Chadha, 2005).

The components to consider in the development of a Precision Agriculture system are discussed.

Computers and Network

Computer has been used in agriculture to organize and manage data more effectively. It helps in acquisition, management, analysis and output of large amounts of spatial and temporal variability information's. Advent of the networking of computers brings together the information provider and ultimate user.

Global positioning Systems (GPS)

The satellite positioning through Global Positioning System (GPS) is a burgeoning technology, which provides unequalled accuracy, and flexibility of positioning for navigation, surveying and GIS data capture. It has tremendous amount of application in GIS data collection, surveying and mapping. It uses satellite and computers to compute positions anywhere on earth. As a result, numerous observations and measurements can be taken at specific position and GIS can be used to create field maps based on GPS data to record and assesses the impact of farm management decisions.

The technology is a set of 24 satellites in high attitude orbit above the earth developed for pinpointing objects on the surface of the earth. The satellites continuously transmit radio signals that are picked up and deciphered by special receivers. A GPS receiver requires at least four satellites to determine its position on earth. However the GPS signal is not sufficiency accurate to determine position and is needed to provide the necessary accuracy, which can come from a land-based reference signal or another satellite. GPS are used in agriculture for yield mapping and variable rate applications. It has capability of providing location accuracy of less than 1m distance. GPS enables field operation in night hours also.

Sensors

Sensors are devices that transmit an impulse in response to physical stimulus such as heat, light, magnetism, motion, pressure and sound. They have been developed to measure and monitor soil properties, crop

stress, growth conditions, yields, influent ions factors that effecting yield, atmospheric properties, water etc in horticultural crops. These are also used to monitor Pest and disease dispersal along with crop growth indicators such as water stress using aerial or satellite photography in conjunction with crop scouting. They provide the precision farmer with instant information that can be used to adjust or control operational inputs. They can be used to measure soil and crop properties as the tractor passes over the field, as scout goes over the field on foot or as an airplane or satellite photographs the field from the sky.

Remote Sensing (RS)

Remote sensing is the science and art of acquiring information (spectral, spatial, temporal) about material objects, areas, or phenomena through the analysis of data acquired by a device from measurements made at a distance without coming into contact with the objects area, or phenomena under investigation. Initially the data are collected by manually sampling the field along regular grid and by interpolating the analyzed results using geo-statistical techniques, but this is time consuming and expensive. The solution to this lies in the use of remote sensing technology to obtain spatial and temporal variable information almost instantly.

Geographic Information System (GIS)

Geographic Information System (GIS) is defined as an information system that is used to input, store, retrieve, manipulate, analyze and output geographically referenced data or geospatial data, in order to support decision making for planning and management of land use, natural resources, environment, transportation, urban facilities, and other administrative records in horticultural crops.

The key components of GIS are a computer system, geospatial data and users, A computer system for GIS consists of hardware, software and procedures designed to support the data capture, processing, analysis, modeling and display of geospatial data. The sources of geospatial data are digitized maps, aerial photographs, satellite images, statistical tables and other related documents.

GIS for Decision Support

GIS can be a very important tool in decision making for sustainable development in horticulture, because GIS can provide decision makers with useful information by means of analysis and assessment of spatial database. Decision support combine traditional management skills with PF tools to help precision farmers make the best management choices for their crop production system. GIS are used in precision farming as database functions for farm record keeping and for comparing management decisions for yield estimate, pest activity, water quality and other concerns related to past and current agricultural practices. GIS can be used for linking and integrating data of soil, crop etc. with simulation or spatially distributed process models as the basis for subsequent decisions.

Steps in Precision Farming

Management of Variability

The basic steps in precision farming are assessing and managing variation and then evaluation. The available technologies enable in understanding the variability and site specific agronomic recommendations can manage the variability that make precision farming viable (Nawab Ali and Chadha, 2005). And finally evaluation must be integral part of precision farming system. Assessing variability is the critical step in precision farming.

Geo-referencing

The relationship among data based on their geographic locations is referred as georeferencing. Georeferencing gives farmers the option to map and visually display farm operations in horticulture. This gives insights into both production variability as well as inefficiencies in crop production and farm operations.

Crop, Soil and Climate Monitoring

These variables are measured using sensors. The output given by sensors is being utilized for crop production. Such sensors include Yield sensors, biomass and crop response sensors, and radio-networked weather stations.

Attribute Mapping

The data generated by crop, soil and climate sensors are often large and intensive. It needs to be managed, cleaned and interpolated in a database to permit analysis. The precision farming technology involved in generation of data sets for the use and variable rate applications. That makes new challenges for mapping. The use of GIS made tremendous improvement in mapping and displaying of data.

Decision Support System (DSS)

Decision support system use agronomic and environmental data combined with information in possible management techniques, to determine optimum management strategy for production. Some of the DSS have been developed such as WHEATMAN,COTTONLOGIC or APSIM to site-specific situations. There is need to develop a DSS that is able to site-specifically model plant environment interaction in terms of yield quality of crop by incorporating sensor gathered data.

Application Areas of Precision Farming

Precision farming is useful in Rice, wheat sugar beet, onion, potato and cotton among field crops and apple, grape, tea, coffee and oil palm among horticultural crops.

Nutrient Management

Precision farming can help Indian farmers in Nutrient management. Most cultivated soils in India are acidic and spatial variation in pH is high. Detecting nutrient stress using remote sensing and combining data in GIS can help in site-specific application of fertilizers and soil amendments such as lime, manure, compost, gypsum and sulphur (Singh, 2005). This in turn would increase fertilizer-use efficiency and reduce nutrient losses. In semi-arid and arid tropics, precision technologies can help growers in scheduling irrigation more profitably by varying the timing, amounts and placement of water.

Pest and Disease Management

Pest and diseases cause huge losses to Indian crops. Remote Sensing can help in detecting small problem areas caused by pathogens, timing of applications of fungicides. Recent studies in Japan show that pre-visual crop stress or incipient crop damage can be detected using radio-controlled aircraft and near infrared narrow-band sensors. Likewise air-borne video data and GIS have been shown to effectively detect and map black fly infestations in citrus orchards, making it possible to achieve in pest control.

Strategy and Action plan for Precision Farming

India is only beginning now to embark up to this potentially powerful technology. We need to move forward holistically in terms of capacity building human resource development and R & D programmes with participation of all relevant disciplines before approaching the farmers for adoption of this technology. The pilot demonstration projects need to be implemented at various growers' locations by involving farmers at all stages of the project (Wiebold; Sudduth; Davis; Shannon and Kitchen, 1998). The pilot projects must attempt to answer the growers needs and emphasize the operational implementation of technology and complete analysis of costs and savings involved. Documentation of pilot projects would help in examining the operational weaknesses and identification of remedial measures. The projects can be used to train innovative farmers and early adopters.

The action plan for implementing precision farming in Indian agriculture could be in phases. The short-term plan may be the development of sensors and processes for precision farming related parameters for fixed and variable rate precision applicators for seeds, fertilizers, water and chemicals. The medium-term plan may include development of databases, expert systems and decision support systems for their use in precision farming applications. The long-term plan, then could include application of precision farming technologies on minimum manageable zone made for selected cropping systems, involving GIS,GPS and RS systems.

Suggested strategies for effective utilisation of ICT

Multi-pronged strategy in deploying ICT is required if it is to make a real dent in the upliftment of the poor. Some points are enumerated below.

1.Content development: Generic and indigenous knowledge, success stories in local language to meet local needs. 2.Unified dissemination: Research and development institutes to develop synergy in content development and delivery (e.g. interlinking of websites). 3.Capacity development programmes: Regional/intermediary institutions may identify emerging training needs and impart training for various stakeholders. 4.Every village a knowledge centre: Improve connectivity by using wireless. low-cost technologies, low-power alternatives. 5. Enable intermediary organisations: Better e-linkage among rural institutions, extension agents, local NGOs, and producer associations to improve their delivery efficiency. 6.Emphasis on gender equity: Providing women-oriented content, easy access, capacity building, and involvement in indigenous knowledge acquisition and management. 7.Strengthen monitoring and feedback: Deploy ICT in community knowledge gathering and eliciting people's feedback for research/development projects and democratic governance. 8. Low-cost training institutes: Schools and panchayat offices can impart ICT trainings. Students can be effective 'no cost trainers'. 9.Location specific knowledge bank: Document the most common sets of questions, and create a library of responses, as well as provide a mechanism to identify key issues that smallholders-friendly agricultural research agenda should address.

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Short communication

Survey and collection of aonla germplasm from eastern Uttar Pradesh

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Aonla (*Emblica officinalis* Gaertn) a member of family Euphorbiaceae is being cultivated in India since *Vedic* era. As a result of intensive research and developmental efforts aonla has attained a commercial status and proved to be a potential fruit crop for arid ecosystem. The fruit is recognized mainly for its nutritive, medicinal and high therapeutic properties (Shukla *et al.*, 2002). The fruit is a rich source of vitamin-C and mainly grown in North India particularly Uttar Pradesh, Madhya Pradesh, Bihar, Rajasthan and Gujarat.

Exploration was conducted during November 2004 to identify elite aonla genotypes of aonla from Vindhyan hills and part of eastern UP. During survey seven genotypes were identified i.e. three from Vindhyan hills, one from Allahabad, three from Pratapgarh. While identifying the elite plant, twenty fully ripe fruits were randomly collected from different directions of the plant and subsequently fruits were analysed for physico-chemical characteristics. Total Soluble Solid (TSS) was determined by using Hand Refractometer. The fruit and stone size was measured with the help of Vernier Callipers. Canopy spread was measured with the help of meter tape where as size of determinate shoot was measured with scale. The locations of identified plants were earmarked for collection of bud wood material. Further, the bud wood of identified genotypes was collected during August 2005, which was subjected to *in-situ* budding in field repository of aonla at CIAH, Bikaner.

Table-1 Physico-morphological observations of identified elite genotypes in aonla surveyed in Eastern UP

Genotype	Plant height (m)	Canopy spread (m)		Size of determinate shoot (cm)	No of fruit per shoot	Age of plant (Years)	No. of segments/ fruit	Time of flowering	Time of harvesting	Colour of fruit
		EW	NS							
AKS/CIAH/EO27	4.0	3.0	3.5	4.5	9	12	7	Feb-March	Dec-Jan	Reddish green
AKS/CIAH/EO28	5.5	3.5	3.0	5.7	6	9	8	February	Dec-Jan	Reddish green
AKS/CIAH/EO29	3.5	2.5	3.0	4.8	7	11	7	February	Nov. Dec	Red
AKS/CIAH/EO30	9.0	4.5	5.0	7.5	6	30	8	March-April	Nov-Dec	Green
AKS/CIAH/EO31	5.5	3.2	3.5	10.8	5	8	6	Feb-March	Oct-Dec	Greenish yellow
AKS/CIAH/EO32	4.8	4.0	3.2	11.4	7	7	7	Feb-March	Oct-Nov	Yellow
AKS/CIAH/EO33	5.0	3.4	3.6	9.8	6	9	6	Feb-March	Nov-Dec	Yellowish green
Range	3.5	2.5	3.0	4.5	5.0	8.0	6.0	–	–	–
	-9.0	-4.5	-5.0	-11.4	-9.0	-12	-8.0	–	–	–

Genetic variability is the most important basis for diverse economic use of aonla fruit. Variability in aonla is found in seedling population for vegetative growth, fruit characters, yield and quality attributes due to outcrossing behaviour, Dhandar and Shukla (2003). The seedling aonla plants commonly observed in Vindhyan hills bears heavily however, fruit size is comparatively smaller. The present survey was aimed to identify elite type genotypes among the existing variability from eastern UP and to collect bud wood of identified genotypes for further research and evaluation under arid agro ecosystem of Rajasthan.

As a result of survey of eastern part of Uttar Pradesh, seven genotypes were identified i.e. three from Vindhyan hills (AKS/CIAH/EO-27, 28 and 29) one from Allahabad (AKS/CIAH/EO-30) and three from Pratapgarh (AKS/CIAH/EO-31, 32, 33). Based on observation it was noted that AKS/CIAH/EO-28 and 29 were red coloured, profuse and cluster bearing with small-fruited type. There was wide

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range of variability with regards to physico-chemical properties of fruit samples collected during identification of aonla genotypes. Variability with respect to various physical parameter exhibited marked variation with respect to plant height, size of determinate shoot and No. of fruit per shoot (Table 1). The maximum plant height 9.0m was observed with AKS/CIAH/EO-30 where as the dwarfing height i.e. 3.5m was recorded with AKS/CIAH/EO-29 with canopy spread of 2.5m (E-W) and 2.3m (N-S). This difference is highly correlated with important character of fruit weight and size (Table 2).

Size of determinate shoot, which is an important character of aonla is basically responsible for bearing of flowers and fruit. A remarkable difference was also observed for this character in different genotypes. The maximum length (11.4cm) of determinate shoot was found in AKS/CIAH EO32 where as the shortest size (4.5cm) recorded with AKS/CIAH EO27 genotype. The maximum number (9) of fruit per shoot was with AKS/CIAH EO27 as compared to minimum number (5) of fruits with AKS/CIAH EO31. The colour of fruit differed with respect to genotypes and an excellent red coloured fruit were observed with AKS/CIAH EO29. Thus this genotype revealed two distinguishing characteristics of dwarfing nature and red colour of fruit that may be considered elite genotype in crop improvement programmes.

A marked variability in aonla with respect to fruit characters was also recorded under investigation. Maximum fruit weight (44.78g) was recorded in genotype AKS/CIAH EO32 where as the same was recorded to be minimum (3.27g) in AKS/CIAH EO29 Singh *et al.* (1994) have also recorded variation in fruit characters of aonla genotypes. The fruit size in terms of length and width was measured and variable sizes of fruits from 1.52 to 3.88 cm long and 1.84 to 4.62 cm wide was recorded in different genotypes (Table 2). The stone weight and size also varied with respect to different genotypes from 0.53g to 1.93g stone weight and length of stone measured from 1.12cm to 1.74cm and width 1.10 to 1.54cm. These measurements clearly indicate the variability of fruit quality in terms of pulp/stone ratio indirectly. Total soluble solids (TSS) which generally determine the quality of fruits for nutritive and shelf life of produce also differed with respect to genotypes and maximum TSS (25%) was recorded in AKS/CIAH EO27 followed by AKS/CIAH EO29 (23%) as compared to minimum with AKS/CIAH EO31 (13%).

The final economic part of the fruit is the pulp quantity and this character was measured in different genotypes and a high pulp weight (42.95g) with AKS/CIAH EO32 where as minimum pulp weight (5.10g) with AKS/CIAH EO27 was recorded. The per centage of pulp content was found highest (95.91) with AKS/CIAH EO32 as compared to minimum (84.01%) with AKS/CIAH EO27. The per centage of stone content was measured and the minimum (4.09%) was observed with AKS/CIAH EO32 as compared to maximum (16.21%) with AKS/CIAH EO29. It is evident from the data given in table-1 and 2 that genotype AKS/CIAH EO32 seems to be superior with respect to several physical and quality parameters for crop improvement programmes.

Table 2. Variability in elite genotypes of aonla with respect to fruit characters surveyed in Eastern UP

Genotype	Fruit weight (g)	Fruit size (cm) L	W	Stone weight (g)	Stone size (cm) L	W	TSS (%)	Pulp weight (g)	stone content (%)	Pulp content (%)	Acidity (%)
AKS/CIAH/EO27	6.07	2.10	2.20	0.97	1.40	1.22	25	5.10	15.98	84.01	2.3
AKS/CIAH/EO28	10.68	2.38	2.78	1.05	1.44	1.30	20	9.63	9.84	90.16	1.7
AKS/CIAH/EO29	3.27	1.52	1.84	0.53	1.12	1.10	23	2.74	16.21	83.79	2.6
AKS/CIAH/EO30	12.43	2.54	2.94	0.66	1.16	1.10	18	11.77	5.31	94.69	2.0
AKS/CIAH/EO31	26.61	3.12	3.82	1.26	1.48	1.30	13	25.35	4.74	95.26	1.4
AKS/CIAH/EO32	44.78	3.88	4.62	1.83	1.60	1.46	15	42.95	4.09	95.91	2.2
AKS/CIAH/EO33	37.60	3.58	4.28	1.93	1.74	1.54	15	35.67	5.14	94.86	1.8
Range	3.27	1.5	1.84	0.53	1.12	1.10	13	2.74	4.09	83.79	1.4
	-44.7	-3.88	-4.62	-1.93	-1.74	-1.54	-25	-42.95	16.21	-95.91	-2.6

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Short communication

An evaluation ber based farming system in hot arid eco-system of western Rajasthan

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The arid regions cover about 12% area of the total geographical area of the country. The hot arid regions spread over the states of Rajasthan, Gujarat, Andhra Pradesh, Punjab, Haryana, Karnataka and Maharashtra which are characterized by hostile agro-climate and fragile eco-system (Anon., 1998-99). Despite the various bio-physical constraints, the hot arid areas of western Rajasthan like Bikaner district offers very good opportunities for ber based farming system including rearing of cow, buffalo, sheep, goats and camels with ber production. Monocropping is a very risky profession in hot arid regions of western Rajasthan due to frequent occurrence of drought, which results in famine. Therefore, people of this region adopt subsistence and mixed farming system i.e. crop production with livestock rearing. It has been observed that the ber production with livestock rearing is a very dominant emerging farming system in western Rajasthan. However, the authentic information about recent development in ber based farming system practiced in arid eco-system of western Rajasthan are not available. Such information may be of paramount importance for strategic plan formulation for further encouragement of ber based farming system and other alike programmes for the farmer's welfare in arid regions of the country.

Thus, keeping the above facts in mind, the present study was conducted in Bikaner district of western Rajasthan with the objective "To evaluate the ber based farming system and related practices followed by the farmers" in arid eco-system.

The present study was conducted in Bikaner district of western Rajasthan to evaluate the ber based farming system practiced by the farmers in arid environment. The district consists of eight Tehsils, out of these, two Tehsils namely: Lunkarnsar and Dungargarh Tehsils were selected purposively (as per need of the Project). With the help of secondary data available at headquarter of each Tehsil, the lists of all the villages falling under these Tehsils were prepared separately and these villages were grouped into two categories viz., small and large villages. Further, five villages were selected randomly from each categories (i.e. small and large village) of villages of the selected Tehsils. Thus, a total of 20 villages (five small and five large villages from each Tehsils) were selected for the study. The researcher himself went to these villages one by one and discussed with villagers about the population of ber growers. With the help of key persons of the selected villages, a comprehensive list of ber growers in each village was prepared. Further, six ber growers were selected randomly from each small and large village so selected for the study in two Tehsils. Thus, a total of 120 ber growers were selected from two Tehsils of Bikaner district for the purpose. The selected ber growers were personally contacted and interviewed by the researchers and responsive data/information were recorded on a semi-structured interview schedule. The data so collected were coded, decoded, processed and arranged in tabular forms by using statistical tools like frequencies, numbering, percentage, etc. to draw inferences and conclusion of the study.

The results of the present study revealed that over all 22.28 and 17.72 per cent farmers grew ber (both country type and improved varieties) in irrigated and rainfed conditions in surveying area of the district. The area covered under ber orchards by different farmers varied between 0.2 – 2.2 ha. Mishra *et. al.* (2003) also reported more or less similar finding in their study.

Perusal of data presented in Table-1, reveals that in *kharif* season (irrigated conditions) 54.28 per cent ber growers grew cluster bean / mateera / snapmelon / kachari / roundmelon / ridge gourd/ Indian aloe, groundnut etc. as an inter-crops in ber orchards on an area ranging from 0.3-0.8 ha. While in rainfed conditions (*Kharif*) mateera, snapmelon, kachari, round melons, pearl millet / seasemum / moth bean / cluster bean, etc. were grown by them in mixed form and different combinations as intercrop in ber orchards. Such kind of cropping system was the most prominent system of cropping in arid environment of the Bikaner district, which is practiced by majority of the ber growers during Kharif season.

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Table 1: Intercrops grown in ber orchards

Season	Condition	Intercrops	Area (ha)	Percentage of ber growers who grew intercrops.
Kharif	Irrigated	Brinjal, chilli (*Capsicum annum*), Cluster bean (*Cymopsis teragonoloba*), mateera (*Citrullus lanatus*), snapmelon (*Cucumis melo var. momordica*), kachari (*Cucumis callasus*), round melon (*Citrullus vulgaris*), ridge gourd (*Luffa acutangula*), Indian aloe (*Aloe barbadensis*), ground nut in ber, orchards	0.3-0.8	54.28
	Rainfed	Mateera, snapmelon, kachari, round melon, pearl millet, seasemum, moth bean and cluster bean in various combinations	0.5– 1.9	77.82 (depending on rainfall)
		khejri (*Prosopis cineraria*)	0.8 - 39 plant/ ha.	72.25
Rabi	Irrigated	Brinjal, bottle gourd, mustard (leaves), spinach, coriander, carrot, radish, pea, green onion, cauliflower, cabbage, chilli, fenugreek, mustard, wheat, gram, etc. in ber orchards	0.1-0.7	41.50
Zaid (Summer)	Irrigated	Mateera, snapmelon, kachari, bottle gourd, ridge gourd, round melon, etc. in ber orchards	0.1-0.6	36.33

Under rainfed condition, plantation of perennial khejri (*Prosopis cineraria*) plant was a very important source of vegetable in arid regions. The *Prosopis* tree produces the pods (sangari) for vegetable and loong (leaves) as a nutritious fodder for the farm animals. During the study 08 – 39 perennial plants of *Prosopis* (per ha) in ber orchards were observed which were major source of traditional vegetable (*sangari*) and fodder for farm animals. These khejri plants were either grow naturally or grown by the farmers. Similar information has been reported in vision-2020 (Anon., 1997).

During *rabi* season under irrigated conditions 41.50 per cent ber grower grew brinjal, cauliflower/cabbage, spinach, fenugreek, coriander (leaves), carrot, radish, pea, green onion, mustard, wheat, gram, etc. as an inter-crops in ber orchards on a small scale (0.1-0.7 ha). Some of the farmers having irrigation facilities grew few vegetables in ber orchards during Zaid (Summer) season also. It was found that out of total ber growers, 36.33 per cent of them grew mateera, snapmelon/ kachari, bottle gourds/ ridge gourds/ round melon / *kakadi*, brinjal, cluster bean (veg.), okra, tomato, etc. as inter - crops during summer season in ber orchards in an area ranging from 0.1-0.6 ha.

It was also observed that more than 70% of the ber growers of locale of the study grew country type varieties of the above-mentioned vegetables. However, a few ber growers grew hybrid/improved varieties of mateera (AHW-19, AHW-65), snapmelon (AHS-10, AHS-82) and kachari (AHK-119, AHK-200) and other vegetables in their ber orchards.

Ber-cum-livestock production system

The results of the present study further revealed that the ber growers of locale study area of Bikaner district grew not only ber but also reared some economic farm animal with ber production as a subsidiary enterprise. Since, in arid areas like Bikaner district, ber production is a risky enterprise and uncertain due to shortage of water and occurrence of frequent droughts and famines. Under such conditions the majority of the ber growers rear farm animals (livestock) as another important source of their income and employment.

The data presented in Table 2, revealed that cow, buffalo, sheep, goats and camels were the major farm animals, which were reared by 42.25, 21.50, 28.75,32.20 and 39.50 per cent ber growers, respectively. Similar type of findings had also been reported by Singh, (1999).

The major breeds of cow reared by the ber growers were, country types, Rathi, Tharparker, Jersey, Holstein Frision and cross breeds. The cows were reared 01 - 14 in numbers by 42.25 % ber growers mainly for the production of milk, FYM and draft purpose. Amongst the buffalo breeds, country type, Murrah, Surti, Jaffarabadi etc. were the major breeds which were reared by 21.50 % ber growers

Table 2. Livestock/ farm animals reared by ber growers

Major farm animal reared	Total population of farm animals in the district (2003)*	Major breeds of farm animals reared by ber growers	Percentage of ber growers rearing animals	Herd size of animals per ber grower	Major purposes of rearing farm animals
Cow	608597	Country type, Rathi, Thar parker, Jersey, Holstein Frisien, cross breeds etc.	42.25	01-14	Milk and Draft, FYM
Buffalo	132732	Country type, Murrah, Surti, Jaffarabadi, etc.	21.50	01-05	Milk & FYM
Sheep	928832	Chokla, Magra, Poogal, Sonadi, Marwari, Nali, cross breeds, etc.	28.75	10 - 32	Wool, Meat, Milk, FYM
Goat	686509	Marwari, Jakharana, Lohi, Cross breeds	32.20	05 - 22	Milk, Meat, FYM, Hairs
Camel	61861	Bikaneri, Jaisalmeri, cross breed transportation, wool.	39.50	01 - 03	Draft,

Dainik Bhaskar, News Paper, June 03, 2004 (Bikaner)

having herd size from 01-05 for milk and FYM production. The Chokla, Magra, Poogal, Sonadi, Marwari , Nali and cross breeds were the major breeds of Sheep, which were reared by 28.75 % of the ber growers having herd size 10 - 32 for wool, meat, FYM and milk production. The ber growers (32.20%) reared some goats also for milk, meat, FYM and hair production having herd size from 05 – 22. The major breeds of goat reared by ber growers were Marwari, Jakharana, Lohi, cross breeds, etc. The camels were reared by 39.25 per cent ber growers ranging 01-03 in number for draft in different agricultural operations. The cross breeds, Bikaneri, Jaisalmeri, etc. were the major camel breeds, which were reared by the ber growers. These findings are on the line of findings as reported by Sardana *et. al.* (2003).

It was concluded that more than one third population of the farmers of Bikaner district (Rajasthan) grew country type and improved varieties of ber. The majority of ber growers grew various crops like mateera, snapmelon, kachari, brinjal, bottle gourd, ridge gourd, round melon, Indian aloe, spinach, carrot, radish, green onion, fenugreek, cauliflower, chilli, cluster bean, pearimillet, cowpea, groundnut , mustard, gram, wheat, coriander, cumin, etc. as inter – crops in ber orchards during different seasons of the year. It was also observed that most of the ber growers reared various farm animals for different purposes. The major farm animals reared by ber growers were cows, buffaloes, sheep, goats and camels. These animals were reared for various purposes viz, milk, wool, meat, FYM, hair, skin production, draft purposes, for extra income and employment generation. Therefore, ber growers adopted mixed farming system to reduce risk and uncertainty in their farming system to sustain their livelihood especially during drought and famine conditions.

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Short communication

Studies on physical properties of fruits as indices of maturity in Lasora (*Cordia dichotoma* Forst 'F')

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Lasora (*Cordia dichotoma* Forst 'F') fruit is generally used as vegetable and for pickle making at home scale. It is an established fact that stage of maturity has a direct effect on the post harvest quality and storage life of the fruits. Early harvesting results in poor quality and uneven ripening, whereas delayed harvesting significantly reduces the shelf-life. In addition, stage of maturity influences the quality of the processed produce. Therefore, it is imperative that the fruits should be harvested at right stage of maturity.

Physical appearance like size and colour of a fruit strongly influences initial human reaction to fresh fruit. Physical characters of the fruits are widely used to determine their harvesting time. These characters are widely accepted by fruit growers through out the world. Although different scientific techniques are available to pin point harvesting stage of the fruit, yet the significance of physical characters cannot be ruled out.

Fruit size is one of the traditional visual means of judging harvesting maturity in several fruits. It is highly correlated to fruit weight (Badiyala 1991; Patel and Katrodia, 1994). Various workers have suggested fruit colour as a maturity index in several fruits (Chundawat 1990; Chandra and Pareek 1992). Singh (1984) observed that specific gravity is an easy method to assess the maturity. Keeping in view the above facts, the present study was conducted to assess the fruit maturity and right stage of harvesting for pickle purpose.

Experiment was conducted at KVK, Rampura, Rewari (Haryana) on correlate plant, which beared large size fruit. Three healthy trees of each were selected purposively. First sampling of fruits was taken after 45 days of peak flowering during 1999 and 48 days during the year 2000, with subsequent sampling at 3 days interval till ripening of fruits on each sampling date. A sample of 20 fruits were harvested randomly from tagged shoot in morning hours and the physical characters were observed in the laboratory. The data were statistically analysed in randomised block design.

Results presented in Table 1 show that fruit length and breadth increased progressively from the first date of sampling upto the date of colour break of the fruit. Likewise, the fruit weight increased progressively upto the date of colour break. Maximum fruit weight 11.98 and 13.16g was recorded on date of colour break during both the years of study and was significantly different at 5% level. After the colour break, fruit size and weight remained more or less constant. Similar findings have also been reported by Chander and Khajuria (1983) in peach, Gupta *et al.* (1983) in ber and Patel and Katrodia (1994) in sapota.

Perusal of data revealed that the pulp/stone ratio decreased progressively with the advancement of fruit development, irrespective of the type of fruit. Optimum pulp/stone ratio of (5.42 and 4.97) in fruit were attained in subsequent years. It is clear that accumulation of pulp was faster at early stages, whereas the increase in stone weight primarily contributed towards the increase in fruit weight at later stages. These results are in contrast to the findings of Chahill *et al.* (1980) and Khalil and Stino (1987) in peach crop.

The specific gravity of fruit increased upto 51 days after flowering thereafter it declined progressively. The optimum value of specific gravity in mature fruits was 1.01 to 1.01. On the other hand, the optimum value of specific gravity of ripe fruits was 1.01 and 1.01 for large fruited. Thus, the specific gravity for the mature fruits did not differ much from that of the ripe fruits. The fruit colour was dark green at the beginning of the sampling and there was no change in the colour of the fruit up to 60 days after flowering (large fruited). It changed from dark green to light green subsequently and lasted for nearly one week. By the proposed date of maturity, the colour of the fruits changed to yellowish green with a colour rating of 3. Fruit colour changed to yellow at ripening. These results are in accordance with Chundawat (1990). Loss of green colour might be attributed to the degradation of Chlorophyll and Synthesis of yellow coloured pigments like carotenoides.

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Table 1. Developmental changes in pulp/stone, weight of fruit, Sp Gravity and Colour of large fruit of lasora

No.of days after flowering	Large fruited type							
	Pulp/stone 1999	Weight (gm) 2000	Sp. Gravity 1999	Colour* 2000	1999	2000	1999	2000
45	10.03	8.66	4.29	4.24	1.11	1.04	1	1
48	9.13	8.48	5.20	5.32	1.13	1.05	1	1
51	8.39	7.45	7.74	6.73	1.12	1.06	1	1
54	7.13	6.76	9.05	8.41	1.08	1.06	1	1
57	7.28	6.47	9.64	9.17	1.07	1.06	1	1
60	6.97	6.32	9.76	10.31	1.06	1.04	1	1
63	6.62	5.88	10.35	10.57	1.04	1.02	2	2
66	6.44	5.59	10.72	12.17	1.03	1.02	2	2
69	5.42	4.97	11.98	13.16	1.01	1.01	3	3
72	5.28	4.95	11.98	13.16	1.01	1.01	3	3
75	5.28	4.94	11.98	13.16	1.01	1.01	4	4
CD (P = 0.05)	0.57	0.36	0.43	0.23	0.04	0.02	0.006	0.006

* 1=dark green, 2=light green , 3=yellow green , 4=yellow

In conclusion, the green mature stage of harvesting of the fruit was attained 69 days after full bloom. This stage of fruit is more suitable for pickle preparation because of higher pulp at this stage.

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Short communication

Dehydration methods and their impact on microbial contamination in Kachari *(Cucumis callosus)* products

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Kachari (*Cucumis callosus*) is an important cucurbitaceous vegetable grown in arid region of Western Rajasthan. The quality attributes with reference to microbial contamination, their role on nutrients depletion and myco toxicity are important concern in any post harvest products prepared from fruits and vegetables. Different products are prepared from vegetables and stored for long and short term but storage of post harvest products after convenient treatment is important to maintain the nutritional status and hygienic level under various conditions. Out of different horticultural crops of arid region, very limited works on post harvest process and storage conditions have been carried in crops like pomegranate. Low temperature (2°C) was suitable for fruits with flavour similar to that at harvest but main losses occurred by *Penicillium* spp. at 5°C and the quality and shelf-life of pomegranate could be improved by curing at 2°C and intermittent warming during cold storage (Artes *et al.*, 1996; 2000). However, post harvest pathogens can spoil those products stored under unhygienic conditions having favourable climatic conditions for growth and sporulation. Kanwar *et al.* (1974) reported the effect of temperature and relative humidity on the development of soft rot of pomegranate fruits due to *Rhizopus arrhizus* Fischer. *Kachari* as important arid vegetables stored in different form to meet out the demand during off season. The powder prepared from the dry fruits is used in *garam masala* industries. However, no attempts have been made so far to study the effect of different drying methods and their impact on microbial contamination and hence, the present study was undertaken and the enumeration of microbial population in different dehydration methods on *kachari* products are discussed.

This study was carried out using the dehydrated *kachari* products stored for different periods of time in the post harvest technology laboratory of CIAH, Bikaner during the year 2005. The total microbial population including bacteria and different species of fungi associated with these products were enumerated through artificial inoculation of samples in specific culture medium. Yeast extract agar (Yeast extract- 10.00 g, glucose-10.00g and agar 15g) was used for the growth of different fungal species and Nutrient glucose agar medium (Protease peptone 20g, beef extract 5g and agar 15g) was used for the isolation of bacterial population. The media were adjusted with pH 7.0 and as per the medium compositions. Sterilized media were poured (20 ml/plate) in Petri plates.

A set of samples from each treatments (oven dried for 30 months without peel, Sun dried (16 months old), Shade dried (16 months old), Sun dried (3 months old), Shade dried (3 months old), Oven dried (03months old), Sun dried (16 months old), Shade dried (16 months old), Oven dried (16 months), Powder with peel –30 months (Refrigerator), Powder with out peel-30 months (Refrigerator), Powder with peel 16 months at ambient conditions) were randomly drawn and pooled together. After through mixing of these samples, few bits were taken from each treatment and used for the isolation of microbial populations.

Samples were cut into small pieces with a sterile scalpel and placed over the Petri plates containing sterile solid medium. Petri plates were incubated at constant temperature ranging from 25 ± 2°C maintained in B.O.D. incubator. Growth of the fungi and bacteria were monitored at 24hrs intervals and the number of colonies from each plate was recorded. The genera of the fungal population were identified based on the cultural and morphological characters. Observations under simple microscope on mycelia, conidiophores and conidia of the test of fungal genera were further confirmed with the standard descriptions (Barnett,1960; Webster, 1980 and Sarbhoy, 2000). All experiments were repeated twice and each treatment was replicated for 3 times (5 plates in each replication) in completely randomized block design. Data on per cent colonization were subjected to suitable transformation for analysis of variance (ANOVA) and assumed at $p<0.01$ and 0.05% level of significance.

The overall results presented in Table 1 revealed that the *kachari* products were associated with different genera of saprophytic fungal and bacterial populations. However,

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the intensity or the level of contamination varied among the dehydration methods. Out of twelve different treatments, *kachari* without peels subjected to tray drying did not have any microbial colonization even after two and half year of storage under ambient conditions. Perhaps due to the treatment effect in addition to the nature of the samples which did not contain the surface tissues (peeled) which may normally act as carrier of the contaminants at storage stage. Conversely, the same product stored under refrigerator conditions was infected (20%) by *Rhizopus* sp. Maximum colonization of *Rhizopus* sp ranging from 30-100% was noticed in *kachari* slices dried under shade and direct sun light. Powder form of *kachari* fruits contained more bacterial population. Shade dried (16 months old) product showed 60% *Rhizopus* sp, 10% *Penicillium* sp and 10% bacteria. The post harvest products colonized by the toxigenic fungi like *Penicillium* spp as evidenced from the present investigation is important concern in terms of health point of view. However, most of the other toxigenic fungi did not contaminate rest of the samples. This is the first kind of investigation revealing the importance of dehydration methods on quality of *kachari* products.

Although no works have been carried out so far in this crop, few reports on mycoflora of other arid vegetables like *Khejri* are available. Bohra and Purohit (2000) have studied the mycoflora of stored seeds of *Prosopis cineraria* (*Khejri*) collected from different localities of Rajasthan using the blotter paper technique. *A. flavus* was dominant in almost all samples tested. *A. niger, A. fumigatus* and *A. ochraceus* were also present in abundance, while species of *Fusarium, Curvularia, Chaetomium, Alternaria, Stachybotrys* and *Rhizopus* were recorded in some of the samples. The results showed in *P.cineraria*, 23 out of 54 isolates of *A. flavus* produced aflatoxins.

In present study, *kachari* fruits under shade dry contained the toxin producing fungal genera like *Aspergillus* and *Penicillium* spp. Of the toxigenic isolates, 21 produced B_1 aflatoxin, whereas 2 produced both B_1 and B_2 aflatoxins. The amount of aflatoxin produced by the isolates from seeds was up to 1690 µg/kg and in pods was up to 1956 µg /kg. Among the 21 seed samples screened, only 9 were contaminated naturally with aflatoxins and the concentration of aflatoxin B_1 was up to 285 µg /kg in seeds and up to 1610 microgram/kg in pods (Bohra, and Purohit, 2003). A study conducted by Bohra and Purohit (2000) on the biodeterioration of seeds of *P. cineraria* by *A. flavus* showed a reduction in reducing sugar, total soluble sugar and protein content, and an increase in phenol concentration and such kind of basic works are further required in case of *kachari* also. It is summarized that the dehydration methods have great influence on quality parameters particularly on microbial population. Further works are required on refinement such tray or oven drying method in large scale with scope on industrial use to maintain the quality and nutritive value of *kachari* products.

Table 1. Microbial population in dehydrated products of Kachari

Products from dehydrated methods	Microbial population in different media	
	NA	YEA
Oven dried 30 months without peel	Nil	Nil
Sun dried (16 months old)	30% Bacillus sp Rhizopus sp 20%	Rhizopus sp 90%
Shade dried (16 months old)	30% Bacillus sp 60% Rhizopus sp	100% Rhizopus sp 25% Aspegillus spp.
Sun dried (03 months old)	30% Bacillus sp 45% Rhizopus	35% Rhizopus sp
Shade dried (03 months old)	25% Rhizopus sp 10% Bacillus sp	25% Rhizopus sp 15% Aspegillus spp.
Oven dried (03months old)	10% Bacillus sp 10-Rhizopus sp	15% Rhizopus sp
Sun dried (16 months old)	95% Rhizopus sp	100% Rhizopus sp
Shade dried (16 months old)	60% Rhizopus sp 10% Bacteria	10% Penicillium sp 25% Rhizopus sp
Oven dried (16 months)	20% Rhizopus sp	20% Rhizopus sp
Powder with peel –30 months (Refrigerator)	50% Bacteria 20% Rhizopus sp	40% Rhizopus
Powder with out peel-30 months (Refrigerator)	55% Bacteria 20% Rhizopus sp	25% Rhizopus sp
Powder with peel 16 months, ambient conditions	100 % Bacteria	14.5% Rhizopus

Values are means of 3 replications each after 28hrs of incubation
NA = Nutrient Agar, YEA = Yeast Extract Agar

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Short communication

Studies on preparation and biochemical changes in guava ready-to-serve beverage during storage

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Guava (*Psidium guajava* L.) is one of the important fruits of India and ranks fourth in area and production after mango, banana and citrus. The fruits are rich in Vitamin-C, pectin, phosphorus and calcium (Wilson, 1980). The chemical composition of fruits differ with variety, stage of maturity, size and season. Guava is available in plenty during the fruiting season. Its disposal becomes a serious problem particularly in rainy season. Its utilization is very little in processing industry. Only jelly is made from its fruits. But its excellent flavour and nutritive value have a great potential in beverage. The beverage are becoming popular in comparison to synthetic or carbonated drinks. Therefore, the present study was undertaken to exploit its potential in the bevarage industry drinks.

The present study was carried out at the Department of Horticulture, College of Agriculture, I.G.A.U., Raipur during 2003-04. The semi-ripe fruits of Lucknow-49 guava were cut into pieces and after separation of seeds, juice was extracted. The juice was kept for 3-4 hours to settle down the coarse particles. The supernatant solution was siphoned-off, leaving the coarse particles. Syrup was prepared by adding sugar and citric acid to the water and dissolved by heating. The filtered syrup was mixed with the filtered juice after cooling and filled immediately in already sterilized bottles leaving 5 cm head space and sealed air tight. The ready-to-serve had 10 per cent pulp, 12 per cent total soluble solids and 0.3 per cent acidity. No synthetic colour and essence were added to the ready-to-serve. The product was stored at ambient condition (30±2°C).

The chemical composition viz., TSS was determined by Hand Refractometer, while total sugar, reducing sugar, acidity and ascorbic acid was estimated by the method as suggested by Ranganna (1997). Non-reducing sugar was determined by subtracting the value of reducing sugar from total sugar. The pH value was taken on digital pH meter. Ready-to-serve beverage were subjected to sensory evaluation by a panel of five judges following the Hedonic rating test as described by Ranganna (1997).

Biochemical composition changes in guava ready-to-serve (RTS) during storage period presented in the Table 1, clearly indicates that the ascorbic acid content in guava ready-to-serve (RTS) beverage decreased continuously during storage periods. Reduction in ascorbic acid might be due to oxidation by trapped oxygen in glass bottle, which might have resulted in the formation of dehydro ascorbic acid. Loss in ascorbic acid content of fruit beverage has also been noticed in papaya (Kumar, 1990), in mango (Rabbani, 1992) and in guava (Pandey and Singh, 1998).

The increase in acidity in ready-to-serve (RTS) during 150 days of storage may be due to formation of organic acids by ascorbic acid degradation as well as progressive decrease in pectin content. Similar findings were also reported in the beverage of papaya (Kumar, 1990), Mango (Rabbani, 1992) and guava (Baramanray *et al*, 1995; Pandey and Singh, 1998; Pandey, 2004).

The pH value in guava's ready-to-serve (RTS) showed a decreasing trend with increasing periods of storage upto 150 days under room temperature. The reduction in pH could be attributed to simultaneous increase in acidity and total soluble solids of ready-to-serve (RTS) at storage temperature. The present findings are in agreement with those of Sethi (1993) and Prasad and Mali (2000) in litchi and pomegranate squash beverage, respectively.

The increase in reducing sugar as well as total sugar corresponded to the increase in total soluble solids (TSS) and ultimate decrease in non-reducing sugar in ready-to-serve beverage during storage period. The variation in different fraction of sugar might be due to hydrolysis of polysaccharides sugar into reducing sugar as increase in reducing sugar was correlated with the decrease in non-reducing sugar. The increased level of total sugar was probably due to conversion of starch and pectin into simple sugars. Similar findings were reported by Murari and Verma (1989) and Baromanray *et al.*, (1995) in guava and by Shrivastava (1998) in mango beverages.

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Table 1. Changes in biochemical composition in guava ready-to-serve (RTS) during storage period at ambient temperature

Storage period (days)	Ascorbic acid (mg/100g)	Acidity (%)	pH	Total soluble solids (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	Organoleptic evaluation (At a scale 36)
0	9.75	0.32	5.74	12.00	11.05	2.58	8.30	26.15
30	9.75	0.32	5.74	12.01	11.05	3.06	8.00	26.09
60	9.25	0.32	5.26	12.03	11.07	3.22	7.87	25.67
90	9.15	0.34	5.15	12.10	11.09	3.59	7.50	25.38
120	9.00	0.42	4.99	12.15	11.10	4.10	7.00	24.84
150	8.38	0.49	4.88	12.20	11.12	4.28	6.85	23.85
S.Em ±	0.03	0.01	0.01	0.01	0.00	0.07	0.01	0.14
C.D. (5%)	0.09	0.03	0.02	0.04	0.01	0.21	0.02	0.43

There was a considerable decrease in ready-to-serve (RTS) in sensory mean score for taste, flavour and taste, flavour and overall acceptability during storage periods. The sensory mean score for each attribute was highest on the day of preparation, which decreased with increasing periods of storage. There are many extrinsic factors which determine the storage stability of products and temperature plays an important role among them. There are certain biochemical changes which occurs under low pH and high temperature that leads to formation of brown pigment and produces off flavour in the beverages.

The other possible reasons could be the loss of volatile aromatic substances responsible for flavour and taste which decreased acceptability in storage at ambient condition. The present findings are in accordance with the view of Baramanray *et al.* (1995) in guava nectar and Thakur and Barwal (1998) in Kiwi fruit squash.

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Short communication

Response of GA_3, $Ca(NO_3)_2$, bavistin and neem extract on the storage life of Nagpur mandarin (*Citrus reticulata* Blanco)

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The mandarin (*Citrus reticulata* Blanco) cultivar-Nagpur belongs to family rutaceae and is one of the important fruits of citrus group. Nagpur mandarin are of importance because of their pleasant flavors and refreshing taste. It is a sub acidic fruit, used for preparing commercial pectin, refreshing drinks and making cosmetics. However, the fruits are perishable in nature. During harvesting season, there is a gult in the market compelling the farmers to sell their produce at throw away prices. The fluctuation in market price can be controlled by selling the fruits in phases and this can be achieved by storing the fruits with the treatment of different chemicals to prolong the shelf life of mandarin fruits. The main objectives of different types of chemicals is to control the rate of respiration, transpiration, ripening and also other undesirable bio-chemical changes and disease infections (Naik, 1985).

It is, however, advisable that the suitability of these methods under a particular condition should be tested before putting them in to commercial use. The establishment of a suitable treatment would help in market regulation, fetch higher prices and may be equally useful for consumers. Keeping these facts in view, the present investigation on Nagpur mandarin fruits were under taken.

The investigation was carried out at Navsari Agricultural University, Navsari (Gujarat) in completely randomized design with three replication and nine treatments during the year 2004. Fully ripe greenish yellow healthy fruits were procured from the *Phal Ane Saak Bhaji Mandi*, Dudhia Talao, Navsari. They were brought to the laboratory and sorted. Thus, fruits of uniform shape, size and ripeness were treated with different concentrations of gibberellic acid, calcium nitrate, bavistin and neem extract after initial physico-chemical analysis. The treatments were T_1 Control, T_2 Gibberellic acid 150 ppm, T_3 Gibberellic acid 250 ppm, T_4 Calcium nitrate 0.5 percent T_5 calcium nitrate-1.0 per cent, T_6 Bavistin- 500 ppm, T_7 Bavistin 750 ppm, T_8 Neem extract 1.5 per cent, T_9 Neem extract 2.0 per cent

Each treatment comprised of 3 kg fruits, five fruits were kept for physical observation and remaining for chemical analysis. Each treatment was termed as one unit. For fungicidal dip treatment fruits were washed in tap water, air dried and then after all fruits were dipped in the solution of fungicide. Bavistin (Carbendazim) 500 and 750 ppm for five minutes. The fruits were air dried and packed in polythene bags. For Gibberellic acid and calcium nitrate treatment, fruits were dipped in different concentrations of GA_3 and $Ca(NO_3)_2$ for five minutes, air dried and packed in polythene bags. For neem extract treatments, neem extract was prepared from the fresh neem leaves by boiling and then desired concentration of extract was prepared by increasing the volume by the addition of distilled water. Fruits were dipped in different concentrations of Neem extract for five minutes, air dried and packed in polythene bags. Fruits used as control were washed in the same way as the treated ones and dipped in distilled water for the same period and packed in poly bags. The bags of 45 x 30 cm^2 of 200 gauge thickness having 2 per cent area under perforations were used for the study.

Physical characteristics

The effect of different concentrations of GA_3, $Ca(NO_3)_2$, Bavistin and Neem extract on physiological characteristics are presented in Table-1. The physiological loss in weight was affected significantly by all treatments at 28 days of storage except control. The loss in weight was higher in control and minimum loss in weight was recorded in GA_3 150 ppm at 28th day of storage.

Similar results have also been reported in grapefruit and orange (Roy, 1985; and 1989) and mango (Naik, 1985

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The values of various parameters at 0 hrs of treatment are depicted in table below.

SNo	Observation	Values (%)
1	Physiological loss in weight	0.00
2	Rotting percentage	0.00
3	Juice content	49.00
4	Total soluble solids	8.50
5	Active acidity (pH)	3.40
6	Total sugars	7.69
7	Reducing sugar	2.45

and Singh 1987). The reduction in weight loss was possibly due to loss in moisture through transpiration and utilization of some of the reserve food materials in the process of respiration.

The rotting of fruits was significantly affected by all the treatments except control. The bavistin 750 ppm showed minimum rotting percentage (33.46) at 28th day of storage and control showed maximum (78.41). Neem extract also minimized the per cent fruit rotting next to bavistin. The minimum rotting percentage recorded in fruits treated with bavistin and neem extract might be due to the chemical fungicides which check the fungal growth and Neem extract a bio-pesticide. Motine and Locke (1993), Bhoromick and Vardhan, 1981also reported similar findings. The treatment GA_3 250 ppm showed minimum loss in juice percentage (39.13) at 28th day of storage. While control showed the maximum decreasing trend of juice content (27.27) on the 28th day of storage as compared to all the treatments. Juice of mandarin fruits decreased slowly during advancement of storage period. Mandarin oranges when packed in polythene bags helped in minimizing the juice percentage reduction to some extent. (Singh and Rana, 1992). Similar results have been obtained by Dhillon *et al.* (1977) in kinnow mandarin.

Chemical characteristics

The effect of different concentrations of GA_3 $Ca(NO_3)_2$ Bavistin and Neem extract on chemical characteristics are given in Table 1. The rate of increase in TSS percentage was higher in control (11.44) as compared to other treatments. GA_3 (250 ppm) showed minimum TSS (9.61) on 28th day of storage. The total soluble solids content in mandarin fruits increased during storage, which was possibly due to hydrolysis of polysaccharides to monosaccharide and increased concentration of juice as a result of dehydration (Das and Dash, 1967). The findings reported by Singh, 1987 in mango and Singh *et al.* 1970 in guava comfirm to this prerequisite. In active acidity (pH) control registered highest increasing rate (3.67) of pH as compared to other treatments at the 28th day of storage. Overall minimum pH was observed (3.57) under treatment of GA_3 150 ppm. The active acidity, declined in the fruits with the advancement of storage period. This reduction was partly due to decline in acid content. Further, possibly of utilization of some of the acids in the process of respiration and conversion of some of them to sugar also could not be ruled out. These results are in conformity with the observations of Singh (1987) in mango, Hurding (1954) and Kumar *et al.*, 1987 in citrus fruits. Total sugar content increased continuously with the advancement of storage. The maximum total sugar content recorded in control (9.95)

Table 1: Effect of GA_3 $Ca(NO_3)_2$, Bavistin and Neem extract on physical and chemical characteristics at 28th day of storage.

Treatment	Physiological loss in weight (%)	Rotting per cent	Juice content (%)	T.S.S.) (%	Active acidity (pH)	Total sugar (%)	Reducing sugar content (%)
Control	36.96	78.41	27.27	11.44	3.67	3.95	9.95
GA_3 150 ppm	17.41	42.90	39.04	10.09	3.57	3.76	9.86
GA_3 250 ppm	17.91	41.96	39.13	9.61	3.60	3.66	9.76
$Ca(NO_3)_2$, 0.5%	23.35	64.92	33.60	10.57	3.61	3.80	9.76
$Ca(NO_3)_2$, 1.0%	23.29	61.84	34.60	10.28	3.62	3.93	9.80
Bavistin 500 ppm	23.27	35.20	32.99	11.05	3.66	3.92	9.93
Bavistin 750 ppm	19.11	33.46	39.02	10.76	3.59	3.95	9.45
Neem extract 1.5%	23.52	38.81	34.55	10.86	3.63	3.76	9.74
Neem extract 2.0%	23.43	37.10	34.16	10.57	3.61	3.83	9.80
SEm±	0.040	0.053	0.404	0.100	0.033	0.086	0.082
C.D. 5%	0.141	0.199	1.104	0.219	NS	0.157	0.147

on 28th day of storage. In case of reducing sugar per cent, all treatments showed increasing trend for reducing sugars except bavistin 750 ppm which showed decrease in reducing sugars as compared to all other treatments. The rise in sugars was possibly due to hydrolysis of polysaccharides to mono-saccaharides and increased concentration of juice as a result of loss of moisture by transpirations. These findings are comparable to some earlier reports in guava (Singh *et al.*, 1970) and in litchi (RayChoudhary *et al.*, 1992).

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Short communication

Bacterial leaf and fruit spot : A major constraint in pomegranate orchards

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Pomegranate (*Punica granatum* L.) belongs to the family *Punicaceae*. It has wider application in both Ayurvedic and Unani traditional medicinal systems of medicine (Anonymous, 1989). Owing to different alkaloids particularly tannins, constituted in pomegranate leaves and fruits, there is no occurrence of much disease in this crop. But the leaf and fruit spots are the major diseases in humid regions of India, which indirectly affects the yield, and economic value of fruits in India. It is popularly known as oily spots in Maharastra area and nodal blight in Karnaraka. Ramesh *et al.* (1991) have reported that pomegranate bacterial blight appeared as an epidemic in Bangalore, Karnataka, India, causing 60-80% yield losses.

There was a severe out break of this particular disease and consequently, an expert committee constituted by ICAR has surveyed pomegranate orchards in the area of Chik-Mahud, Kadlas, Jadhavwadi, Sangola in Solapur district and Jalihal, Umdi abd Tikondi in Sangali district of Maharastra. Appearance of this disease in different orchards of these locations was seen by the experts. Incidence, intensity and diversified symptoms on different cultivars were also assessed by random sampling method. The ooze test from different infected parts collected from different orchards were observed under microscope in the Plant pathology laboratory in Agriculture college, Pune. Subsequently, casual organism of this disease was confirmed and identified as *Xathomonas axonopodis* pv. *punicae* Vautern by standard culture technique. and further Bacterial leaf spot was first reported from Delhi in 1952 and now became prime disease occurring in almost all commercial varieties of pomegranate. Disease intensity varied in different locations of the country. *X.axonopodis* pv. *punicae* produced typical black spot symptoms when inoculated on different parts of pomegranate plants. Cent per cent lesion formation was recorded both under artificial as well as field conditions in Indian Punjab in 1997 (Rani *et al.*, 2002a). In present surveys, this particular disease has posed a major threat on pomegranate orchards and could infect most of the commercial varieties like Mirdula, Bhagava, Ganesh in the areas of Chik-Mahud, Kadlas, Jadhavwadi and Sangola in Solapur district of Maharastra. Though, the average incidence intensity was ranging from 0.33 to 2.5%, quality of fruits was completely lost in most of the places visited.

In present investigations, different types of symptoms were observed in most of the commercial cultivars like Ganesh, Mirdula and Bhagava. In leaves, almost similar kind of symptoms were seen except in case of cv Mirdula. dark spots surrounded by yellowish green halo and in other cases the spots are surrounded with yellow halo. The bacteria could migrate from the spots to stems through leaf petioles to central veins and slowly enters in to stem forming dark lesions. Bark tissues are severely distorted by bacterium in advanced stage of infection. In cv. Ganesh, water soaked lesions were prominent and subsequently appeared as necrotic spots without much halos on young fruits. In severe cases, many spots coalesced to form necrotic lesions and progress to the extent of epidermal cells of rind. When the infection occurs on matured fruits, the rinds are cracked easily and such fruits are congenial for colonization of saprophytic fungi and insects damage. In flower buds also, deep-seated necrotic lesions were seen. In contrast to necrotic and water soaked spots on rind, initially dark brown spots with sunken lesions appeared on cv. Mirdula. In advanced stages, fruits cracking were severe as compared to other varieties. Systemic migration of the pathogen was seen as symptoms expressed by the bacterium in vascular tissues. The bacteria colonized in the inter-cellular spaces in mesophyll cells before moving to the petiole and finally down to the node. Invaded cells were killed resulting in blight and therefore, it is also known as nodal blight disease of pomegranate which is very common in Bangalore area. The pathogen infected the leaves, nodes, flowers and fruits of pomegranate plants (Ramesh *et al.*,1991). Rani *et al.* (2001a) reported that *X. axonopodis* pv. *punicae* produced typical black spot

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symptoms on different parts of pomegranate. Water-soaked turn dark brown which are raised and oily in appearance (Rani *et al.*, 2001b) and these results are in agreement with present results.

Isolates of bacterium from different parts of various commercial cultivars were grouped based on the cultural and chemostatic parameters and the causal organism was isolated and identified as *Xanthomonas campestris* pv. *punicae* and its pathogenicity was also confirmed. Rani *et al.* (2002) reported that based on the morphology of the bacterium isolated from infected fruits, leaves, and twigs, the pathogen was identified as *Xanthomonas axonopodis* pv. *punicae*. Ramesh *et al.* (1993) also reported different isolates of pathogenic bacteria from various parts of pomegranate cultivars and their variability in growth rate under the exposure of different antibiotics. It is concluded from present studies that leaf and fruit spots caused by *X.axonopodis* pv. *punicae* is the major disease in pomegranate orchards not only in Maharastra state but also in rest of the southern states and it can cause heavy loss in near future, if proper management strategies are not worked out.

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