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Strategies for enhancing water productivity in horticultural crops

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Abstract

Water is the most critical input for horticultural productivity, and efficient use of water is critical for the development of sustainable horticulture. The efficiency of irrigation water use continues to be low with adverse environmental repercussion. Increasing water- use efficiency through improved irrigation systems as an alternative or a complement to physically enhanced water supplies is an important issue in water resource management. Micro-irrigation has emerged as an appropriate water saving techniques for all wide spaced high value crops in water scarce, undulated and sandy areas of hot arid ecosystem. This paper deals with the present status of micro-irrigation research, economics of different micro-irrigation systems and the need for affordable and low cost micro-irrigation systems. Future research on micro-irrigation is needed (i) to improve the performance of drip system, and (ii) to include fertigation study. The various studies revealed that the productivity of horticultural crops can be enhanced to the tune of about 60-70 percent by adopting micro-irrigation.

Key words : *Water productivity, microirrigation, water management and horticultural crops*

Introduction

Agriculture is the largest single user of water, with about 75% of the world's freshwater being currently used for irrigation. In some countries, irrigation accounts for as much as 90% of the total amount of water available (FAO, 2003, 2005). Given that water productivity in agriculture continues to be low and that improvements are only being made very slowly, and that freshwater has always been an integral component of food production, it is obvious that huge amounts of water will be required to produce enough food for the future population of the world. The situation is more alarming in arid and semi-arid regions where the water is very scarce, rainfall is low and erratic and deep groundwater level with low recharge capacity perennial water storage structures. Due to these factors, majority of the areas remain dry and fallow which limits agricultural production.

Such areas can be fruitfully utilized for commercial cultivation of horticultural crops because majority of horticultural crops are perennial in nature, widely spaced, low water requirement in comparison to field crops, deep and extensive root system capable of extracting water from deeper layers, large canopy to harvest optimum natural resources better and high yielding. In addition to above, the irrigation water requirement of horticultural crops differs with respect age, growth stages and season. Because of this the irrigation scheduling of these crops can be planned in advance so that available water can be optimally utilized.

Since the crops are widely spaced a large interspaced area remains uncultivated hence there is need to develop technologies to provide water at the site of consumption so that various losses such as evaporative, seepage, conveyance and water required to wet interspaced area can be avoided which will save the large amount of water that can be utilized to irrigate additional area which otherwise remains barren. This will improve water productivity in arid and semiarid regions by producing more biomass with the same of water giving through traditional method. Water is fundamental requirement in development of horticulture and hence horticulture relies on irrigation, whereby responsible water use is the key to the success of horticulture. Here excess and scarcity of water often cause considerable losses both in quantity and quality in fruit production. Therefore, optimum water use practices considering the water requirement and application techniques must be followed.

Due to increased water scarcity, the irrigated area is unlikely to expand in the dry land region of the country. Therefore, life saving irrigation, supplemental irrigation, the combination of dry land farming irrigation at critical growth stages, and regulated deficit irrigation, would be an ideal choice for improving horticultural crop yields in this region. Good irrigation scheduling requires the timing of irrigation, crop water requirement and the amount of water applied to match actual field conditions. This needs

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information on soil moisture status (whether in terms of water content or water potential) at the time of irrigation and, when using irrigation, close cooperation among farmers to be effective. The choice of irrigation scheduling method also depends to a large degree on the objectives of the irrigator and the irrigation system available. The more sophisticated scheduling methods generally require higher precision application systems; nevertheless even less sophisticated systems such as flood irrigation scheduling can benefit from improvement in irrigation scheduling. The pressures to improve irrigation use efficiency and to use irrigation for precise control of vegetative growth, as in regulated deficit irrigation (RDI), both imply a requirement for increased precision in irrigation control, maintaining the soil moisture status within fine bands to achieve specific objectives in crop management (Jones, 2004).

Studies have shown that following strategies can be adopted to enhance the water productivity through horticultural crops

1. Use of water conservation techniques such as mulching, pitcher irrigation, double walled pot, use of soil amendments, water absorbing polymer, etc.
2. Use of pressurized irrigation, tank irrigation, *ex-situ* and *in-situ* water harvesting methods can be used
3. Application of water at critical times in relation to growth and development stages of fruit and vegetable crops and varying agro climatic conditions.

Method of Irrigation

Different irrigation methods of irrigation have been used in orchards depending on water availability, topography, fruit species, age of tree, intercrops, etc.

Check basin

For irrigating different fruit crops, check basin system has been used. The size of basin depends on the plant age and is kept small in the beginning. Singh *et al* (1961) suggested that young citrus trees upto 5 years should be irrigated by basin system. Irrigating water should not touch the main trunk, otherwise there are chances of disease infection. Heaping soil around the tree trunk is good practice to avoid moisture contact with scion. The basin should, therefore, be made sloping downwards from the tree trunk

Almost 60-80 per cent of root activity in citrus is confined to the top 60 cm profile and the roots spread beyond the canopy of the trees. Aiyappa *et al.* (1970) reported that furrow irrigation is wasteful and ineffective irrigation system. For young plants of sapota, small basins are made which are increased in the size as the tree grows in age. In coastal Gujarat, 0.5 m high mounds are made around the trees to save them from bending by wind action and to conserve soil moisture (Singh, 1969).

Ring basin

Young mango trees are best irrigated by modified ring method (Singh, 1969). When intercrops are taken, the basins of trees are connected in a series to make them independent of the intercrop (IIHR, 1985b). Ring and furrows or basin methods are generally adopted to irrigate the bearing tree. Irrigation water should not touch the trunk of papaya plants therefore, ring method of irrigation is considered best in which basins are kept sloping downwards from the trunks (Singh, 1978).

Pitcher irrigation

The technique is very useful to establish young plants in sandy wasteland areas having little or no irrigation facility (Pareek, 1987). Small pitcher of about 3 litre capacity having a hole at bottom fitted with a wick is buried alongside a newly planted sapling. The pot is occasionally filled with water and its mouth is kept closed. In a grown up orchard, one or two or three pitchers around a tree, depending on its age and spread can be buried. In a 16-year-old Mosambi orchard, two 30-liter pitchers per tree gave satisfactory growth (Patil *et al.*, 1987).

Rainwater harvesting

The rainwater harvesting system for agriculture in arid and semi-arid areas may follow have following components or phases depending upon the location specific situation:-

1. Direct rainwater conservation
2. *In-situ* moisture conservation
3. Water harvesting (runoff collection and storage)

Direct rainwater conservation :

The approach to rainwater harvesting and conservation are through agronomic and engineering measures. This will not only harvest, conserve water but also prevent soil erosion particularly in semi-arid tract. The measures are contour framing, strip cropping, farming terraces, cover crops, off season tillage in light soils, deep tillage in hard pan areas, summer fallow, mulching, providing vegetative barrier on contour in the land. Deep tillage helps in increasing water intake in soils having textural profiles or hardpan. Surface mulch in post rainy season reduces evaporation resulting higher crop yields. The engineering measures adopted differ from place to place with reference to slope, soil type and intensity and total rain etc. Depending upon the parameters, the methods followed are – the contour trenching, contour stone walls, staggered trenching, constructing temporary and permanent check dams, gully plugging, contour bunding compartmental bunding, land leveling.

In-situ moisture conservation :

In most of the arid and semi-arid tropics, the rainfall is erratic and falls within a short time. The moisture may not be available to the crop at the critical stage of its growth. In situ moisture conservation can help in retaining soil moisture regimes for a longer duration. For tree crops, Micro-catchments, saucer basin/semi-circular bunds and catch pits can be introduced. It is necessary to adopt the *in-situ* moisture conservation techniques in addition to the large-scale soil and moisture conservation and water harvesting measures in the watershed. By adopting these

measures, it is possible to increase the survival percentage in tree crops may be even 90-95 percent. The technique is most effective since the deep-rooted perennial fruit trees can draw the runoff water concentrated even in the deep soil profiles from the few rainfall incidences. However, the runoff generation depends upon several characteristics of the catchments e.g. size, slope, soil structure, covers surface characteristics such as compaction, smoothness,

Table 1. Catchments area per tree and plant population per hectare with different slopes of sandy catchments

Fruit	Canopy area (m^2)	Runoff supple-ment (mm)	Catch-ment's slope (%)	Catch-ment's area (m^2)	Area per tree (m^2)	Popul-ation per ha
Ber	36	300	0.5	100	136	74
			5.0	75	111	90
			10.0	60	96	104
Pome-granate	20	800	0.5	148	168	60
			5.0	111	131	76
			10.0	89	109	92
Guava	56	800	0.5	415	471	21
			5.0	311	367	27
			10.0	249	305	33
Fig	56	800	0.5	415	471	21
			5.0	311	367	27
			10.0	249	305	33
Aonla	56	500	0.5	259	375	32
			5.0	194	250	40
			10.0	156	212	47
Sour Lime	36	1000	0.5	333	369	27
			5.0	250	286	35
			10.0	200	236	42
Custard apple	20	300	0.5	56	76	132
			5.0	42	62	161
			10.0	33	53	189

vegetation, etc., besides rainfall pattern (intensity and duration etc.) of the region. Therefore, catchments size, its slope and other characteristics would vary in different regions.

The watersheds are divided into micro catchments considered optimum either for a tree or a group of trees, arranged in a row or other patterns suited to the location. In nearly flat areas, catchments could be provided on two sides of a tree row or around each tree. The optimum catchments are worked out considering water requirement and root architecture of the fruit specie, on one hand, and the expected water input through rainfall and runoff, on the other. Study gave estimates of the catchments area (Table 1) required per tree and tree per hectare of different fruits for growing in sandy catchments. Using the formula, A= TS/RC, where A is catchments area per tree in m^2, T is canopy are of the tree in m^2, S is runoff supplement required in mm per tree to meet the rainfall deficit, R is average annual rainfall in mm and C is runoff coefficient of the soil.

Ber plantation has been raised with in situ runoff concentration system under hot arid climatic conditions of North West India. The fruit yield in Gola and Seb cultivars of ber increased with increase in degree of slope and decreased with length of run as a result of increase in runoff and moisture storage in a 3 m soil profile. The highest fruit yields were obtained when 0.5 and 5 percent respectively had 8.5 and 7 m length of run and 72 and 54 m^2 catchments area per tree giving 2 and 1.5 contributing per planted area ratios.

Water harvesting (Runoff collection and storage):

Water harvesting refers to collecting the excess run-off from rain on the farm in ponds and utilizing it later for both domestic and agricultural uses. The systems either concentrate water into a storage reservoir or apply water directly to the soil in the cropped area. Both types of systems can vary in scale from a few hectares benefiting a single farmer to a few hundred hectares (watershed) saving a larger group of people. Rainwater harvesting is achieved either (i) *in-situ* through terraces, trenching, conservation tillage, mulching, contour barrier and run-off controlling crops, or (ii) *ex-situ* collection of run off in devices such as tanks, ponds, reservoirs and dams. Rainwater harvesting through tanks, ponds and reservoirs has been practiced traditionally in India for a long time. Several indigenous methods based on local wisdom were devised to store the rainwater in dry Rajasthan (in the form of nadi, tanka, khadin and percolation tanks); bhandharas in Maharashtra; bandhis in MP and UP; and ahars in Bihar (Samara *et al.*, 2002). Due to the limited volume of water that can be stored in these traditional structures, the technology is usually used together with other water-saving measures such as sowing the plants with a small amount of water at the time of planting, plastic mulching, root zone drip irrigation, sprinkler irrigation and under mulch irrigation. Especially the micro-irrigation systems like drip and sprinkler economize both water and fertilizers. These systems could be popularized to increase the productivity of limited rainwater. And therefore, the stored water can be successfully used in the production of cash crops like watermelon, greenhouse vegetables and fruit crops; thereby it will also provide an even greater economic benefit to the framer. The use of harvested rainwater for supplementary irrigation in the stress period particularly to trees and crops caused tremendous increase in the yield of several crops in different regions (Venkateswarlu, 1981). Most common tankas are 2.5 to 3 m deep having storage capacity of 10 to 21 m^3. More recently, tankas of 50 m^3 capacity have successfully been popularized for meeting drinking demands as well as establishing horticultural plantations in 1 ha area (Gupta *et al.*, 1998). Studies conducted at Jhanwater watershed near Jodhpur, harvested rainwater from a farm pond of 271 m3 capacity was used to grow *ber* plantation and subsequently to provide supplemental irrigation, which resulted in increased fruit yield (8 q ha^{-1}) with 1.67 : 1 benefit : cost ratio (Narain and Goyal, 2005). Some more studies also revealed that supplemental irrigation from tankas in loamy sand soils had increased fruit yield by 46-124% of ber (*Ziziphus mauritiana*) and 70-199% of pomegranate.

Thus water harvesting and its utilization have become a strategic measure for social and economic development in this region, providing an effective means of alleviating poverty and allowing a breakthrough in dry land farming/ horticulture.

Water management for harvested water :

Development of dry land/arid horticulture as understood does not mean that no irrigation development altogether takes place as part of this programme. Giving one or two irrigation to a crop at certain critical stages of water stress during its growth cycle is now recommended in dry land/arid horticulture. To make such irrigation possible, dry land horticulture development includes watershed development programme. The irrigation is provided once/twice in the crop season from the meager water resource such as farm pond/wells giving less water.

Soil management

The loss of soil moisture through evaporation, especially in arid regions can amount to 50% or more of total precipitation (Hillel, 1998). This much evaporation losses can be reduced by modifying the albedo of the sandy soil through mulching. Covering or mulching the soil surface with vapour barriers or with reflecting materials can reduce the intensity with which external factors, such as radiation and wind, act on the surface (Hanks, 1992). Reductions in direct evaporation of water from the soil surface could improve the efficiency with which water is used. For decades, the farmers have been trying to use various materials such as dry leaf, paddy straw, paddy husk, jowar trash, saw dust, dry grass, dry sugarcane leaves, dry coconut leaves, coconut husk etc. for reducing water evaporation losses. Checking weed growth, and create a micro-climate which regulates soil temperature, humidity and microbial activity. However, all these materials, though beneficial, were found to have inherent weaknesses and cost disadvantage. This lead to the use of plastics films as mulches, which are today the most preferred material. At present, around 10,000 ha area is under plastics mulching in India (Choudhary and Kumar, 2005). The importance of synthetic mulches especially in vegetable crops has been proved beneficial in increasing the soil moisture conservation, moderating the soil temperature and eliminating the weed growth and hence increases the crop yield. LDPE and LLDPE plastic films are commonly used for mulching. LLDPE black colour mulch films are more popular owing to the twin properties of possible down-gauging and better puncture resistance. Down-gauging leads to the availability of thinner films at lower cost and the puncture resistance and opacity check the weed growth under the film.

Comparative performance of synthetic and organic mulches with control in brinjal (*Solanum melongena* L.) grown in aonla based multistory cropping system was studied by Awasthi *et al.* (2006) under hot arid ecosystem of Bikaner. The results revealed that synthetic mulches (black and white polyethylene of 75 micron thickness) conserved 46 to 50 more moisture in comparison to control. The effect of synthetic mulches (77-84%) was more pronounced on fruit yield than the organic mulches (58-60%) compared with control. In one study, it was also reported that straw mulching increased the mean yield of tomato and okra by 107 and 388%, respectively.

Table 2. Area covered under drip irrigation in India

S. No.	State	Hectare
1	Maharashtra	46000
2	Karnataka	31500
3	Tamil Nadu	21000
4	Andhra Pradesh	15000
5	Kerela	4700
6	Gujarat	4500
7	Madhya Pradesh	2300
8	Orissa	1750
9	Rajasthan	1700
10	Haryana	1400
11	Punjab	1100
12	Uttar Pradesh	700
13	Goa	300
14	Nagaland	250
15	Manipur	200
16	Sikkim	100
17	Others	2500

Table 3. Fruit crop-wise area under drip irrigation in India

S. No.	Crop	Hectare
1	Coconut	36000
2	Grapes	36000
3	Banana	22500
4	Citrus	21000
5	Mango	19500
6	Pomegranate	17000
7	Sapota	6000
8	Ber	6000
9	Guava	4500
10	Arecanut	4500

Micro Irrigation

The growth of micro irrigation has gained momentum in the last ten years. From a mere of 1500 hectares in 1985, the area under drip irrigation has gone to over 3.0 lakh hectares at present (Singh *et al.*, 2000). Coverage of total and fruit crop area under drip irrigation at national level is presented in Table 2 and Table 3.

Drip irrigation or more broadly known as micro irrigation is mainly suited for orchard and plantation crops where it saves 30-70 per cent irrigation water and increase yield by 25-80 per cent. Evidences from drip irrigation trials have clearly indicated the advantages like water saving, higher productivity, limited weed growth, better management of assets, off season maturity, better fruit quality and reduced

Table 4. Relative performance of crops with drip irrigation in comparison with that of traditional irrigation methods

Crop	Location	Yield (q ha^{-1})		Irrigation water (cm)		WUE (Q ha^{-1} cm^{-1})		Advantages of drip irrigation	
		Surface	Drip	Surface	Drip	Surface	Drip	Saving of water (%)	Increase in yield (%)
ASH gourd	Jodhpur	108	120	84	74	1.3	1.6	12	10
Beet	Coimbatore	5.7	8.9	86	18	0.07	0.5	79.1	36
Bottle gourd	Jodhpur	380	558	84	74	4.5	7.5	12	31.9
Bitter gourd	Chalakudy	32	43	76	33	0.42	1.3	56.6	25.6
Brinjal	Akola	91.0	148.0	168.0	64.0	0.55	2.3	62.0	38.5
	Delhi	280.0	33.8	45.0	35.0	6.2	9.7	22.2	17.2
	NCPA	280.0	320.0	90.0	42.0	3.11	7.6	53.3	12.5
	Pune	225.0	245.0	78.0	51.0	2.9	4.8	34.6	8.2
	Rahuri	280.0	280.0	90.0	42.0	3.11	6.7	53.3	0.0
Broccoli	Delhi	140	195.0	70.0	60.0	2.0	3.25	14.3	28.2
Cauliflower	Akola	83.0	116.0	39.0	26.0	2.1.0	4.5	33.3	28.4
Chilly	Pantnagar	171.0	274.0	27.0	18.0	6.3.0	15.2	33.3	37.6
Cucumber	NCPA	42.3	60.9	109.0	41.7	0.30	1.5	61.7	30.5
Ladyfinger	Pune	155.0	225.0	54.0	24.0	2.9	9.4	55.6	31.1
	Coimbatore	100.0	113.1	53.5	8.6	1.87	13.2	84.0	11.6
	Delhi	360.0	480.0	42.0	26.0	8.6	18.5	38.1	25.0
	Rahuri	189.0	203.0	219.0	113.0	0.86	1.8	48.4	7.0
Onion	Delhi	284.0	342.0	52.0	26.0	5.5	13.2	50.0	17.0
	Hisar	93.0	112.0	50.0	45.0	1.6	2.5	25.0	17.0
Potato	Delhi	172.0	291.0	60.0	27.5	2.9	10.6	54.2	41.0
	Hisar	235.7	344.2	20.0	20.0	11.8	17.2	0.0	31.5
	Parbhani	334.0	480.0	30.0	22.0	11.1	21.8	26.7	30.4
Raddish	Coimbatore	10.5	11.9	46.0	11.0	0.23	1.1	76.1	11.8
Sugarbeet	Hisar	418	489	50.0	37.0	8.4	13.2	26.0	14.5
Sweet potato	Coimbatore	42.4	58.9	63.0	23.0	0.67	2.4	60.3	28.0
Tomato	Akola	45.0	58.0	102.0	77.0	0.44	0.75	24.5	22.4
	Coimbatore	6108	88.7	49.8	10.7	1.24	8.28	78.5	30.3
	Delhi	257.0	396.0	47.0	25.0	5.5	15.8	46.8	35.1
	Ncpa	320.0	480.0	30.0	19.0	10.7	25.3	36.7	33.3
	Pantnagar	104.0	137.0	22.0	14.0	4.7	9.8	36.4	24.1
	Parbhani	320/0	480.0	32.4	22.2	9.9	21.6	31.5	33.3
	Pune	292.0	413.o	31.0	20.0	9.4	20.7	35.5	20.3
	Rahuri	16.4	17.2	29.7	20.8	0.6	0.82	30.0	4.7
	Udaipur	144.0	175.0	41.0	28.0	3.5	6.3	31.7	17.7
Banana	Hawanisagar	277.0	329.0	186.0	172.0	1.5	1.9	7.5	15.8
	Kharagpur	290.0	400.0	106.0	106.0	2.74	3.8	0.0	27.5
	Ncpa	575.0	875.0	176.0	97.0	3.27	9.0	45.0	34.3
Ber	Belvatgi	13.7 kg/tree	18.0 kg/tree	15.4 m^3/plant	12.5 m^3/plant	0.9	1.4	18.8	23.9
Grapes	Dharwad	101.0	101.0	53.0	28.0	1.91	3.6	47.2	0.0
	Ncpa	264.0	325.0	53.0	28.0	5.0	11.6	47.2	18.8
Guava	Allahabad	0.16 /plant	0.22 /plant	6.4 m^3/plant	5.21 m^3/plant	0.03	0.04	18.6	27.3
Kinnow	Delhi	68.0	98.0	22.1	17.3	3.1	5.7	21.7	30.6
Lemon	Delhi	15.0	27.0	23.0	17.5	0.65	1.54	23.9	44.4
Papaya	Coimbatore	130.0	230.0	228.0	73.0	0.6	3.20	685.0	43.5
	kalyani	312.0	383.0	24.0	11.0	13.0	34.8	54.2	18.5
Pomegranate	Belvatgi	7.4	14.4	10.7	8.7	0.7	1.7	18.7	48.6
	Delhi	34.0	67.0	21.0	16.0	1.62	4.2	23.8	49.3
	Hyderabad	15.0	37.0	183.0	178.0	0.08	0.21	2.7	59.5
Water Melon	Jodhpur	294.6	882.0	80.0	80.0	3.7	11.0	0.0	66.6
	Pune	82.1	504.0	72.0	25.0	5.9	20.2	65.3	16.3

incidence of insects and pests and disease (Sivanappan *et al.*, 1978).

Mis-management of available irrigation water throughout the tree growth is one of the reasons for low productivity in fruit crops. Thus, the available water must be used effectively and efficiently for the fruit crops so as to increase their productivity.

Magar and Firke (1994) reported the results in respect of the quantity of water applied, water saving and water use efficiency compared to conventional method of irrigation in different fruit crops. The relative performances of crops with drip irrigation in comparison with that of traditional irrigation method studied at various locations and their results were given in Table 4.

Banana (*Musa* Spp.)

Banana is one of the important fruit crops of the country, which consume huge quantity of water (Rajput and Sharma, 1998). Sivanappan *et al.* (1977) reported better performance of banana under drip irrigation compared to surface irrigation method. Tiwary *et al.* (2000) reported the increase in yield and net seasonal income of banana could be obtained by 60.2% and 61%, respectively, using drip irrigation with plastic mulch as compared to conventional basin irrigation. Shivanappan (2000) reported that in banana, drip irrigation increased the fruit yield by 52% and saved the 45% irrigation water over conventional system. Srinivas and Hedge (1990) reported that increasing evaporation replenishment upto 60% increase the yield

Table 5. Effect of methods of irrigation on growth and yield of Ganesh pomegranate

Method	Water used Litres	Tree height (m)	Stem diameter (m)	Fruit yield (q/ha)	WUE Q/ha cm
Check basin					
0.6 IW/CPE	4800	2.35	3.78	40.6	0.82
0.8 IW/CPE	6600	2.56	4.02	47.5	0.69
Trickle Daily					
20% WA	3580	2.16	3.79	52.5	1.25
30% WA	5322	2.44	4.02	55.9	0.72
Alternate day					
20% WA	3580	2.30	3.84	48.6	1.16
30% WA	5322	2.24	4.01	57.3	0.92

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significantly. Srinivas and Singh (1992) demonstrated that drip irrigation saved water to the tune of 45% in banana. In semi-arid conditions, about 10% increases in yield and 50% water saving has been reported (Anonymous, 1987). At NRC for Banana, Trichy, in cv. Poovan, it was observed that maximum number of fruits per bunch and bunch weights were recorded with higher level of irrigation and nitrogen fertigation.

Pomegranate *(Punica granatum)*

Sivanappan and Natrajan (1976) reported that drip irrigation system may prove to be economic and water saving for pomegranate orchard. Bangal *et al.*, (1987) reported that pomegranate crop requires irrigation from January to July for fruit harvest and drip system with mulch saved about 78% irrigation water over check basin system. Pampattiwar *et al.* (1993) found that drip irrigation method, applying water equivalent to 20 per cent area is superior method of water application over surface method and average annual irrigation requirement of pomegranate through drip method is 20cm. Varshney *et al.* (1993) reported that in cv. Ganesh, drip irrigation, in addition to water use efficiency, marketable produce increased as no cracking was observed. In arid conditions of western Rajasthan, Sharma *et al.* (2001) found that in pomegranate crop, drip irrigation system saved 25% irrigation water and increase the yield by 87.5% over pipe irrigation system. Trickle irrigation on alternate day with 30% wetted area gave maximum fruit yield (57.3 q ha^{-1}) of Ganesh cultivar of pomegranate (Anon., 1987). Kulkarni (1988) reported that water use efficiency was maximum (3.38 q ha^{-1} cm^{-1}) in 20% wetted area daily treatment followed by 20% wetted area drip irrigation alternate day (3.32 q ha^{-1} cm^{-1}). In fertigation trial, it was observed that irrigation @ 20 per cent AWC along with 125 percent level of fertilizer dose have given maximum fruit yield (Anonymous, 2000) The data in Table 5 revealed that although tree growth was not affected, the fruit yield and water use efficiency were considerably increased by drip irrigation in *cv.* Ganesh pomegranate at Rahuri in Maharashtra.

Ber (*Ziziphus mauritiana*)

In northern India most crucial period of irrigation in ber is during the commencement of new flush and fruit development and which comes respectively between June to July and September to January. Considering the season and soil conditions, ber plants requires about 20-35 litres water per day. Singh *et al.* (2000) reported that in drip irrigation system saved about 19% irrigation water and increased the fruit yield by 24% over surface irrigation system. Sharma *et al.* (2002) reported that in extreme arid conditions, drip fertigation saved the 25% irrigation water and increased fruit yield (87.5%) over pipe irrigation system. The maximum water use efficiency (21.05 g l^{-1}) in ber was recorded when plants were irrigated at 0.75 CPE through drip (Anonymous, 2002).

Aonla (Emblica officinalis)

Aonla is a promising fruit crop for arid and saline wastelands (Supe, 1995). In this crop, optimum availability of soil moisture can enhance the quality of the fruit. Under North Indian conditions plant growth occurs during March and April and August to November, therefore, assured irrigation to this crop is very much essential. Considering the critical stage of growth and fruit development, 160-180 days of irrigation through drip is essential during this period. Irrigation regimes and frequencies influence the growth characters of plants. Maximum plant height, girth and spread were recorded with 60% CPE level of irrigation at 3

days interval. Shukla and Pathak (1996) reported that irrigation through drip with plastic mulch increased the fruit yield and plant growth in saline-sodic soils.

Mango (*Mangifera indica*)

Experiment conducted at Rahuri indicated that micro irrigation through drip could save 50 pe rcent of irrigation water (Desai, 1995). At CISH, Lucknow, in mango cv. Dashehari, the results revealed that the irrigation to the tune of 60 per cent open pan evaporation combined with fertigation (half dose of N) has recorded highest yield (83.10 kg/tree) in young orchard as compared to control (56.24 kg/tree) (Anonymous, 2000).

Guava (*Psidium gujava*)

Singh *et al.* (2000) reported that drip irrigation saved about 19 per cent irrigation water and increased the fruit yield to the level of 27 per cent over surface irrigation method. In cv. Sardar, the results revealed that the irrigation at 60 per cent replenishment of evaporation along with 50 percent nitrogen fertigation had produced maximum yield (75.11 kg/tree) followed by 40 and 20 per cent replenishment of evaporation (62.87 and 39.06 kg/tree), respectively (Anonymous, 2000)

Citrus

In North India, weekly irrigations are provided during March-June and fortnightly during November-February (Ghosh, 1985). The critical period for irrigating citrus trees is during summer when frequent light irrigations help to lower soil temperature and to raise humidity (Singh, 1969). During spring and summer months, soils may somewhat dry out but wilting should never be allowed to occur. Even in high rainfall areas, water stress may occur in summer. During summer (May-June), irrigation should be done at weekly interval (Singh, 1978). In Nagpur mandarin, water stress of 30 to 40 days duration in December-January, followed by scheduling of irrigation after flowering at 50 to 75 per cent depletion of available moisture, in clay loam soil under hot, dry climatic conditions, resulted in optimum growth and fruit yield (Chinappa *et al.*, 1977).

Date Palm

The date orchards must be regularly supplied with irrigation water during the flowering and fruit development period i.e., during February to August in North West India. To maintain vigour, less frequent irrigations are required during rest of the year. Date palm can withstand in high saline irrigation water.

Grape

In North India, vines need regular irrigation from March to June during the growth and fruiting period. No watering is normally done during the dormancy period in water. However, one or two irrigations may be required if there is prolonged dry spell. The first irrigation is applied after pruning and the second after 25-30 days to ensure good fruit set. Later on, irrigation is applied at 7-10 days interval until fruit maturity, depending on growth phase, temperature and other environmental factors. Withholding watering during flowering results in high bunch and berry weight and yield but lack of irrigation at fruit set and moisture stress during berry development reduces fruit size and yield. Frequent heavy irrigations before fruit set encourages vegetative growth at the cost of fruiting. Irrigation is normally stopped when berries have started maturing. Excessive irrigation at this stage would cause splitting and rotting of berries and reduction in fruit quality. Prolonged flooding also destroys the root system. However, the vines should not suffer of water stress. In North India, up to 9 irrigations from March to the ripening of fruits in June are given. In Western India, 6 irrigations are given during the fruiting season from October to March and 3 from April till the break of monsoon (Singh, 1969). In South India, vines are irrigated weekly from the time of summer pruning until the onset of monsoon and thereafter at 10-12 days interval until winter pruning (IIHR, 1986). Too frequent irrigations are avoided after summer pruning as it adversely affects flower initiation by promoting vegetative growth. Similarly, too frequent irrigations from flower opening to peak stage of berries should also be avoided as they aggravate the problem of downy mildew disease.

Some of the specific research strategies to enhance the water productivity in horticultural crops would be as under :

a) The water requirements of the field crops under surface irrigation are reasonably well known. However, the water requirement of orchard crops under different agro-climatic zones of the country needs to be worked out.

b) The moisture distribution pattern consisting of wetting zones in the horizontal and vertical directions would differ from soil to soil according to infiltration characteristics and other factors. It is essential that the wetting pattern have to be studied properly for different crop-soil combinations to evolve the requirement of wetting at different stages for attaining the higher water efficiency under micro-irrigation.

c) The irrigation frequency and proper scheduling need to be established for different crops under varied soil and climatic conditions.

d) A scientific basis for replenishing moisture in root zone at different stages of tree growth has to be standardized under micro-irrigation system.

e) The application method, fertilizer quantity, frequency and mode of applications should be determined for different crops under different soil and climatic conditions of the country.

f) It is necessary to evolve a package of practices to use saline water for tolerant crops through micro-irrigation system in salt affected areas of the country.

g) Experimental studies should be carried for exploring the feasibility of micro-irrigation system in other areas.

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Impact of polyploidy on morphological and physiological parameters in ber

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Abstract

Polyploidy has played a pivotal role in the evolution of plants and production of genetic variability. Although, the impact of polyploidy on plant vegetative, floral and fruit characters have been documented indepth, but impact on physiological efficiency has been studied rarely. The present attempt was to screen the polyploid taxa on the basis of physiological parameters in a polyploid sense of ber (*Ziziphus mauritiana* Lam.). Our results demonstrated that in this species, the polyploidy has shown variable effect in different cultivars. In cv. Illaichi it reduced the physiological efficiency but in cv. Gola it maintained at par.

Key words: *Ziziphus mauritiana, photosynthetic rate, polyploidy*

Introduction

Ber (*Ziziphus mauritiana* Lam.) also known as poor man's fruit and desert apple is an important fruit crop of arid and semi-arid ecosystem. The plants are drought hardy and hence can produce economic yields under low moisture availability. The fruits are rich in vitamins (C,A and B-Complex) and minerals. Since cultivation of ber requires less care hence, the trees can be grown in resource poor areas. A rich genetic diversity of this crop has been collected and maintained at National Repository of CIAH, Bikaner (Shukla *et al.*, 2004a).

The analysis of karyotype of ber has revealed that the genus has the basis number x = 12 (Bowden, 1945; Khoshoo and Singh, 1963; Nehra *et al.*, 1983). Among the genetic variability available in India Khoshoo and Singh (1963) reported 2n =48 in about 33 genotypes. Similarly, Nehra *et al.* (1983) reported the chromosome number to be 96 in cv. Illaichi, Gola and Bordi and 2n =48 in cv. Umran.

Despite the fact that the cultivars of *Z. mauritiana* demonstrate variable chromosome numbers. Yet the attempts to study the impact of this on plant morphometry and physiological parameters is scanty. Accordingly, during the course of present study, an attempt was made to evaluate the effect of polyploidy in 4 cultivars of ber differing in their chromosome numbers.

Material and methods

The studies were undertaken on well established trees of 4 cultivars viz. Umran, Seb, Gola and Illaichi. The plants were 7 years old and in bearing stage. The normal, uniform cultural practices were adopted in all plants. The data on plant morphometry was recorded during the month of December. The plant height, spread were recorded with the help of measuring pole. The leaf dimensions were recorded in centimeter.

The observations on rate of photosynthesis and associated parameters were measured, on well established plants of cultivars under study. The observations were recorded during fruiting season in the forenoon using LI-6200 Infra Red Gas Analyzer. The values of carboxylation efficiency and water use efficiency were measured by using the method as described by Das *et al.* (1999).

Results and discussion

Impact of polyploidy on vegetative parameters

The influence of polyploidy on plant morphometry was earlier studied in a variety of plants (Stebbins, 1971; Bose and Flory, 1965; Raghuvanshi and Pathak, 1975; Karihaloo, 1977 and Singh, 1990).

During the course of present study, two cultivars having genomic constituents as tetraploid (Umran and Seb) and two with genomic constitutent as Octaploid (Gola and Illaichi) were studied for the impact of polyploidy on vegetative characters. The data thus obtained are presented in Table 1. Perusal of table reveals that the plants of Gola demonstrated the maximum magnitude in terms of vegetative characters. This is illustrated by the fact that the plants of Gola are 4.58 m tall with stem diameter of 16.8 cm, having plant canopy spread of 5.3 m x 5.2 m and leaf size of 6.9 cm x 4.8 cm. On the contrary, Umran (4x) demonstrate the lowest magnitude with the plant height of 2.60 m, plant spread of 2.3 m x 2.8 m, stem diameter of 8.6 cm

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Table 1. Morphological parameters in polyploid series in ber

Variety	Pl. ht. (m)	Pl. spread (m)	Stem dia. (cm)	Leaf size (cm)	Pruned wood wt. (kg)
Umran (4x)	2.60	2.3 x 2.8	8.6	7.3 x 3.4	14.0
Seb (4x)	4.3	4.0 x 4.4	12.50	6.9 x 4.5	13.0
Gola (8x)	4.58	5.3 x 5.2	16.8	6.9 x 4.8	34.0
Illachi (8x)	3.50	2.8 x 3.0	16.8	7.5 x 5.0	08

and leaf size of 7.3 cm x 3.4 cm. The other two cultivars showed intermediate values. Thus, our study reveals that polyploidy showed differential response in terms of its effect on plant vegetative parameters. In case of Gola it enhanced the magnitude but in case of Illaichi it reduced the magnitude with respect to Seb but shows improvement over Umran (4x). The results are in line with those reported by Chaudhry (1996) who reported that tetraploidy increases vegetative growth.

That the plants shows differential response in terms of polyploidy has been demonstrated earlier also. In case of *Naricissus tazelta*, similar variations has been reported among different cultivars (Bhargava *et al.*, 1985).

The pruned wood weight was also estimated in each case which reflects the quantum of vegetative growth achieved during season. It was demonstrated that Illaichi (8x) had the lowest pruned wood weight (8 kg.). The tetraploid types Umran and Seb had 14.0 and 13.0 kg respectively. But Gola (8x) demonstrated highest pruned wood weight (34.0 kg). The results thus reveal that in cultivar Gola (8x) the polyploidy has enchanced the magnitute of vegetative parameters but in Illaichi it has depressed the same.

Impact of polyploidy on fruit characters

The impact of polyploidy on fruit characters were also studied during the course of present study. The data thus generated is presented in Table 2. Perusal of data reveals that, as in case of vegetative parameters, with respect to fruit characters also, the cultivars showed variable response with the imposition of polyploidy.

Perusal of data in Table 2 reveals that Seb (4x) showed the minimum length but highest diameter. Whereas, Umran (4x) showed maximum length and moderate diameter. On the contrary, the fruit of Gola (8x) and Illaichi (8x) demonstrated smaller fruit size as compared to Umran. This illustrates that in ber, the polyploidy has reduced the size

Table 2. Fruit characters in polyploid series of ber

Variety	Fruit size (cm)	Fruit wt. (g)	Stone wt (g)	TSS (°Brix)	Yield (kg/ tree)
Umran (4x)	5.3 x 3.8	50	1.10	20.00	42.0
Seb (4x)	2.8 x 4.2	42.0	1.95	21.0	32.0
Gola (8x)	4.0 x 3.7	35.0	1.9	22.50	35.0
Illachi (8x)	3.1 x 3.1	8.0	0.7	24.0	18.0

of fruit. Perusal of data on fruit weight and stone weight also demonstrated that imposition of polyploidy has reduced the fruit and stone weight. This is illustrated by the fact that the average fruit weight of Gola (8x) and Illaichi (8x) is only 35.0g and 8.0 g respectively, whereas that of Umran (4x) and Seb (4x) was 50.0g and 42.0g, respectively. Similar, trend was also observed with respect to stone weight and fruit yield (Table 2). Similar results has also been shown by Singh (1990) and Pathak and Pathak (1993) where it has been demonstrated that polyploid reduces the vegetative and fruit characters.

Although, the polyploidy has reduced the morphometric parameters in ber, but it has further improved the TSS content of ber fruits. This is illustrated by the fact that TSS of Umran (4x) and Seb (4x) was 20% and 21% respectively whereas in octaploid taxa Gola (8x) and Illaichi (8x) it was 22.5% and 24% respectively.

Impact of polyploidy on physiological parameters

Some physiological parameters were also investigated in these polyploid taxa which are presented in Table 3. Perusal of data presented in Table 3 reveals that the cultivars showed variable response with respect to polyploidy.

In case of cv. Illaichi (8x) the photosynthetic rate was found to be lowest (0.935 mg CO_2 $m^{-2}s^{-1}$) as compared of other cultivars. Similarly, the water use efficiency (1.23) was moderate and carboxylation efficiency (0.09) was also reduced as compared to tetraploid taxon. The cultivar also recorded lowest RWC (64.59%) and a higher rate of transpiration (1.143 mg H_2O $m^{-2}s^{-1}$). All these parameters reveals that cv. Illaichi has poor photosynthetic rate which reflects on the low yield of the cultivar (18 kg/tree).

In contrast to above cv. Gola (8x) is at par with Umran (4x) in the rate of photosynthesis, has lowest transpiration rate (0.666 mg H_2O/m^2 s^{-1}.), maintain high RWC (91.32%) but has poor carboxylation efficiency (0.097).

The cv. Seb (4x) had the highest photosynthetic rate

Table 3. Physiological parameters in polyploid series of ber

Variety	Photosynthesis rate (mg CO_2 $m^{-2}s^{-1}$)	Transpiration rate (mg $H_2Om^{-2}s^{-1}$)	Stomatal conductance (cm s^{-1})	WUE	Carboxylation efficiency	RWC (%)
Umran (4x)	1.087	1.130	2.259	0.955	0.087	88.39
Seb (4x)	1.468	0.739	2.691	1.980	0.164	76.43
Gola (8x)	1.057	0.666	3.867	1.587	0.097	91.32
Illachi (8x)	0.935	1.143	2.585	1.234	0.090	64.59

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Variation and association of ber Genotypes for powdery mildew and contributing traits

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Abstract

Thirty-five genotypes of ber collected from different places were studied for their variance, heritability, genetic advance and correlation coefficient for various traits. The PCV was higher than GCV, as powdery mildew exhibited highest PCV (52.76) and GCV (41.72) while highest heritability observed for fruit length (99.01). High Genetic advance as percent mean was observed for powdery mildew (96.09). Powdery mildew also has highly significant and positive correlation with fruit breadth (0.3483). So powdery mildew, stone breadth stone weight, fruit weight, etc., should be given due consideration while performing selection for jujube improvement.

Key words: *Variability, heritability, correlation, powdery mildew, Ziziphus mauritiana*

Introduction

In India, there is rich biodiversity of Indian jujube (*Ziziphus mauritiana* Lam.). It is one of the most ancient and common fruits of India. It belongs to buckthorny family (Rhamnaceae) and is grown throughout the tropical, sub-tropical and arid regions of the world but it is most popular fruit of arid region. The northern India is unique due to its typical climatic conditions. Indian jujube is quite popular due to low cost of cultivation, wide adaptability, ability to withstand drought and good economic returns. In its cultivation, powdery mildew caused by *Oidium eryriphoides* f. zhizhyphi Fr, is a serious problem leading to varying degree of losses in all the ber growing regions of India. All the cultivars with large fruit size succumb to this disease under high input management conditions, sometimes rendering the entire produce unmarketable. Small fruits are reported to be less susceptible (Pardeep and Jambhale, 2001).

The possibility of improvement in any crop is measured by variability available in the crop. Wider the genetic variability, greater the chances of improvement with respect to different desirable traits. Knowledge of association between powdery mildew and contributing traits of crop is of paramount importance in selection and hybridization programme particularly for Indian conditions. Keeping this in view, the present investigations were undertaken to know the association between powdery mildew and other traits and among them in Indian jujube thus an effort was made to identify the sources of resistance to powdery mildew for initiating resistance or tolerance breeding programme.

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Materials and methods

Thirty-five genotypes of *Ziziphus mauritiana* were studied for ten morphological traits. The selected genotypes planted at 8 m x 8 m spacing in RBD with three representative plants of twenty-seven year age, having uniform training and pruning budded on *Ziziphyus rotundifolia* rootstock constituted as experimental plant material.

The observations were recorded for ten traits viz., powdery mildew, leaf length, leaf breadth, leaf area, fruit weight, fruit length, fruit breadth, stone weight, stone length, and stone breadth during 2005-2006. The statistical analysis for estimating the genotypic and phenotypic coefficients of variation, heritability in broad sense, genetic advance as percentage of mean were done as suggested by Burton (1952). Phenotypic and genotypic correlations were calculated as per Fisher (1954).

Results and discussion

The mean sum of squares due to genotypes were highly significant (at 1% level) for all the traits (Table 1) which indicated that sufficient amount of variability was present in the germplasm for all the traits. The PCV was higher than GCV (Table 2). Powdery mildew exhibited highest PCV (53.76) and GCV (41.72), which were followed by stone weight (34.44 g), fruit weight (30.76 g) and leaf

Table 1. Mean sum of square obtained from the analysis of variance for various traits in ber genotypes

Sr. No.	Source of replication	d.f.	Powdery mildew	Leaf length	Leaf breadth	Leaf area	Fruit weight	Fruit length	Fruit breadth	Stone weight	Stone length	Stone breadth
1.	Replication	2	50.25	0.53	1.5	10.87	0.47	0.01	0.01	0.00	0.17	0.01
2.	Treatment	34	1490.42	213.24	2.17	197.30	52.97	2.17	0.32	0.16	0.93	0.06
3.	Error	68	72.12	22.73	0.14	6.83	0.61	0.01	0.00	0.00	0.02	0.00
	CV (%)		19.56	6.28	7.57	9.28	5.64	2.34	1.94	9.93	5.72	8.08

Table 2. Mean range, coefficient of variation (genotypic and phenotypic), heritability and genetic advance for powdery mildew and its contributing traits in ber genotypes

Sr. No.	Traits	Mean ±SE	Range	Coefficient of variation		Heritability (%)	Genetic advance as % of mean
				Phenotypic	Genotypic		
1.	Powdery mildew	14.42±4.90	10.67-84.33	53.76	41.72	86.76	96.09
2.	Leaf length	9.21±0.33	6.73-13.83	16.52	2.68	85.55	29.12
3.	Leaf breadth	4.86±0.21	3.23-6.90	18.58	1.55	83.40	31.93
4.	Leaf area	28.13±1.51	14.83-51.99	29.79	15.60	90.29	55.40
5.	Fruit weight	13.82±0.45	3.92-20.88	30.76	8.46	96.64	61.23
6.	Fruit length	3.78±0.50	1.94-5.42	22.57	1.74	99.01	46.03
7.	Fruit breadth	2.67±0.03	1.93-3.30	12.25	0.66	97.50	24.60
8.	Stone weight	0.69±0.04	0.20-1.21	34.44	0.46	91.69	65.06
9.	Stone length	2.34±0.07	1.06-3.15	24.83	1.11	94.70	48.44
10.	Stone breadth	0.82±0.04	0.53-1.14	19.03	0.26	81.98	32.14

Table 3. Phenotypic and genotypic correlation coefficient among various traits

Sr. No.	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm)	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Stone weight (g)	Stone length (cm)	Stone breadth (c
1.	-0.2555	0.0734	-0.0857	0.2463	-0.1453	0.3483*	0.1552	-0.2253	0.1249
2.		0.5622	0.8300**	0.0042	0.1457	-0.0864	-0.0062	0.1718	-0.1606
3.				-0.0591	0.1414	-0.1781	-0.1840	0.1991	-0.3186
4.					0.7002**	0.8968**	0.6176**	0.6105**	0.3846*
5.						0.3622	0.4063	0.9636**	-0.0982
6.							0.6767*	0.2667	0.6620**
7.								0.4080*	0.8455**
8.									-0.1119
9.									-
10.									

area (29.79 cm²). This indicated that there was sufficient amount of variability present among genotypes for all these traits. Considerable genetic variability for yield and contributing traits were also reported in Indian jujube by Bisla and Daulta (1986). Heritability estimates were high for all the traits. The maximum heritability was recorded for fruit length (99.01%) while minimum for stone breadth (81.98%). The highest expected genetic advance as per cent of mean was observed for powdery mildew (96.09) followed by stone weight (65.06) and the lowest for fruit breadth (26.60). High heritability coupled with high genetic advance became more useful in selection were also reported by Bisla and Daulta (1986) and Saran *et al.* (2007a) in ber genotypes.

The correlation coefficients estimated in all the possible ways among the different traits are presented in Table 3. The values of genotypic correlation coefficient were higher than phenotypic correlation coefficient for all the traits. Powdery mildew had positive and significant correlation with fruit breadth (0.3483). Leaf length showed positive correlation with leaf area (0.830). Leaf breadth also showed positive correlation with leaf area (0.9648). The fruit weight showed high positive correlation with fruit length (0.7002), fruit breadth (0.8968), stone weight (0.6176) and stone length (0.6105). Fruit length has positive correlation with stone length (0.9636) and fruit breadth also has positive

correlation with stone weight (0.6767) and stone breadth (0.6620) while stone weight showed positive correlation with stone length (0.4080) and stone breadth (0.8455). Significant correlation of these traits suggests the scope of direct and indirect effective selection for further improvement for powdery mildew as well as yield of jujube crop. Similar reports on yield and quality of ber genotypes were also reported by Saran *et al.* (2007b) and Bisla and Daulta (1986). They observed that the significant positive correlation of these traits with fruit yield was due to fruit weight.

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Effect of intercropping in kinnow based production system

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Abstract

Intercropping under Kinnow based production system showed a significant effect on the growth of pre-bearing trees. The available nitrogen content during pre-bearing stage in leaves of Kinnow was found lower under all the intercrops and varietal combination thereof as compared to bearing trees and it increased progressively towards bearing of the tree. The intercrops did not show any significant effect on physico-chemical parameters of Kinnow fruits, whereas, the number of fruits/plant and fruit yield/plant was maximum under moong and minimum under cotton.

Key words: *Kinnow, intercrops, moong, cotton*

Introduction

Intercropping- a practice of growing two or more crops in association is gaining popularity in widely spaced crops primarily due to claims that it augments yield on sustainable basis. Kinnow mandarin is one of the major citrus fruits under irrigated aridisols particularly in canal command areas of western Rajasthan. Many crops such as vegetable, pulses and fodder crops have been found suitable for intercropping in citrus orchards (Bajwa and Jawanda, 1954).

Suitability of intercrops depends primarily on soil and climatic conditions, however, compatibility aspect deserves prime consideration. Crops of competitive nature, may it be for light, space, nutrients or due to chemo-toxicity, are largely unpreferential and such crops are usually not grown as an intercrop. Exhaustive crops like maize, wheat, sugarcane, cotton, etc. are not worth cultivation in citrus orchard (Krishnamurthy,1959; Naik,1963). In contrast, crops with companion and synergistic attributes are considered compatible.

Cultivation of compatible intercrop is sure to accentuate early income, optimize land use efficiency, facilitate better harvest of solar radiation, reduce the soil erosion, increase biological efficiency both in time and space dimensions in fruit based production system. With such considerations, present study was undertaken at Agriculture Research Station, Sri Ganganagar for systematic investigations and various types of intercrops and their interrelations with kinnow so as to draw inferences pertaining to suitable intercrop combination.

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Materials and methods

The present study was undertaken in pre-bearing and bearing Kinnow orchards of 3-5 and 8-10 years age, respectively raised on rough lemon at the farmer's field (Lyallpur Model Farm, Sri Ganganagar). The experiment was conducted for two consecutive years from 2001-02 and 2002-03, in randomised block design with three replications. During zaid, cotton and moong whereas in rabi, barley and gram and different combination theirof were grown in both bearing and prebearing orchards. The effect of intercropping on tree growth parameters, leaf nutrient status, number of fruits, fruit yield and physico-chemical parameters were studied. The canopy volume of tree was calculated as per standard formula = $(E\text{-}W+ N\text{-}S)^2/4 \times ½$ plant height x 4.19. The leaf samples were analyzed for N, P and K status by conventional methods. No.of fruits were counted and weighed to get yield. Physico-chemical parameters of the fruit were observed. Total soluble solids were recorded using hand refractometer. Titratable acidity of juice was determined by titrating the juice against 0.1 N NaOH using phenolphthalein as an indicator and expressed in terms of citric acid (AOAC, 1970). The data recorded were subjected to statistical analysis and their significance was judged at 5% level of significance.

Results and discussion

The data presented in Table 1 clearly indicates that there was significant effect of intercrops on the growth of the trees in pre-bearing and bearing orchards during first year (2001-02) of experimentation. However, in the second year of experimentation, there was non-significant effect on the growth of tree volume under pre-bearing stage.The data pertaining to the effect of intercrops on leaf nutrient status of kinnow crop is depicted in Table 2. The results

Table 1. Effect of intercropping on kinnow tree volume

Production System	2001-02 Prebearing (m^3)	2001-02 Bearing (m^3)	2002-03 Prebearing (m^3)	2002-03 Bearing (m^3)
Cotton -Moong	2.51	46.76	5.56	47.02
Cotton -Barley	3.19	42.86	5.27	47.66
Cotton -Gram	2.57	43.27	4.11	51.18
Cotton	2.43	35.34	3.87	47.58
Moong	2.61	35.64	5.58	48.23
Gram	2.47	45.04	5.42	59.48
Barley	2.45	47.61	5.18	49.60
Control	2.64	41.26	4.16	52.08
C D at 5%	0.10	1.32	N.S.	N.S.

indicated that available nitrogen content during pre-bearing in Kinnow leaves was lower than the normal leaves under all the intercrops as compared to bearing trees. However, the nitrogen content varied from 1.48 to 2.33% in bearing tree leaves (2001-03) under different production systems.

Table 2. Effect of intercropping on leaf nutrient status of kinnow trees

Production System	2001-03 Prebearing (%) N	P	K	2001-03 Bearing (%) N	P	K
Cotton -Moong	1.73	0.10	2.77	2.08	0.11	2.67
Cotton - Barley	1.55	0.11	2.71	1.72	0.11	2.71
Cotton -Gram	1.75	0.10	2.66	2.10	0.10	2.60
Cotton	1.36	0.10	2.72	1.48	0.12	2.95
Moong	2.05	0.11	2.48	2.10	0.12	2.85
Gram	1.96	0.10	2.55	2.15	0.11	2.80
Barley	1.33	0.10	2.69	1.95	0.11	2.65
Control	2.40	0.11	2.59	2.33	0.11	2.71
C D at 5%	0.54	N.S.	N.S.	0.48	0.45	0.80

This may be due to fewer requirements and consequently less absorption of nitrogen during pre-bearing stage of the orchard. This is also true for P and K content when pre-bearing and bearing orchard leaves are compared. The available K in the leaf was non- significant in both types of leaves during 2003.

The data presented in Table 3 on the effect of intercrops on physico-chemical characters of kinnow fruit did not show any significant effect on total soluble solids content, acidity and ascorbic acid content of kinnow fruits during both the years of experimentation i.e., 2001-03.

Table 3. Effect of intercropping on physico-Chemical parameters of kinnow fruit

Production System	TSS (° Brix)		Acidity (%)		Ascorbic acid (mg/100 ml juice)	
I 2001-02 I 2002-03	I	II	I	II	I	II
Cotton -Moong	10.40	10.06	1.09	1.04	26.13	27.20
Cotton -Barley	10.50	11.20	1.07	1.06	25.06	28.26
Cotton -Gram	11.13	10.40	1.01	1.00	22.93	35.20
Cotton	10.33	10.06	1.18	1.06	22.40	29.86
Moong	9.86	10.06	1.13	1.11	22.93	34.13
Gram	10.33	10.20	1.08	1.09	25.06	34.66
Barley	10.40	11.03	1.27	1.11	20.26	28.80
Control	10.26	10.16	1.04	1.09	25.06	29.33
C D at 5%	N.S.	31.66	N.S.	N.S	N.S	4.80

Perusal of data (Table 4) clearly shows that number of fruits/plant under various treatments varied from 219 under cotton to 299 under control. The less number of fruits/ plant under cotton intercropping might be due to exhaustive nature of cotton crop resulting in nutrient competition with the kinnow crop.

The number of fruits per plant under intercrops was maximum (293) in sole cropping of pulse moong closely

Table 4. Effect of intercropping on the number of fruits and fruit yield in bearing kinnow

Production System	No. of fruits/plant 2001-03 (Pooled Mean)	Fruit yield /plant (kg) 2001-03 (Pooled Mean)
Cotton-Moong	228	45.63
Cotton-Barley	277	53.67
Cotton-Gram	280	57.47
Cotton	219	43.78
Moong	293	58.76
Gram	260	50.97
Barley	224	46.19
Control	299	59.99
C D at 5%	9.34	8.28

followed by cotton-gram (280) and cotton- barley with (277) fruits. The yield per plant varied from 43.78 kg in cotton to 57.47 kg under cotton-gram intercrops. However, the yield/plant was maximum (58.76 kg) in sole cropping of moong and minimum under sole crop of cotton (43.78 kg). This indicated beneficial relationship of leguminous crops on kinnow trees owing to complimentary interaction of green gram being leguminous in nature. Similar findings were reported by Sanchez *et al.* (1991) who reported

beneficial effect of leguminous crops on sweet orange trees. Singh *et al.* (1999) also corroborated such type of findings and reported beneficiality of pulses as intercrops in mandarin orchards owing to their ability to mobilize atmospheric nitrogen to the plant system. Under cotton based production system in either or combination mode of intercropping, less yield of fruit was recorded. It may be attributed to competitive interaction of cotton for space, water, nutrient, O_2 and CO_2 required commonly for growth and production of the plant (Reddy and Reddy, 2005).

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Genetic variability and correlation studies in brinjal

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Abstract

The extent of genetic variability, heritability, genetic advance and correlations in respect of eight economic characters in 30 genotypes of brinjal were studied under hot arid environment. The phenotypic and genotypic coefficients of variation were high for number of fruits and fruit yield per plant and fruit weight. High heritability estimates along with high genetic advance for number of fruits and fruit yield per plant and fruit weight indicated the role of additive gene action. Correlation studies revealed that fruit yield per plant was significantly and positively associated with number of fruits per plant and fruit weight. The genotype AHB 02, KSB 73, KSB 33, KSB 39 and F_2 (AHB 04 x PPC) showed high mean performance for fruit yield per plant along with earliness trait which can be further tested for direct use as variety or may be used in breeding programme for improving fruit yield.

Key words : *Brinjal, genetic variability, arid environment*

Introduction

Brinjal (*Solanum melongena* L.) is the most popular vegetable and has regional consumer's preferences in the country. There is increasing demand of its varieties for different culinary purposes. In the arid and semi arid regions it is an important rainy-autumn season crop, and also to some extent it is taken as a *rattoon* and summer crop. A wide variation in the form of size, shape, colour, and quality of fruits and fruit yield potential is available in the land races being grown in these regions. The main reasons might be consumer's preferences for specific types of brinjal in the different localities/communities and different level of selection pressure for the maintenance of desirable land races/local types in this indigenous crop by the growers and tribal community (Samadia, 2004).

For crop improvement, the information on magnitude of genetic variability, heritability and extent of genetic advance of the desirable traits is essentially important because phenotypic selection depends on the range of genetic diversity present in the population. In spite of its commercial significance in the arid and semi arid regions of the country, not much has been done for the varietal improvement in the brinjal. Hence, an attempt was made to assess the genetic variability in the brinjal genotypes so as to develop superior genotypes for the environmentally stressed areas.

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Materials and methods

The study was conducted at Central Institute for Arid Horticulture (ICAR), Bikaner (28° N latitude and 73° 18' E longitude at an altitude of 235 m above mean sea level) in the rainy-autumn season of 2002-03 under hot arid agro - climatic conditions. However, the research work on germplasm evaluation (more than 100) was started from year 2000 but a set of thirty genotypes, of which 25 land races collected from parts of Rajasthan and Gujarat under NATP on sustainable management of plant bio-diversity and five potential genotypes, were employed for the analysis. The experiment was laid down in a randomized block design with three replications. Thirty-five days old seedlings were transplanted at 60 cm x 45 cm spacing in rows (20-25 cm deep furrows) of five meters in length accommodating eleven plants for each genotype/ replication. The observation were recorded from randomly selected five plants for each genotype in each replication for days to first harvest after transplanting (DFH, DAT), number of fruits per plant (NF/P), fruit weight (FW, g), fruit length (FL, cm), fruit diameter (FD, cm), plant height (PH, m), number of branches per plant (NB/P) and total fruit yield per plant (FY/P, kg). Fruit characters were assessed at marketable stage from ten randomly selected fruits. To assess the yield potential of the genotype, total number of fruits harvested per plant was taken into consideration i.e. 120 days of the harvesting period. The data were analyzed adopting standard procedures suggested by Panse and Sukhatme (1985), Burton and De Vane (1953), Johnson *et al.* (1955), Robinson *et al.* (1949) and Al Jibouri *et al.* (1958) using computer packages.

Results and discussion

Analysis of variance revealed highly significant genotypic differences for all the eight characters depicting greater diversity in the experimental material (land races/ genotypes) under study (Table 1 and 2). Among the land races, the earliest harvest (< 55 DAT) was recorded in KSB 61 (49.77 DAT) followed by KSB 73, KSB 77, KSB 78, KSB 63, KSB 67, KSB 39, KSB 46 and AHB 02. The number of fruits per plant ranged from 43.06 to 132.24. The genotypes, F_2 (AHB 04 x PPC), Pusa Kranti, KSB 52, KSB 33, KSB 64 and KSB 39 recorded higher number of fruits (>100) per plant. A wide spectrum of variations for weight (49.76 – 141.6 g), length (5.81 – 12.46 cm) and diameter (3.40 – 6.47 cm) of the fruits were recorded at marketable stage. The plant height and number of branches per plant ranged from 51.03-79.34 cm and 5.81-10.18, respectively. Among the tested genotypes, total fruit yield per plant ranged from 2.85-8.69 kg with a population mean of 5.58 kg. Maximum fruit yield per plant was recorded in AHB 02 (8.69 kg) followed by KSB 73 while minimum in KSB 78. The genotype AHB 02, KSB 73, KSB 33, KSB 39 and F_2 (AHB 04 x PPC) were found to be potential genotypes for higher early yield along with more number of fruits per plant. These five genotypes also possess good fruit quality characters like size, shape and colour for consumer's preferences. It is noteworthy that the land races/genotypes under investigation were diverse and had great potential for improvement for quality fruit yield of brinjal under arid environment.

Genotypic and phenotypic coefficient of variation (GCV and PCV) study indicated that there is an ample scope for the improvement of this crop (Table 2). In general, the

Table 1. Plant growth and fruit yield characters in brinjal genotypes under hot arid environment.

Genotypes	Days to first harvest (DAT)	Fruits/ plant	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)(cm)	Plant height	Branches /plant	Fruit yield plant^{-1} (kg)
KSB 8	68.31	58.37	59.27	8.23	5.76	66.63	7.30	3.42
KSB 12	72.42	59.62	75.19	11.18	4.34	71.55	8.40	4.39
KSB 20	64.61	55.29	100.31	7.82	6.46	66.74	7.13	5.32
KSB 21	63.42	71.56	80.80	6.58	6.75	72.69	6.10	5.68
KSB 31	58.30	54.39	80.54	6.34	5.83	71.20	9.10	4.34
KSB 33	58.51	119.00	65.53	7.44	5.60	79.34	8.30	7.66
KSB 35	56.26	81.11	58.54	9.30	4.55	56.68	7.10	4.67
KSB 39	55.62	106.28	67.99	6.15	5.47	61.48	10.18	7.13
KSB 42	56.53	55.70	98.51	9.65	5.21	59.22	7.21	5.36
KSB 46	55.27	72.76	74.64	6.75	5.79	66.98	9.25	5.23
KSB 47	56.77	98.38	52.55	6.51	5.19	62.30	9.25	5.14
KSB 52	67.32	122.78	65.18	8.36	4.74	65.35	10.14	7.79
KSB 55	72.28	56.14	85.01	8.64	6.21	71.05	8.22	4.76
KSB 59	70.89	51.89	141.67	8.46	6.46	57.51	8.14	7.15
KSB 61	49.77	75.36	68.38	12.46	4.14	63.32	7.19	5.08
KSB 63	52.32	89.34	50.80	11.30	3.40	60.41	8.52	4.47
KSB 64	66.41	115.48	59.83	8.22	5.63	58.06	8.21	6.67
KSB 67	52.37	59.31	75.52	10.80	5.83	63.56	9.27	4.37
KSB 73	50.82	82.79	100.27	7.55	6.46	65.28	8.38	8.28
KSB 77	51.54	43.06	69.03	5.81	5.29	61.35	5.81	2.91
KSB 78	51.60	55.79	52.16	11.48	6.22	67.05	7.04	2.85
AHB 01	57.52	72.73	77.71	6.34	5.43	55.99	8.15	7.13
AHB 02	55.21	85.00	104.90	6.71	5.81	63.40	7.19	8.69
AHB 03	70.22	48.51	72.84	6.64	6.47	60.01	8.69	3.45
AHB 04	70.57	62.32	106.28	7.24	5.24	57.41	9.25	6.48
F_2 (AHB 04 x PPC)	55.12	132.34	58.91	6.67	4.76	62.48	8.02	7.65
PKM 1	55.34	97.65	56.06	6.24	4.83	59.81	6.16	5.19
Pusa Kranti	53.24	123.78	53.81	8.48	4.19	61.21	8.06	6.30
Pusa Bindu	55.26	89.89	49.76	6.35	5.35	51.03	7.32	4.31
Arka Kusumkar	53.89	84.75	68.93	10.33	5.75	57.75	8.29	5.48
Mean	59.26	79.38	74.36	8.13	5.44	63.23	8.04	5.58
CV	3.14	4.42	3.94	1.76	2.59	3.71	6.04	3.42
C D at 5%	3.04	5.74	4.79	0.23	0.23	3.84	0.79	0.31

Table 2. Genetic variability characters for brinjal genotypes

Characters	Mean	SE	F Value	GCV (%)	PCV (%)	h^2 (broad sense)	Genetic advance	Genetic advance % of mean
Days to first harvest	59.26	1.07	45.75	12.13	12.33	97.81	14.64	24.71
Fruits/plant	79.38	2.02	157.76	31.98	32.18	99.37	52.14	65.68
Fruit weight	74.36	1.69	153.16	28.10	28.22	99.35	42.88	57.66
Fruit length	8.13	0.08	517.62	23.12	23.14	99.81	3.87	47.58
Fruit diameter	5.44	0.08	97.30	14.73	14.81	98.97	1.64	30.18
Plant height	63.23	1.35	19.26	9.18	9.42	94.81	11.63	18.40
Branches/plant	8.04	0.28	15.46	13.27	13.72	93.53	2.12	26.43
Fruit yield/plant	5.58	0.11	208.68	28.48	28.58	99.52	3.27	58.55

Table 3. Genotypic and phenotypic correlations among various characters in brinjal

Character		DFH	NF/P	FW	FL	FD	PH	NB/P	FY/P
DFH	G	-	-0.251	0.376*	-0.097	0.286	0.186	0.208	0.008
	P		-0.246	0.373*	-0.095	0.283	0.175	0.199	0.008
NF/P	G		-	-0.468**	-0.155	-0.431*	-0.054	0.274	0.602**
	P			-0.466**	-0.154	-0.429*	-0.052	0.260	0.598**
FW	G			-	-0.087	0.497**	0.032	0.033	0.378*
	P				-0.087	0.493**	0.027	0.034	0.375*
FL	G			-		-0.351	0.061	-0.005	-0.275
	P					-0.349	0.062	-0.003	-0.274
FD	G					-	0.252	-0.071	0.026
	P						0.238	-0.067	0.029
PH	G						-	0.031	0.001
	P							0.046	0.003
NB/P	G							-	0.311
	P								0.304
FY/P	G								-
	P								-

Significant * 5 % and ** 1 %

estimates of PCV were higher than GCV for all the characters. A close correspondence between PCV and GCV values in respect of all the characters indicate that environment has very little influence on the expression of the characters. Number of fruits per plant exhibits a high (> 25) estimate of PCV and GCV followed by fruit yield per plant and fruit weight. Thus, indicating better scope for phenotypic selection to enhance fruit yield in brinjal.

High heritability estimate was recorded in respect of all the characters. Though heritability estimates gives a useful indication of the relative value of selection based on phenotypic expression. Still it cannot give more reliable conclusion, unless genetic advance under selection is not taken in to consideration along with heritability (Johnson *et al.*,1955). Genetic advance in the present study ranged from 18.40 to 65.68% of mean. High heritability accompanied with high genetic advance for number of fruits per plant, fruit yield per plant and fruit weight characters indicates additive type gene action. Simple selection therefore could be effective for the improvement of these traits. High heritability accompanied with low genetic advance in respect of plant height, days to first harvest, branches per plant and diameter and length of fruit was probably due to non-additive type of the gene action and selection for these characters will be less effective, Panse and Sukhatme (1957). The present studies on genetic variability components are in agreement with the results of Sharma and Swaroop (2000) and Baswana *et al.* (2002) in brinjal.

The genotypic correlation coefficients were higher in magnitude than the corresponding phenotypic correlation coefficient (Table 3) except for plant height with number of branches and yield per plant. These findings are in agreement to those of Singh and Singh (1981), Khurana *et al.* (1988) and Sharma and Swaroop (2000) in brinjal. Correlation coefficient studies indicate that fruit yield per plant was significantly and positively correlated with number of fruits per plant and fruit weight both at genotypic and phenotypic level. Thus selection programme based on these traits might bring an improvement in fruit yield of brinjal. Sharma and Swaroop (2000) also reported similar results in brinjal. Number of branches per plant showed non-significant positive correlation with fruit yield. Fruit

weight had significant and positive correlation with fruit diameter. Fruit weight and diameter had significant and negative correlation with number of fruits per plant.

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Studies on genetic variability, correlation and path co-efficient analysis in kachri

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Abstract

The genetic variability, heritability in broad sense, genetic gain, correlation and path coefficient analysis were studied in 29 diverse populations of kachri. Wide range of variation was observed in most of the characters. The magnitude of PCV was greater than the corresponding GCV for all the characters indicating importance of environment in expression of characters. High values of PCV as well as GCV were recorded for yield per vine, weight of fruit and number of fruits per vine. Out of 14 characters studied, yield per vine and weight of fruit showed high GCV and heritability coupled with high genetic advance which showed that these two characters had additive gene effect and, therefore, they are more reliable for effective selection. Correlation coefficient revealed that fruit yield per vine can be successfully improved by making selection for higher fruit weight, more fruit length, greater fruit diameter and minimum node number at which first female flower appeared. Path coefficient analysis revealed that maximum weightage should be given primarily to number of fruits per vine, weight of fruit, diameter of fruit and node number at which first female flower appeared, while formulating selection indices for improvement of yield per vine in kachri.

Key words: *Genetic variability, correlation, path coefficient, kachri, Cucumis callosus*

Introduction

Kachri or cucumber pubescent (*Cucumis callosus* L.) commonly known as *kachariya, Petha, senga, gordi* is an underutilized cucurbitaceous vegetable. It is hardy and grows wildly in arid and semi arid conditions of Rajasthan during rainy season. Fruits are smooth, roundish and 4-5 cm long. Tender fruits are bitter, while the ripe fruits are sour and usually cooked for various vegetable preparations like *chutney,* pickles and for garnishing vegetables. Ripe fruits are peeled and dried whole or sliced and stored as such or in powder form and used in combination with chilli, turmeric, cumin, fenugreek, coriander and other spices to manufacture various kinds of curry powder (Pareek and Samadia, 2002).

Kachri is a cross-pollinated vegetable, thus, its natural population has tremendous variability for fruit colour, shape, taste, etc. Being an important crop for arid climate, the research work on kachri is very scanty. Evaluation of genotypes to assess the existing variability is considered as preliminary step in any crop improvement programme. In order to pursue an effective breeding programme, the present investigation was carried out to gather information on genetic variability, heritability, genetic gain, correlation and path analysis for different characteristics in kachri.

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Materials and methods

The present investigation comprised of 29 genotypes of kachri collected from different places of Rajasthan. The genotypes were sown in randomized block design with three replications at Department of Horticulture, Rajasthan College of Agriculture, Udaipur during rainy season 2001. Each genotype was planted in a single row of 3 m length, maintaining row to row and plant to plant spacing of 250 cm and 30 cm, respectively. Observations on five randomly selected plants from each replication were recorded for days to anthesis of first male flower, days to anthesis of first female flower, node number at which first female flower appeared, weight of fruit, length of fruit, diameter of fruit, days to first harvest, number of fruits per vine, number of branches per vine, vine length, total soluble solids, dry matter content, ascorbic acid content and yield per vine. Data recorded were subjected to statistical analysis.

Genotypic coefficient variation (GCV) and phenotypic coefficient variation (PCV), broad sense heritability, genetic advance, correlations (genotypic and phenotypic) and path coefficient were computed by the methods suggested by Al-Jibouri *et al.* (1958) and Dewey and Lu (1959).

Result and discussion

The analysis of variance revealed highly significant differences amongst 29 genotypes of kachri for all the characters studied. The magnitude of PCV, as expected, was greater than the corresponding GCV for all the characters indicating importance of environment in expression of characters. Maximum range was recorded for yield per vine (256.37-3236.47 g) followed by fruit (31.10 - 280.92 g), number of fruits per vine (3.53 – 21.20) and length of fruit (4.33 – 14.33 cm) indicating maximum variability present in these traits which showed a greater scope for selection among the existing genotypes while the smallest range was observed for days to maturity (Table 1). The findings are in accordance with Mohanty and Mishra (1999) in pumpkin and Sindhu and Brar (1978) in watermelon. High values of PCV as well as GCV were recorded for yield per vine, weight of fruit and number of fruits per vine. The high magnitude of GCV further revealed the great extent of variability present in the characters, thereby suggesting good scope for improvement through selection.

The GCV does not offer full scope to estimate the variation that is heritable and, therefore, estimation of heritability becomes necessary. In the present study, all the traits expressed high heritability which ranged from 62.09 per cent (node number at which first female flower appeared) to 99.99 per cent (ascorbic acid content) suggesting thereby the major role of genetic constitution in the expression of the character and such traits are considered to be dependable for breeding point of view. Out of 14 characters studied, yield per vine and weight of fruit showed high GCV and heritability coupled with high genetic advance which showed that these two characters had additive gene effect and, therefore, they are more reliable for effective selection. Similar results were also reported by Hawlader *et al.* (1999) in bottle gourd and Methew and Khader (1999) in snake gourd.

The estimates of genotypic correlation were slightly higher than their corresponding phenotypic correlation for all the characters except for number of fruits per vine, days to first harvest and ascorbic acid content where the value of r_g and r_p were same. Similar finding was also reported by Rao *et al.* (2000) in ridge gourd. Yield was found to be positively and significantly correlated with weight of fruit, length of fruit, diameter of fruit and node number at which first female flower appeared both at genotypic and phenotypic levels (Table 2) indicated that any increase in the later four characters should bring about an enhancement in the yield. Correlation coefficient between yield and fruit weight and fruit diameter have also been observed by Sarkar *et al.* (1999) in pointed gourd. Further, weight of fruit has positive correlation with length of fruit and diameter of fruit suggesting thereby the increase in either of one will take care for the increase in fruit weight. Fruit yield is influenced by its components directly as well as indirectly. Deeper understanding would emerge from the path coefficient analysis (Table 3).

Path analysis revealed appreciable amount of direct positive effect of weight of fruit followed by number of fruits per vine, days to anthesis of first female flower on yield indicating, therefore, the dependability of the earlier three traits on the latter i.e. yield. Significant genotypic correlation coefficients between fruit weight and days to anthesis of first female flower with yield further strengthened their reliability in the process of selection for higher yield. The results are in agreement with those of Gwanama *et al.* (1998) in pumpkin and Sarkar *et al.* (1999) in pointed gourd.

Table1. Estimates of genotypic coefficient of variation, phenotypic coefficient of variation, heritability, genetic gain for different characters studied in kachri

Characters	PCV (%)	GCV (%)	Heritability (%)	Genetic Gain (%)
Days to anthesis of first male flower	7.97	7.40	86.24	14.16
Days to anthesis of first female flower	7.23	6.59	83.24	12.39
Node at which first female flower appeared	15.87	12.50	62.09	20.30
Weight of fruit (g)	55.74	54.67	96.26	110.45
Length of fruit (cm)	33.47	31.74	89.93	62.61
Diameter of fruit(cm)	23.68	22.28	88.49	43.17
Days to first harvest	5.04	4.46	78.32	8.13
Number of fruits per vine	46.67	46.00	97.15	93.41
Number of branches per vine	22.78	22.18	94.79	44.48
Vine length (cm)	19.16	18.92	97.59	38.51
Total soluble solid ("Brix)	21.84	19.81	82.29	37.02
Dry matter content (%)	13.59	13.24	94.95	26.58
Ascorbic acid content (mg/100g)	19.23	19.23	99.99	39.62
Yield per vine (g)	60.62	60.03	98.06	122.46

Table 2. Genotypic (r_g) and phenotypic (r_p) correlation coefficient between characters studied in kachri

Character		Days to anthesis of first male flower	Days to anthesis of first female flower appeared	Node number at which first female flower	Weight of fruit (g)	Length of fruit (cm)	Diameter of fruit (cm)	Days to harvest	Number of fruits per vine	Number of branches per vine	Vine length (cm)	TSS (°Brix)	Dry matter content (%)	Ascorbic Acid (mg/ 100 g edible portion)	Yield per vine (g)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	r_g	1.00	0.33	0.16	0.03	-0.03	-0.12	0.39*	-0.55**	0.07	0.13	0.10	-0.07	0.16	-0.30
	r_p	1.00	0.27	0.17	0.02	-0.02	-0.09	0.30	-0.51**	0.08	0.11	0.08	-0.07	0.15	-0.28
2	r_g		1.00	0.34	0.16	-0.01	0.24	0.76**	-0.23	-0.23	-0.09	-0.05	-0.25	0.27	0.13
	r_p		1.00	0.23	0.14	0.01	0.22	0.66**	-0.20	-0.22	-0.08	-0.01	-0.22	0.25	0.11
3	r_g			1.00	0.48**	0.28	0.39	0.03	-0.09	-0.11	0.24	0.16	-0.18	0.51*	0.58**
	r_p			1.00	0.36	0.20	0.29	0.07	-0.09	-0.11	0.18	0.11	-0.14	0.40	0.44*
4	r_g				1.00	0.76**	0.89**	-0.04	-0.33	-0.06	0.41*	-0.07	-0.04	0.33	0.67**
	r_p				1.00	0.71**	0.83**	-0.04	-0.34	-0.06	0.39*	-0.06	-0.05	0.22	0.66**
5	r_g					1.00	0.66**	-0.05	-0.28	-0.14	0.33	0.02	0.20	0.05	0.47**
	r_p					1.00	0.55**	-0.02	-0.26	-0.16	0.31	0.05	0.19	0.04	0.44**
6	r_g						1.00	0.02	-0.33	-0.02	0.41*	-0.17	-0.23	0.27	0.56**
	r_p						1.00	0.05	-0.31	-0.01	-0.37*	-0.11	-0.22	0.25	0.52**
7	r_g							1.00	-0.29	-0.23	0.04	0.19	-0.11	0.11	-0.15
	r_p							1.00	-0.26	-0.21	0.04	0.18	-0.11	0.09	-0.15
8	r_g								1.00	-0.25	-0.26	0.09	0.25	-0.14	0.37
	r_p								1.00	-0.24	-0.25	0.08	0.24	-0.14	0.37
9	r_g									1.00	0.13	-0.13	-0.30	-0.10	-0.37*
	r_p									1.00	0.13	-0.11	-0.28	-0.10	-0.36
10	r_g										1.00	0.01	-0.12	0.26	0.17
	r_p										1.00	0.02	-0.11	0.25	0.16
11	r_g											1.00	0.48**	-0.09	0.02
	r_p											1.00	0.41*	-0.09	0.01
12	r_g												1.00	-0.25	0.05
	r_p												1.00	-0.24	0.04
13	r_g													1.00	0.29
	r_p													1.00	0.29
14	r_g														1.00
	r_p														1.00

*** Significant at 5 per cent and 1 per cent level, respectively

Table 3. Direct (diagonal) and indirect effects of yield components on yield in kachri

Character	Days to anthesis of first male flower	Days to anthesis of first female flower	Node number at which first female flower appeared	Weight of fruit (g)	Length of fruit (cm)	Diameter of fruit (cm)	Days to harvest	Number of fruits per vine	Number of branches per vine	Vine length (cm)	TSS (°Brix)	Dry matter content (%)	Ascorbic Acid (mg/ 100 g edible portion)	Genotypic correlation coefficient with yield
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**-0.0628**	0.0030	0.0417	0.0272	0.0009	0.0246	0.0051	-0.3232	-0.0131	0.0000	-0.0017	0.0084	-0.0080	-0.3017
2	-0.0205	**0.0091**	0.0888	0.1540	0.0003	-0.0473	0.0101	-0.1324	0.0405	-0.0000	0.0008	0.0289	-0.0137	0.1259
3	-0.0100	0.0031	**0.2616**	0.4583	-0.0073	-0.0767	0.0004	-0.0543	0.0202	0.0001	-0.0027	0.0206	-0.0260	0.5825**
4	-0.0018	0.0015	0.1268	**0.9456**	-0.0195	-0.1764	-0.0005	-0.1952	0.0104	0.0001	0.0012	0.0050	-0.0167	0.6707**
5	0.0021	-0.0001	0.0739	0.7142	**-0.0258**	-0.1188	-0.0007	-0.1606	0.0244	0.0001	-0.004	-0.0234	-0.0024	0.4704**
6	0.0078	0.0022	0.1013	0.8422	-0.0155	**-0.1981**	0.0003	-0.1934	0.0028	0.0001	0.0029	0.0269	-0.0135	0.5575**
7	-0.0243	0.0069	0.0074	-0.0369	0.0013	-0.0044	**0.0133**	-0.1683	0.0404	0.0000	-0.0032	0.0129	-0.0053	-0.1547
8	0.0348	-0.0021	-0.0243	-0.3163	0.0071	0.0656	-0.0038	**0.5837**	0.0443	-0.0001	-0.0016	-0.0291	0.0071	0.3669
9	-0.0047	-0.0021	-0.0299	-0.0555	0.0036	0.0031	-0.0030	-0.1465	**-0.1766**	0.0000	0.0022	0.0351	0.0052	-0.3726*
10	-0.0081	-0.0008	0.0637	0.3846	-0.0085	-0.0818	0.0006	-0.1521	-0.0231	**0.0002**	-0.0003	0.0143	-0.0129	0.1663
11	-0.0062	-0.0004	0.0420	-0.0693	-0.0006	0.0334	0.0025	0.0540	0.0229	0.0000	**-0.0169**	-0.0560	0.0048	0.0168
12	0.0045	-0.0022	-0.0458	-0.0403	-0.0051	0.0455	-0.0015	0.1445	0.0527	-0.0000	-0.0081	**-0.1174**	0.0216	0.0463
13	-0.0099	0.0024	0.1346	0.3116	-0.0012	-0.0529	0.0014	-0.0825	0.0182	0.0001	0.0016	0.0293	**-0.0506**	0.2946

*, ** Significant at 5 per cent and 1 per cent level, respectively
Underlined figures denote direct effects
Residual Effect (genotypic) = 0.26

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Effect of crop geometry and fertility levels on growth, yield and quality of kharif onion in semi-arid conditions

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Abstract

A field experiment to study the effect of crop geometry and fertility levels on growth, yield and quality of kharif onion was conducted at Horticulture Farm, SKN College of Agriculture, Jobner during kharif seasons of 2001 and 2002. Plant spacing 45cm x 10 cm was superior over different spacing in relation to growth (number of leaves plant^{-1}, fresh and dry weight of leaves), yield attributes (neck thickness, neck length, equatorial diameter, polar diameter, number of scales bulb^{-1}, fresh weight and volume of bulb) and quality attributes (N, P and K in bulb). Yield of bulbs was maximum at 30 cm x 10 cm spacing. Fifty per cent recommended dose of NPK + vermicompost 2.5 t ha^{-1} significantly improved the growth, yield and quality attributes (pungency and vitamin C) over rest of the treatments.

Key words: *Onion, spacing, fertility levels, growth, yield, quality*

Introduction

Onion (*Allium cepa* L.) is one of the important bulb and cash crop. India ranks second in onion production, which shares 5 per cent of total vegetable production (Anonymous, 2005). Generally, onion is cultivated in rabi season but early kharif and late kharif crops are also taken in various states. During October-November, there is shortage of onion in the market, which leads to high price. Therefore, production of onion in kharif season is more important to have continuous supply of onion round the year. However, in Rajasthan, kharif onion is cultivated in very less area due to the lack of suitable production technology. The optimization of crop geometry is an important factor, which has direct influence on growth, bulb yield and quality. Integrated nutrient supply system for the crop by judicious mixture of organic manure along with the inorganic fertilizer has a number of agronomic and environmental efficiencies. The information on the balance use of chemical fertilizers along with vermicompost for kharif season onion in arid and semi-arid regions is very scarce. Hence, keeping these facts in view an investigation on effect of crop geometry and fertility levels on growth, yield and quality of kharif onion (cv. N-53) in semi-arid conditions was conducted.

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Materials and methods

The experiment was conducted using N-53 cultivar of onion at the Horticulture Research Farm, SKN College of Agriculture, Jobner. Experiment was conducted for two consecutive years in kharif season of 2001 and 2002. The soil of the expermental site was loamy sand (85.2% sand, 9.2% silt and 5.4% clay), pH of 8.0, electrical conductivity of 1.20 dS m^{-1}, available carbon, 0.16%, and available N, P_2O_5 and K_2O of 130, 15.20 and 140 kg ha^{-1}, respectively.

The experiment comprised of 32 combinations of four spacing and eight levels of fertilizers related to recommended dose along with vermicompost. The spacing treatment consisted of 30 cm x10 cm (S_1), 30 cm x 5 cm (S_2), 45 cm x 10 cm (S_3) and 45 cm x 15 cm (S_4). Fertility levels used were no fertilizer (T_1), 75 per cent of recommended dose of NPK (T_2), 100 per cent of recommended dose of NPK (T_3), 125 per cent of recommended dose of NPK (T_4), vermicompost @ 2.5 t ha^{-1} (T_5), 25 per cent of recommended dose of NPK + 2.5 t ha^{-1} vermicompost (T_6), 50 per cent of recommended dose of NPK + 2.5 t ha^{-1} vermicompost (T_7), and 75 per cent of recommended dose of NPK + 2.5 t ha^{-1} vermicompost (T_8). The experiment was laid out in split plot design with spacing in main plot and fertility levels in subplots, having 4 replication.

The recommended dose of NPK for onion crop was 100 : 50 : 100 kg ha^{-1}. The application of urea was given in two split doses, first at the time of planting and remaining half dose 40 days after planting. Single super phosphate and Murate of Potash were applied as basal dose. The

Table 1. Effect of spacing and fertility level in growth, yield and yield attributes of onion cv. N-53 (Pooled of 2 years)

Treatment	Plant height (cm)	No. of leaves plant^{-1} at harvest	Fresh weight of leaves at harvest	Dry weight of leaves at harvest	Neck thickness (cm)	Neck length (cm)	Equatorial diameter (cm)	Polar diameter (cm)	No. of scales bulb^{-1}	Thickness of scale (cm)	Fresh weight of bulb	Volume of bulb (cc)	Bulb yield (q ha^{-1})
Spacing													
S_1	50.97	9.95	45.40	5.67	0.82	5.87	4.92	4.64	6.23	0.231	77.41	49.65	257.96
S_2	50.92	10.00	48.47	5.70	0.86	6.04	5.18	4.64	6.20	0.242	77.82	51.10	172.97
S_3	51.15	10.56	52.69	6.02	0.89	6.16	5.24	4.84	6.46	0.235	79.09	52.98	174.64
S_4	51.07	10.61	49.16	5.92	0.91	6.31	5.28	4.81	6.35	0.244	80.32	53.09	115.65
C D at 5%	NS	0.359	1.153	0.179	0.023	0.185	0.121	0.114	0.127	0.006	1.340	1.572	7.562
Fertility levels													
T_1	38.42	6.61	32.68	3.89	0.62	5.73	4.07	3.59	4.74	0.188	56.59	41.63	128.76
T_2	52.29	9.80	48.32	5.52	0.67	5.81	4.80	4.65	4.85	0.212	69.27	48.05	158.51
T_3	52.96	10.67	51.19	6.10	0.72	5.94	5.34	4.83	6.57	0.248	79.53	53.74	182.03
T_4	52.82	10.36	48.77	5.81	0.81	6.08	5.25	4.74	6.26	0.229	76.39	53.50	174.97
T_5	52.47	10.08	47.90	5.71	0.93	6.21	5.15	4.69	6.14	0.221	71.11	51.18	161.27
T_6	52.99	11.17	52.51	6.26	1.02	6.28	5.43	4.97	6.79	0.263	86.48	54.37	198.10
T_7	53.11	11.91	56.92	6.78	1.07	6.32	5.62	5.25	7.17	0.274	94.78	56.03	224.29
T_8	53.16	11.63	55.13	6.57	1.11	6.40	5.60	5.15	6.95	0.272	95.14	55.15	214.54
C D at 5%	1.832	0.338	1.199	0.186	0.030	0.187	0.153	0.143	0.163	0.007	1.230	1.860	7.301

N.S.= not significant

vermicompost contained 2.5 per cent N, 1.5 per cent P_2O_5, and 1.5 per cent K_2O. All the other cultural operations were carried out as per recommended package of practices for onion crop.

The observation on various traits like plant height, number of leaves per plant, fresh weight of leaves at harvest, dry weight of leaves, neck thickness, neck length, equatorial diameter, polar diameter, number of scales bulb^{-1}, thickness of scales, fresh weight of bulb, volume of bulb and bulb yield were recorded. Among quality attributes TSS, vitamin C, N, P, K and S contents of bulb and allyl propyl disulphide (pungency) content in bulbs were analysed.

Results and discussion

Growth attributes

Plant spacing had non-significant effect on plant height whereas, significantly higher number of leaves and more fresh and dry weight of leaves at harvest were noticed with the wider plant spacing i.e., 45 cm x 10 cm and 45 cm x 15 cm whereas S_3 and S_4 were at par. This might be due to the fact that wider plant spacing caused lesser competition for space, nutrients and light. Significantly more plant height, number of leaves per plant, fresh and dry weight of leaves per plant at harvest were recorded with 50 per cent recommended dose of NPK along with vermicompost 2.5 t ha^{-1} (Table1). However, it was statistically at par with 75 per cent recommended dose of NPK along with 2.5 tha^{-1} vermicompost (T_8). The improvement in growth parameters with the application of vermicompost and NPK might be due to better water holding capacity and supply and availability of major and micronutrients due to favourable soil condition (Reddy *et al.*, 1998). The present trend of increase is supported by the findings of Rizk (1997) in onion.

Yield attributes and Yield

Neck thickness, neck length, equatorial diameter, polar diameter, number of scales bulb^{-1}, thickness of scales, fresh weight of bulb and volume of bulb increased with the wider plant spacing of 45 cm x 15 cm or 45 cm x 10 cm (Table1). This might be due to the lesser number of plants in a given area causing lesser competition for nutrient, increasing food assimilatory efficiency and thereby deposited more food in bulbs. However, maximum bulb yield was recorded in closer spacing (30 cm x 10 cm), whereas minimum in wider spacing (45 cm x 15 cm). This was due to lesser number of bulbs accommodated in wider spacing. Increased yield of onion due to closer spacing had also been recorded by Yadav *et al.* (2002). The significant improvement in yield attributes of onion was recorded with 50 per cent recommended dose of NPK along with 2.5 t ha^{-1} vermicompost (Table 1). This treatment also resulted into increased yield by 74.19 per cent over control and by 39.07 per cent over the vermicompost alone (T_5). The present trends of increase in yield and yield attributes are in close conformity with the findings of Patil *et al.* (2002) in onion.

Interaction effects of plant geometry and fertility levels

The interaction effect of spacing and fertility level was found significant for equatorial diameter, fresh weight of bulb and bulb yield. Maximum values for equatorial diameter and fresh weight of bulb were observed when 50 per cent recommended dose of NPK (50:25:50 kg NPK ha^{-1}) along with vermicompost 2.5 t ha^{-1} (T_7) was applied in conjunction with the spacing of 45 x 10 cm (S_3). However, the maximum bulb yield (Table 2) was observed in the

Table 2. Interaction effect of plant spacing x fertility levelon bulb yield (q ha^{-1}) of onion (Pooled of 2 years)

	S_1	S_2	S_3	S_4	Mean
T_1	184.03	123.85	124.55	82.62	128.76
T_2	227.91	153.18	152.04	100.91	158.51
T_3	260.53	173.76	177.02	116.82	182.03
T_4	250.46	168.07	169.22	112.12	174.97
T_5	228.88	155.62	156.64	103.93	161.27
T_6	284.20	189.40	191.73	127.10	198.10
T_7	323.96	215.93	220.91	136.39	224.29
T_8	303.75	204.00	205.06	145.36	214.54
Mean	257.96	172.97	174.64	115.65	
			C D at 5%		
S same, T different			14.601		
S different, T same			18.089		

treatment combination S_1T_7. Although, both fertility levels and plant spacing independently brought significant variation in yield attributes but interaction of S_1 x T_7 showed that response of fertility level was governed by plant spacing and vice-versa. These findings corroborate with the findings of Sharma *et al.* (2003).

Quality attributes

It was observed that plant spacing had non-significant effect on TSS, sulphur content, allyl-propyl-disulphide and ascorbic acid content. Similar results were also reported by Naik and Hosamani (2000) in onion. Whereas, significant increase in N, P and K contents in bulb with wider plant spacing i.e., 45 cm x 10 cm and 45 cm x 15 cm was noticed (Table 3). Wider spacing, increased availability of nutrients, light and moisture to plant coupled with increased metabolic activity at the cellular level might have increased the nutrient uptake and accumulation in the vegetative plant parts, improved metabolism led to greater translocation of these nutrients to repository organ (bulb) of the crop. Significant increase in quality attributes with wider spacing was earlier reported by Jha *et al.* (2000). Increase in fertility levels up to 50 per cent recommended dose of NPK along with vermicompost 2.5 t ha^{-1} increased NPK content and allyl-propyl-disulphide of bulb (Table 3). Sharma *et al.* (2003) also reported the same results.

Economic feasibility

The economics of various treatment combinations with benefit:cost ratio are given in table 4. The data revealed

Table 3. Effect of spacing and fertility levels on quality attributes of onion cv. N-53 (Pooled of 2 years)

Treatments	TSS (%)	S content (%)	Allyl propyl disulphide	Ascorbic acid (mg 100g^{-1})	N content (%)	P content (%)	K content (%)
Spacing							
S_1	12.18	0.666	6.82	9.42	0.760	0.339	1.09
S_2	12.20	0.669	6.86	9.46	0.768	0.343	1.09
S_3	12.22	0.677	6.94	9.53	0.786	0.357	1.12
S_4	12.23	0.675	6.89	9.47	0.777	0.351	1.12
C D at 5%	NS	NS	NS	NS	0.011	0.007	0.175
Fertility levels							
T_1	12.04	0.637	6.57	9.20	0.539	0.263	1.08
T_2	12.09	0.658	6.67	9.23	0.754	0.280	1.09
T_3	12.15	0.678	6.95	9.58	0.801	0.343	1.12
T_4	12.20	0.672	6.81	9.44	0.794	0.315	1.10
T_5	12.22	0.666	6.74	9.36	0.785	0.295	1.09
T_6	12.27	0.684	7.01	9.62	0.814	0.380	1.12
T_7	12.32	0.692	7.23	9.66	0.846	0.474	1.12
T_8	12.36	0.688	7.07	9.68	0.853	0.430	1.12
C D at 5%	0.232	0.011	0.187	0.188	0.012	0.009	0.016

N.S. = not significant.

Table 4. Comparative economics of various treatments

Treatment combinations	Yield (q ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Treatment cost (Rs. ha^{-1})	Total cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
S_1T_1	184.03	21400	5800	27200	101217	74817	2.75:1
S_1T_2	227.91	21400	7500	28900	125351	96451	3.34:1
S_1T_3	260.53	21400	8105	29505	143291	113786	3.86:1
S_1T_4	250.46	21400	8683	30083	137753	107670	3.58:1
S_1T_5	228.88	21400	10800	32200	125884	93684	2.90:1
S_1T_6	284.20	21400	11342	32742	156310	123568	3.77:1
S_1T_7	323.96	21400	11953	33353	178178	144825	4.34:1
S_1T_8	303.75	21400	12530	33930	167063	133133	3.92:1
S_2T_1	123.85	21400	5300	26700	68118	41418	1.55:1
S_2T_2	153.18	21400	7030	28430	107226	78796	2.77:1
S_2T_3	173.76	21400	7605	29005	121632	92627	3.19:1
S_2T_4	168.07	21400	8183	29583	117649	88066	2.97:1
S_2T_5	155.62	21400	10300	31700	108934	77234	2.44:1
S_2T_6	189.40	21400	10842	32242	132580	100338	3.11:1
S_2T_7	215.93	21400	11453	32853	151151	118298	3.60:1
S_2T_8	204.00	21400	12030	33430	142800	109370	3.27:1
S_3T_1	124.55	21400	5300	26700	68503	41803	1.56:1
S_3T_2	152.04	21400	7030	28430	106428	77998	2.74:1
S_3T_3	177.02	21400	7605	29005	150467	121462	4.18:1
S_3T_4	168.22	21400	8183	29583	142987	113404	3.83:1
S_3T_5	156.64	21400	10300	31700	133144	101444	3.26:1
S_3T_6	191.73	21400	10842	32242	162971	130729	4.05:1
S_3T_7	220.91	21400	11453	32853	187774	154921	4.71:1
S_3T_8	205.06	21400	12030	33430	174301	140871	4.21:1
S_4T_1	82.62	21400	4755	26155	57834	31679	1.21:1
S_4T_2	100.91	21400	6485	27885	70637	42752	1.53:1
S_4T_3	116.82	21400	7060	28460	99297	70837	2.48:1
S_4T_4	112.12	21400	7638	29038	78484	49446	1.70:1
S_4T_5	103.93	21400	9755	31155	88341	57186	1.83:1
S_4T_6	127.10	21400	10297	31697	108035	76338	2.40:1
S_4T_7	136.39	21400	10908	32308	115932	83624	2.59:1
S_4T_8	145.36	21400	11485	32885	123556	90671	2.75:1

that the maximum net profit of Rs. 15,492,1.0 ha^{-1} was obtained under the treatment combination S_3T_7 followed by S_1T_7 with a profit of Rs. 14,482,5.0 ha^{-1}. The minimum net profit of Rs. 31,679.0 ha^{-1} was gained under the treatment combination S_4T_1. Data presented in same table further revealed that S_3T_7 treatment combination resulted in the highest B:C ratio of 4.71:1 followed by S_1T_7 whereas, the minimum B:C ratio (1.21:1) was obtained under the treatment combination S_4T_1. Therefore, it could be inferred from findings that S_3T_7 was most economical combination.

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Storage behaviour of ber cultivars under semi-arid environment

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Abstract

Physico-chemical changes and economic shelf life of ber fruits cvs. Gola, Goma Kirti, Umran, Seb and Mundia were studied during storage at ambient temperature under semi-arid environment of Gujarat during the year 2001 and 2002. Increase in physiological loss in weight (PLW), spoilage percentage, total soluble solids, total sugar and reducing sugar and decrease in acidity and ascorbic acid with advancement of storage period were the general trends in all the cultivars. In the present study, Umran recorded the least physiological loss in weight (23.10%) and spoilage loss (20.10%) and exhibited 7 days economic shelf life. Goma Kirti could also be stored up to 7 days during storage. However, Gola recorded maximum physiological loss in weight and spoilage loss and showed only 3 days economic shelf life. In respect of storability, Seb proved to be better than Gola and could be stored up to 6 days at ambient temperature. The lowest rate of respiration rate (0.37 mg CO_2/kg/h) was noted in Umran closely followed by Goma Kirti (0.41 mg CO_2/kg/h) however, Gola showed highest respiratory activity (0.56 mg CO_2/kg/h) on the last day of storage.

Key words: *Ambient temperature, physiological loss in weight, spoilage loss, economic life, respiration rate*

Introduction

Ber (*Ziziphus mauritiana* Lam.) is one of the important commercial fruits owing to its hardy nature and commercial yield potential without much care on marginal lands and is being grown in arid and semi-arid regions of western India. Several biochemical changes occur during ripening and storage of fruits. These changes have significant influence on the nutritional, processing qualities and storability of the fruits. Gola is one of the leading early cultivars of ber but it suffers due to very poor shelf life at room temperature. Goma Kirti is the newly released variety of this research station (Hiwale, 2005) which requires to be compared with the local leading cultivars like Gola, Umaran, Seb and Mundia. Though the fruits of ber are firm and can easily be transported to the distant market, but the potentiality of its storage stability needs to be explored particularly under harsh semi arid ecosystem of Gujarat. The fruit respires and transpires continuously resulting into high weight loss and then becomes susceptible to various diseases, which ultimately reduce the saleable tonnage. Due to prevalence of high temperature (12 ± 2°C - 28 ± 2°C) during the time of harvesting, fruits start spoiling rapidly. So far as research on ber cultivars for evaluating their storage behaviour is concerned, efforts have been made under different climatic conditions (Sharma *et al.*, 2000; Sharma and siddiqui, 2004 and Ghosh and Mitra 2004). To regulate the marketing for consumers'acceptability and greater remuneration, it is necessary to study the storage behaviour of ber cultivars. Storage studies under ambient condition for ber cultivars were lacking particularly under harsh semi arid environment of Gujarat. Therefore, the present studies were conducted to evaluate the post harvest physiological changes and economic shelf life of fruits during storage at room temperature, which will be useful to orchardists, traders and processors.

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Materials and methods

The hand picked mature and healthy fruits of uniform size, free from pest and diseases, injuries, bruises and blemishes were selected from the experimental orchard of Central Horticultural Experiment Station, Vejalpur (Godhra) during the year 2001 and 2002. The ber fruits selected for the study were Gola, Goma Kirti, Umran, Seb and Mundia. The experiment was laid out in factorial completely randomized design with four replications. Fruits were stored at ambient temperature ranging between 12 ± 2°C (minimum) and 28 ± 2 °C (maximum) with a relative humidity 65 ± 3% at 8 a.m. The physiological loss in weight, spoilage loss, total soluble solids and acidity were determined by standard methods. Economic life (in days) of fruits was determined by counting the number of days, on the date after which cumulative spoilage percentage of fruits in particular cultivar exceeded 12%, from the date of harvest of

the fruits (Singh *et al.*, 2003). Ascorbic acid and total sugar content were determined by the methods advocated by AOAC (1980). The respiration rate was measured as suggested by Loomis and Shull (1973).

Results and discussion

The physiological loss in weight (PLW) was found gradually increased in all the cultivars as the storage period advanced (Table 1). Umaran was the most efficient in retaining the PLW in all the days of observations and showed only 23.10 % PLW on 9th day of storage followed by Goma Kirti, Seb and Mundia. Gola was found to be most inferior in this respect and recorded 29.37% PLW on 9th day of storage. The critical observation showed that the rate of loss in weight was much faster in Gola, it was 6.90% on 3rd day of storage, while Umaran and Goma Kirti recorded 3.90% and 4.00% weight loss on that day, respectively. The weight loss with advancement of storage period might be due to the loss of moisture and food substances affected by the process of transpiration and respiration. The variation in physiological loss in weight among the cultivars may be attributed to genetical, textural and skin characteristics. Similar trend was also recorded by Hoda *et al.* (2000), Ghosh and Mitra (2004) and Singh *et al.* (2005) during storage of mango, ber and aonla under various climatic conditions. Spoilage of ber fruits started on 3rd day of storage in all the cultivars (Table 1). The maximum percent of spoilage was recorded in Gola (52.10%) while minimum was in Umaran (20.10%) on 9th day of storage. These findings are in consonance with that of Kananan and Susheela Thirumaran (2003) and Ghosh and Mitra (2004) in ber.

On the basis of spoilage within 12%, the maximum economic shelf-life was exhibited by Umaran and Goa Kirti i.e.7 days, however, Gola had least economic shelf life (3 days) during storage. Varietal differences in respect of shelf life have also been reported by Singh *et al.* (2003) and Singh *et al.* (2005) in aonla. Total soluble solids (TSS) content increased in all the cultivars till the 9th day of storage except 'Gola' in which it increased up to 7th day of storage and then declined (Table 2). Maximum TSS content was recorded in Gola (22.20%) followed by Goma Kirti (21.30%) and Umaran (21.20%) till the termination of storage period (9th day) however, it was noted least in Mundia (19.70%). Increase in TSS during storage might be associated with the transformation of pectic substances, starch, hemicellulose or other polysacharides in soluble sugar and also with the dehydration of fruits (Hoda *et al.*, 2000 and Singh *et al.*, 2004). Similar trend was also recorded during storage of mandarin fruits under ambient conditions (Bhardwaj *et al.*, 2005). During storage, the titratable acidity gradually decreased in all the cultivars (Table 2). The minimum acidity (0.10%) was recorded in Gola on the last day of storage, while the maximum was found in Umaran (0.18%). The reduction in acidity during storage might be associated with the conversion of organic acids into sugars and their derivatives or their utilization in respiration. (Singh *et al.*, 2003; Singh *et al.*, 2004 and Madhavi *et al.*, 2005). Kananan and Susheela Thirumaran (2003), Singh *et al.* (2002) and Kamble and Chavan (2005) also recorded the

Table1. Physiological loss in weight, spoilage loss and economic life of ber fruits during storage

Cultivars	Physiological loss in weight (%)				Spoilage loss (%)				Economic life (Days)
	Days after harvest				Days after harvest				
	3	5	7	9	3	5	7	9	
Gola	6.90	16.34	23.14	29.37	11.10	18.45	30.00	52.10	3
Umaran	3.90	6.80	13.80	23.10	2.00	5.00	11.12	20.10	7
Goma Kirti	4.00	7.00	14.10	24.10	2.50	6.12	11.50	20.50	7
Seb	5.00	8.12	16.10	20.50	3.00	7.00	13.00	24.00	6
Mundia	5.50	12.10	18.14	27.10	6.10	14.20	20.00	43.10	4
C D at 5%	Treatments (T) = 0.14, Days (D) = 0.19, D x T = 0.25				Treatments (T) = 0.07, Days (D) = 0.11, D x T = 0.24				

Table 2. Changes in TSS and titratable acidity during storage of ber fruits

Cultivars	T S S (%)					Titratable acidity (%)				
	Days after harvest					Days after harvest				
	1	3	5	7	9	1	3	5	7	9
Gola	19.50	21.00	22.10	22.70	22.20	0.36	0.26	0.20	0.13	0.10
Umaran	18.80	19.00	19.95	20.90	21.20	0.30	0.28	0.24	0.20	0.18
Goma Kirti	18.90	19.20	20.00	21.00	21.30	0.31	0.27	0.23	0.18	0.17
Seb	18.50	18.70	19.00	19.80	19.90	0.32	0.26	0.18	0.14	0.13
Mundia	18.20	18.50	18.90	19.60	19.70	0.33	0.27	0.19	0.16	0.14
C D at 5%	Treatments (T) = 0.08, Days (D) = 0.16, D x T = 0.24					Treatments (T) = 0.03, Days (D) = 0.02, D x T = 0.02				

Table 3. Changes in ascorbic acid and respiration rate during storage of ber fruits

Cultivars	Ascorbic acid (mg/ 100g) Days after harvest					Respiration rate (mg co_2/kg/h) Days after harvest				
	1	3	5	7	9	1	3	5	7	9
Gola	95.00	83.10	70.12	62.13	50.10	0.19	0.24	0.73	0.63	0.56
Umaran	97.00	90.00	82.00	74.00	62.10	0.14	0.19	0.28	0.42	0.37
Goma Kirti	98.10	92.00	83.00	75.00	65.00	0.16	0.20	0.30	0.46	0.41
Seb	90.00	86.00	76.10	69.20	58.00	0.17	0.21	0.32	0.50	0.43
Mundia	88.00	84.00	74.20	66.10	56.20	0.18	0.22	0.53	0.58	0.54
C D at 5%	Treatments (T) = 3.15, Days (D) = 4.12, D x T =4.10					Treatments (T) = 0.02, Days (D) = 0.08, D x T = 0.07				

Table 4. Changes in total sugar and reducing sugar during storage of ber fruits

Cultivars	Total sugar (%) Days after harvest					Reducing sugar (%) Days after harvest				
	1	3	5	7	9	1	3	5	7	9
Gola	14.00	14.20	14.50	14.90	14.80	5.10	5.30	5.53	5.63	5.60
Umaran	12.75	13.00	14.00	14.50	14.70	4.90	5.26	5.42	5.50	5.55
Goma Kirti	12.80	13.10	14.10	14.60	14.80	4.92	5.30	5.45	5.53	5.58
Seb	11.10	11.34	12.10	12.45	12.70	3.95	4.10	4.25	4.60	4.90
Mundia	11.00	11.30	12.00	12.30	12.60	3.92	4.00	4.20	4.50	4.70
C D at 5%	Treatments (T) = 0.93, Days (D) = 0.14, D x T = 0.22					Treatments (T) = 0.07, Days (D) = 0.08, D x T = 0.12				

similar results in ber and custard apple.

The ascorbic acid content of fruits decreased gradually during storage in all the cultivars (Table 3). Maximum ascorbic acid content (65.00 mg /100 g) was retained by Goma Kirti on last day of storage, closely followed by Umaran (62.10 mg/100g), while it was recorded the least in Gola (50.10mg/100g). Variation in decreasing trend might be associated with genetic variability among the cultivars. During storage, oxidizing enzymes like ascorbic acid oxidase, peroxidase, catalase and polyphenol oxidase might be causing decrease in ascorbic acid of the fruits (Singh *et al.*, 2003 and Singh *et al.*, 2005). This finding are in agreement with those of Kananan and Susheela Thirumaran (2003) and Ghosh and Mitra (2004) in ber.

Fruits of different cultivars showed continuous increase in respiratory activity till the last day of storage (9th day). The highest respiratory activity was noted in Gola (0.56 mg CO_2/kg/h), while Umaran recorded the lowest respiration rate (0.37 mg CO_2/kg/h), which was closely followed by Goma Kirti (0.41 mg CO_2/kg/h) on the last day of storage. The present observations are in consonance with the findings of Singh *et al.* (2003) in aonla under semi arid environment of western India.

Total sugar and reducing sugar contents increased in all the cultivars till the 9th day of storage except Gola in which it increased up to 7th day of storage and then declined (Table 4). Gola recorded maximum sugar content unto the last day of storage, while the least sugar content was found in Mundia on the same day. These findings are in close agreement with the findings of Hoda *et al.* (2000) and Singh *et al.* (2005) in mango and aonla, respectively. The changes in sugar content during storage are very much related with TSS. An increase in sugars during storage was probably due to conversion of starch and polysaccharides into soluble sugars and dehydration of fruits (Hoda *et al.*, 2000). On the basis of spoilage loss and fruit quality attributes, it may be concluded that Umaran and Goma Kirti may be stored up to 7 days during storage at ambient temperature under semi arid environment of Gujarat. However Gola showed only 3 days economic shelf life under ambient conditions.

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Evaluation of guava cultivars for processing and biochemical changes in nectar beverage during storage

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Abstract

The beverages are becoming more popular in comparison to synthetic or carbonated drinks which are available in the market. In view of this, fruit beverages of guava have a great potential in processing industry due to its excellent flavour and nutritive value. Looking to the demand of natural beverages, the present study was carried out during the year 2003-04. The experimental material consisted of four cultivars of guava and six recipes maintained for making nectar beverage with varying levels of TSS per cent. The prepared nectar was kept under ambient condition for storage study up to 150 days. The beverage prepared from the cultivar L-49 had highest content of ascorbic acid and also scored highest organoleptic value. While, acidity, reducing and total sugar were found to be highest in cultivar R-72. Among various recipes tried in this investigation, the nectar prepared from 20 per cent pulp, 0.3 per cent acidity and 17 per cent TSS recorded highest ascorbic acid and organoleptic value. During storage of nectar, the acidity, reducing sugar and total sugar showed an increasing trend with increasing period of storage (0 to 150 days) under ambient condition. While, there was a decreasing trend of ascorbic acid and organoleptic score during storage period upto 150 days under ambient condition.

Key words: *Ambient condition, biochemical changes, guava cultivars, nectar, recipes and storage*

Introduction

Guava (*Psidium guajava* L.), a very popular fruit is indigenous to tropical America and belongs to family 'Myrtaceae'. It is one of the important fruit crops of India and ranks fourth in area and production after mango, banana and citrus. It excels most of the other fruit crops in productivity, hardiness, adaptability and vitamin C content of the fruits (Tandon *et al.*, 1983; Singh *et al.*, 1993). Apart from vitamin C, it is also a rich source of pectin and minerals like calcium, phosphorus and iron. Besides, the fruit contains substantial quantity of vitamin A, pantothenic acid, riboflavin, thiamin and niacin. Although, guava fruit is nutritious but it is highly perishable in nature and can not be transported to distant places for marketing. Fruits are available in plenty during fruiting season but it is sold at unremunerative prices. Besides using as fresh, its fruits are being processed mainly for making jelly. Hence, due to its excellent flavour and nutritive value, there is a great potential in processing of guava beverages which could be economical and made available to a large population. Therefore, the present study was undertaken to evaluate the guava cultivars for processing into nectar beverage alongwith its storage under ambient condition.

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Materials and methods

The present investigation was carried out in the Department of Horticulture, IGAU, Raipur (C.G.) during the year 2003-04 to study the storage stability of nectar beverage prepared from four cultivars of guava viz., Apple Colour (AC), Allahabad Safeda (AS), Lucknow-49 (L-49) and Rewa-72 (R-72). Six recipes were maintained with 20 per cent pulp, 0.3 per cent acidity and varying levels of TSS i.e., 15,16,17,18, 19 and 20 per cent. The experiment consisted 24 treatment combinations in completely randomized design with factorial arrangement and replicated thrice.

Fifteen years old guava trees were used as experimental materials and all the trees were provided with same cultural practices. Firm ripe fruits were selected and a fine fruit pulp was obtained devoid of seeds and skin for the preparation of nectar. The prepared nectar beverage was filtered to obtain a product of uniform consistency and it was filled into sterilized crown bottles of 250 ml capacity and corked air tight. After pasteurization of bottles at 100°C, the product was kept at ambient condition for further study upto 150 days.

The chemical composition of nectar was analyzed at the time of preparation (0 day) and at 30 days interval up to 150 days. The acidity and ascorbic acid were estimated by

the methods suggested by Ranganna (1997). Total sugar and reducing sugar were determined by the method of Lane and Eynon as described by Ranganna (1997). Organoleptic quality of nectar was subjected to sensory evaluation by a pannel of five judges for appearance, flavour and taste following the hedonic rating scale as described by Ranganna (1997). The statistical analysis of data recorded on various aspects was done as given by Panse and Sukhatme (1985).

Results and discussion

Ascorbic acid

The ascorbic acid content in guava nectar showed a decreasing trend with increasing period of storage (Table 1) upto 150 days at ambient condition under all the cultivars and recipe treatments. The nectar of cultivar L-49 had significantly higher ascorbic acid (6.17 mg/100 ml) followed by Allahabad Safeda, Apple Colour and R-72 at the time of preparation of product. Thereafter, a similar trend was observed upto 150 days of storage. At the end of storage (150 days), the nectar of cultivar L-49 contained maximum ascorbic acid (4.71 mg/100 ml) followed by Allahabad Safeda, Apple Colour and R-72. The nectar having the recipe T_3 (20% pulp, 0.3% acidity and 17% TSS) had significantly higher ascorbic acid (6.58 mg/100 ml) at the time of preparation, but it was noted least (3.69 mg/100 ml) under the treatment T_5 (20% pulp, 0.3% acidity and 19% TSS). Thereafter, a similar trend was observed upto 150 days of storage under ambient condition and the product maintained supremacy by retaining maximum ascorbic acid (4.77 mg/100 ml) under the recipe T_3. The combined effects of cultivar and recipe showed similar response to ascorbic acid as observed with individual treatments alone. The decrease in ascorbic acid in nectar during storage might be due to oxidation or irreversible conversion of L-ascorbic acid into dehydro ascorbic acid in the presence of enzyme ascorbic acid oxidase (ascorbinase) caused by trapped or residual oxygen in the glass bottles. Similar reduction in ascorbic acid content has also been reported in guava beverages (Baramanray *et al.*, 1995; Pandey and Singh, 1998; Pandey, 2004).

Acidity

The acidity in guava nectar increased in all the cultivars and recipe treatments under ambient condition at increasing period of storage upto 150 days (Table 2). However, the acidity was not influenced significantly at the time of preparation due to cultivars and recipe in nectar. Subsequently, at 30 days of storage, it increased significantly and the cultivar R-72 retained its higher level (0.46%) followed by Apple Colour, Allahabad Safeda and L-49. Thereafter, the same trend was observed upto 150 days of storage. The nectar having recipe T_6 (20% pulp, 0.3% acidity and 20% TSS) had significantly higher level (0.46%) of acidity at 30 days of storage, while lowest content (0.34%) was noted under the recipe T_3 and the same trend was observed upto 150 days of storage. The interaction of cultivar and recipe showed an increasing trend of acidity with increasing period of storage upto 150 days.

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

Reducing and Total Sugar

The reducing and total sugar content in guava nectar showed an increasing trend with all the cultivars and recipe treatments at increasing period of storage upto 150 days under ambient condition (Table 3 and 4). The nectar

Table 1. Effect of different cultivars and recipes on ascorbic acid (mg/100 ml) of stored guava nectar

Treatments	Storage period (in days)									
Cultivar / Recipe	0 (at the time of preparation)					150				
	AC	AS	L-49	R-72	Mean	AC	AS	L-49	R-72	Mean
T_1	4.25	5.25	6.67	4.50	5.17	2.27	3.67	5.25	2.00	2.29
T_2	5.83	5.92	6.58	5.08	5.85	3.67	4.42	5.42	3.00	4.12
T_3	6.58	6.92	7.58	5.25	6.58	4.33	5.08	5.67	4.00	4.77
T_4	5.83	6.08	5.67	4.33	5.48	3.66	4.83	4.17	2.67	3.83
T_5	3.50	4.58	4.42	2.25	3.69	2.00	2.50	3.00	1.13	2.16
T_6	3.25	4.75	6.08	4.18	4.57	1.33	3.50	4.75	1.33	2.73
Mean	4.87	5.58	6.17	4.27	5.22	2.88	4.00	4.71	2.35	3.48
			CD at 5%					CD at 5%		
Cultivar			0.019					0.022		
Recipe			0.023					0.027		
Cultivar x Recipe			0.047					0.038		

Table 2. Effect of different cultivars and recipes on acidity (%) of stored guava nectar

Treatments	Storage period (in days)									
Cultivar	0 (at the time of preparation)					150				
Recipe	AC	AS	L-49	R-72	Mean	AC	AS	L-49	R-72	Mean
T_1	0.32	0.32	0.32	0.33	0.32	0.87	0.76	0.63	1.03	0.82
T_2	0.31	0.32	0.33	0.33	0.32	0.83	0.72	0.58	0.97	0.77
T_3	0.32	0.32	0.32	0.32	0.32	0.77	0.65	0.49	0.90	0.70
T_4	0.33	0.32	0.33	0.33	0.33	0.90	0.81	0.68	1.06	0.86
T_5	0.32	0.32	0.32	0.34	0.33	0.94	0.86	0.74	1.09	0.91
T_6	0.32	0.34	0.33	0.33	0.33	0.98	0.90	0.79	1.11	0.94
Mean	0.32	0.32	0.32	0.33	0.32	0.88	0.78	0.65	1.02	0.83
			C D at 5%					C D at 5%		
Cultivar			NS					0.011		
Recipe			NS					0.014		
Cultivar x Recipe			NS					NS		

prepared from cultivar R-72 contained significantly higher reducing sugar and total sugar followed by Apple Colour, Allahabad Safeda and L-49 from the time of preparation (0 day) to 150 days of storage. The treatment T_6 (20% pulp, 0.3% acidity and 20% TSS) had a higher amount of reducing and total sugar, while recipe T_1 (20% pulp, 0.3% acidity and 15% TSS) recorded the minimum fraction of both the sugars from the time of preparation (0 day) to end of the storage period (150 days).

The increase in different fractions of sugar might be due to hydrolysis of polysaccharides like starch, pectin and inversion of non-reducing 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. The present findings are in agreement with the report of Murari and Verma (1989) and Baramanray *et al.* (1995) in guava nectar and Shrivastava (1998) in mango beverages.

Organoleptic evaluation of nectar

The organoleptic score decreased with all the cultivar and recipe treatments at increasing period of storage (Table 5). The nectar prepared from cultivar L-49 had a higher score (24.28) followed by Allahabad Safeda (23.28) at the time of preparation and the product of both the cultivars were highly acceptable upto 150 days of storage. The nectar prepared with the recipe T_3 (20% pulp, 0.3% acidity and 17% TSS) had highest organoleptic score followed by T_2 (20% pulp, 0.3% acidity and 16% TSS) upto 150 days of storage. The combined effects of cultivar and recipe also showed similar response to organoleptic score for nectar upto 150 days of storage. The nectar had a gradual decrease in organoleptic quality during storage period at ambient condition.

There was considerable decrease in sensory mean

Table 3. Effect of different cultivars and recipes on reducing sugar (%) of stored guava nectar

Treatments	Storage period (in days)									
Cultivar	0 (at the time of preparation)					150				
Recipe	AC	AS	L-49	R-72	Mean	AC	AS	L-49	R-72	Mean
T_1	4.46	4.15	4.00	4.70	4.33	7.00	6.86	5.65	8.86	7.09
T_2	5.37	5.00	4.85	5.55	5.19	7.79	7.66	6.49	9.66	7.90
T_3	6.17	5.85	5.75	6.35	6.03	8.63	8.40	7.24	10.40	8.67
T_4	7.59	7.35	7.15	7.85	7.48	10.23	10.02	8.84	12.08	10.29
T_5	8.70	8.50	8.25	9.00	8.61	11.52	11.24	10.10	13.27	11.53
T_6	9.87	9.75	9.35	10.10	9.77	13.02	12.43	11.27	14.43	12.79
Mean	7.03	6.77	6.56	7.26	6.90	9.69	9.43	8.27	11.45	9.71
			CD at 5%					CD at 5%		
Cultivar			0.0085					0.0233		
Recipe			0.0102					0.0284		
Cultivar x Recipe			0.0205					0.0569		

Table 4. Effect of different cultivars and recipes on total sugar (%) of stored guava nectar

Treatments	Storage period (in days)									
Cultivar / Recipe	0 (at the time of preparation)					150				
	AC	AS	L-49	R-72	Mean	AC	AS	L-49	R-72	Mean
T_1	14.25	14.15	14.05	14.35	14.20	14.63	14.58	14.46	14.76	14.61
T_2	15.25	15.15	15.05	15.35	15.20	15.58	15.52	15.41	15.64	15.55
T_3	16.25	16.15	16.05	16.35	16.20	16.52	16.45	16.35	16.64	16.49
T_4	17.25	17.15	17.05	17.35	17.20	17.70	17.61	17.53	17.80	17.66
T_5	18.25	18.15	18.05	18.35	18.20	18.78	18.67	18.60	18.87	18.73
T_6	19.25	19.15	19.05	19.35	19.20	19.93	19.72	19.66	20.66	19.87
Mean	16.75	16.65	16.55	16.85	16.70	17.19	17.09	17.00	17.31	17.15
			CD at 5%					CD at 5%		
Cultivar			0.04					0.0076		
Recipe			0.05					0.0960		
Cultivar x Recipe			NS					0.1960		

Table 5. Effect of different cultivars and recipes on organoleptic quality (score) of stored guava nectar (based on a scale 36)

Treatments	Storage period (in days)									
Cultivar / Recipe	0 (at the time of preparation)					150				
	AC	AS	L-49	R-72	Mean	AC	AS	L-49	R-72	Mean
T_1	21.80	23.92	24.93	20.82	22.87	16.52	18.29	20.27	16.00	17.77
T_2	23.76	25.93	25.96	22.27	24.48	18.83	19.00	21.55	17.89	19.32
T_3	25.22	26.97	27.00	24.27	25.87	19.65	21.65	23.44	20.15	21.22
T_4	20.23	21.99	24.00	18.87	21.29	15.29	17.00	19.32	14.83	16.61
T_5	19.12	20.93	22.90	17.17	20.03	13.93	15.98	18.00	13.00	15.23
T_6	18.09	19.91	20.87	16.09	18.74	15.54	14.32	16.79	11.82	13.87
Mean	21.37	23.28	24.28	19.92	22.21	16.13	17.71	19.89	15.61	17.34
			CD at 5%					CD at 5%		
Cultivar			0.0220					0.0410		
Recipe			0.0270					0.0500		
Cultivar x Recipe			0.0540					0.0990		

T_1: 20% pulp, 0.3 % acidity and 15% TSS ;T_2: 20% pulp, 0.3 % acidity and 16% TSS; T_3: 20% pulp, 0.3 % acidity and 17% TSS; T_4: 20% pulp, 0.3% acidity and 18% TSS; T_5: 20% pulp, 0.3 % acidity and 19% TSS; T_6: 20% pulp, 0.3 % acidity and 20% TSS

score for taste, flavour and overall acceptability during storage. The sensory mean score for each attributes was highest on the day of preparation, which decreased with increasing period 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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Quality of grape as influenced by foliar spray of zinc and boron

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Abstract

A field experiment was conducted at Horticulture farm, Rajasthan College of Agriculture, Udaipur. The experiment comprised of sixteen treatment combinations consisting of four levels of zinc and boron (0, 0.2, 0.3 and 0.4%). The foliar spray of zinc and boron were done at pre-bloom and after fruit set stages. Foliar spray of zinc at 0.4% gave the maximum juice content (71.87%), ascorbic acid (8.04 mg/100 ml juice), TSS (21.72%), reducing sugar (4.54%), non-reducing sugar (1.76%), total sugar (16.30%) and gave lowest acidity (0.61%), while foliar spray of 0.2 per cent boron gave the maximum juice content (72.02%), Ascorbic acid (8.18 mg/100 ml juice), TSS (21.47 %), reducing sugar (14.50 %), non-reducing sugar (1.71%) and Total sugar (16.22%) and gave lowest acidity (0.60%).

Key words: *Berry size, foliar spray, fruit set, and oxidation-reduction, pre-bloom*

Introduction

Grape is one of the most delicious, refreshing and nourishing fruit of the world. In India, grape is cultivated in Andra Pradesh, Maharashtra, T.N., Karnataka, Punjab, Haryana, Himachal Pradesh and Rajasthan. It requires a long dry and moderately hot season during maturity of canes and ripening of berries followed by a cool winter. In India 90 per cent produce of grapes is consumed as fresh table grapes and the remaining for raisins and wine making.

Despite the fact that grape can have an important place in the state of Rajasthan, less attention has been given to improve the quality. One of the most important steps which can ensure lucrative income from grape growing is the proper feeding and judicious nutrition to the vines. Among the various macro and micronutrients zinc and boron are important in viticulture. Zinc is required for the normal development of leaf, shoot elongation, pollen formation, fruit set and berry development (Christensen, 1975). Similarly boron is essential for the regulation of carbohydrate metabolism and normal fruit set. It also increases bunch and berry size and sugar content of juice. No attempt appears to have been made for such studies in case of grape in Rajasthan and thus the present investigation has been taken up.

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Materials and methods

The investigation was carried out at nine year old uniform grape vines *cv.* Thompson Seedless, trained on 'Pergola' system at Horticulture farm, Rajasthan College of Agriculture, Udaipur during January, 2001 to June, 2001. The soil of orchard was clay loam in texture, having pH 8.0, total nitrogen 0.073%, available P_2O_5 12.11 kg/ha, available K_2O 252.00 kg/ha, zinc 0.391 ppm and boron 1.2 ppm. Sixteen treatment combination consisting of four levels of zinc and boron (0, 0.2, 0.3 and 0.4%) were laid out in factorial randomized block design with three replications. The foliar sprays of zinc and boron were done at pre bloom and after fruit set stage

Results and discussion

Juice content

Foliar spray of zinc had the significant effect on the juice content of grape (Table 1). The maximum juice content was recorded in treatment Z_4 (0.4%) and minimum in control (67.08%). There is no significant difference between Z_3 and Z_4. Hence at par w.r.t. juice content. The results of the present investigation corroborate the findings of Gonzalez *et al* (1994) in orange.

The application of boron also significantly increased the juice content. The maximum juice content was recorded in treatment B_2 (0.2%) and minimum in control. The possible explanation for the increase in juice content as a result of boron treatment may be due to the fact that increase in boron status of the vine which in turn increased the juice content. It was also noticed that the nitrogen uptake was

Table 1. Effect of spray of zinc and boron on quality of grape

Treatments	Juice Content (%)	Ascorbic acid mg/100 ml juice Juice	Acidity (%)	T.S.S (%)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)
Zinc Spray							
Z_1 Control	67.08	7.91	0.64	19.01	12.65	1.56	14.21
Z_2 0.2 %	69.91	7.98	0.62	20.74	13.82	1.64	15.47
Z_3 0.3 %	71.68	7.99	0.62	21.15	14.09	1.70	15.79
Z_4 0.4 %	71.87	8.04	0.61	21.72	14.54	1.76	16.30
C. D at 5 %	1.556	N S	N S	0.55	0.20	0.03	0.21
Boron Spray							
B_1 Control	68.03	7.96	0.65	19.57	13.05	1.63	14.69
B_2 0.2 %	72.01	8.18	0.60	21.47	14.50	1.71	16.22
B_3 0.3 %	70.80	7.93	0.62	20.90	13.91	1.68	15.60
B_4 0.4 %	69.69	7.85	0.62	20.69	13.63	1.64	15.27
C D at 5 %	1.55	0.12	0.02	0.55	0.20	0.03	0.21

the highest with boron treatment. Walter *et al* (1997) reported that boron application increased the nitrogen uptake. This higher nitrogen content in the plants increased the berry size, which in turn, increased the juice content.

Ascorbic acid

The data presented in Table 1 showed that application of zinc at different levels had non-significant effect on ascorbic acid content and the maximum increase in ascorbic acid content was recorded in Z_3 (8.048 mg/100 ml juice) followed by Z_2 (7.990 mg/100 ml juice) and Z_1 (7.981 mg/100 ml juice). The maximum ascorbic acid content was recorded in treatment Z_4 (0.4%) and minimum in control.

Boron also increased the ascorbic acid content significantly but with increasing concentration beyond B_2 (0.2%) it reduced the ascorbic acid content. The present results are in agreement with the findings of yadav (1998) in guava.

Acidity

Foliar application of zinc had no effect on acidity (Table 1).The foliar spray of boron at different levels had significant effect on acidity in grape juice. The minimum acidity was recorded in treatment B_2 (0.60%) and maximum in control (0.65%). The lowest acid content recorded under treatment B_2 might be due to the reason that the boron helps in conversion of acid into sugar. Similar findings were reported by Hoggag *et al.* (1995) in mango.

Total soluble solids (TSS)

Foliar application of zinc influenced the T.S.S content of grape (Table 1).The maximum T.S.S content was recorded in treatment Z_4 (0.4%) and minimum in control. The increase in TSS content might be due to the fact that it increased photosynthetic activity in the vine, which might have resulted in production of more sugar in grape. Similar results were also reported by Bacha *et al.* (1997) in grape.

The foliar spray of boron at different levels had significant effect on TSS content of grape. The maximum TSS was recorded in treatment B_2 (0.2%)and minimum in control. The increase in TSS by boron treatment might be due to its physiological role in nitrogen metabolism.

Reducing sugar, non-reducing sugar and total sugar

The foliar spray of zinc influenced the reducing sugar, non-reducing sugar and total sugar in grape (Table 1). The maximum reducing sugar (14.54%), non-reducing sugar (1.76%) and total sugar (16.30%) were reported with treatment Z_4(0.4%) and minimum in control. The improvement in the sugar of fruits might be due to improved auxin content with the application of zinc and it also acted as catalyst in oxidation-reduction process. Similar results were reported by Agaev (1985) and Alekperov (1985) in grapes.

The application of boron as foliar spray significantly enhanced the reducing, non-reducing and total sugar in grapes. The maximum reducing (14.50%), non-reducing (1.71%) and total sugar (16.22%) were recorded in treatment B_2 (0.2%) and minimum in control. The improvement in quality of fruits in terms of increase in sugar content might be attributed to enzymatic reactions like hexolumax and formation of cellulose and also acted as catalyst in oxidation-reduction process (Levitt, 1972). Similar findings were also reported by Hoggag *et al.* (1995) in mango.

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Soil test based fertilizer recommendation under IPNS for cumin in torripsamments of Rajasthan

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Abstract

Soil test crop response correlation studies were conducted with cumin (var. RZ-209) under integrated plant nutrition system (STCR-IPNS) in Torripsamments of Rajasthan during rabi, 2004-05. Fertilizer adjustment equations under IPNS were formulated for cumin following Ramamoorthy's inductive-cum targeted yield model. The nutrient requirement for producing one quintal of cumin was found to be 4.06, 2.71 and 4.88 kg of N, P_2O_5 and K_2O, respectively. The per cent nutrient utilization efficiencies from soil and fertilizer nutrients were found to be 21.81 and 27.43 for N, 49.17 and 23.11 for P_2O_5 and 15.59 and 50.93 for K_2O, respectively. Likewise the per cent nutrient utilization efficiency from farm yard manure (FYM) was 7.43 for N, 11.22 for P_2O_5 and 27.71 for K_2O, respectively. In STCR-IPNS technology, the fertilizer doses are tailored to the requirements of specific yield targets of cumin taking into account the contribution from soil, fertilizers and organics.

Key words : *Cumin, STCR-IPNS, fertilizer adjustment equations, Torripsamments*

Introduction

The modern crop production technology emphasizes the need for integrated plant nutrient supply involving the judicious use of combination of organic and inorganic. The use of chemical fertilizers is a must for Indian agriculture but at least one third of the total nutrients must be in organic form for enhancing the efficiency of the inorganic component, cost effectiveness and reducing the burden of environmental damage (Sankaram, 1997).

Rajasthan stands first in area as well as production among cumin growing states. In Rajasthan cumin is being cultivated in an area of about 2.27 lakh hectare with a production of 1.21 lakh tonnes and average productivity of 5.31 q ha^{-1}. (Anonymous, 2004). After coriander, cumin is the second most important condiment used throughout the world. Cumin seeds and oil are used in culinary preparations for flavouring vegetables, pickles, soups, sauces, cheese, seasoning of breads, cakes and biscuits. Cumin is also valued for its typical pleasant aroma from its volatile or essential oil. Apart from its culinary value, cumin is also extensively used in Ayurvedic medicines. Currently, a general recommendation of 10-15 t FYM, 30 kg N and 20 kg P_2O_5 ha^{-1}, is being followed. fertilizer application based on blanket recommendation results in either over use or under use of fertilizers, hence balanced fertilizer application is a must for realizing higher efficiency and economy of fertilizer use (Velayutham and Reddy, 1990). For fertilizer recommendation the existing soil fertility and crop requirements should be taken into account (Ramamoorthy *et al.*, 1967). This demands the maintenance of soil fertility and plant nutrient supply to an optimum level for desired crop productivity through possible sources of nutrients in an integrated manner. With this background an attempt was made to develop IPNS technology for cumin in torripsamments of Rajasthan.

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Materials and methods

A field experiment based on inductive methodology was conducted in Torripsamments of Bikaner during rabi 2004-05 with cumin (Var. RZ-209). The soil of the experiment field was non-saline (EC_2 0.3 dS m^{-1}), loamy sand in texture with pH 8.4. The initial $KMnO_4$-N, Olsen-P and NH_4OAc-K status were 96.20, 23.70 and 148.90 kg ha^{-1}, respectively. Following the inductive methodology of the Ramamoorthy *et al.* (1967), four fertility gradients were created in the preceding season by dividing the experimental field into four equal strips. The first strip received no fertilizer, whereas second, third and fourth strips, half one and two times the standard dose of N, P and K, respectively. An exhaustive crop of clusterbean (var. RGC-986) was grown prior to experimentation.

By growing the exhaustive crop, the operational range of soil fertility was created in the fertility strips, which was evaluated in terms of variations in yield, uptake and soil

test values. After the harvest of the exhaustive crop, each strip of the fertility gradient was divided into four equal blocks across the strip for farmyard manure (FYM) levels. Then each strip was divided into 32 plots and fertilizer treatments were distributed in such a manner that every treatment was accommodated in each gradient strip as well as in FYM block.

Pre-sowing soil samples were collected from each gradient plot before superimposition of the treatments and were analysed for alkaline KMnO4-N (Subbiah and Asija, 1956), Olsen-P (Olsen *et al.,* 1954) and neutral N NH_4OAc-K (Hanway and Heidel, 1952). Cumin (Var. RZ-209) crop was grown with standard agronomic practices. After the harvest of crop, the grain and stover yields of cumin were recorded plot wise. The plant samples from each plot were analysed for total N, P and K content (Piper, 1966) and total uptake was computed using cumin yield data.

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

Results and discussion

Soil available nutrients and cumin yield

The range and mean values of cumin yield, uptake and available soil nutrients of treated and control plots are furnished in Table 1. The $KMnO_4$-N ranged from 82.20 to 92.80 kg ha^{-1} with a mean of 87.40 kg ha^{-1}, Olsen-P ranged from 22.50 to 35.50 kg ha^{-1} with a mean of 29.87 kg ha^{-1} and NH_4OAc-K ranged from 160.50 to 196.40 kg ha^{-1} with a mean of 175.02 kg ha^{-1}. The cumin yield in fertilizer treated plots ranged from 3.12 to 11.12 q ha^{-1} with a mean value of 6.83 q ha^{-1} and in control plots ranged from 2.92 to 6.12 q ha^{-1} with a mean value of 4.03 q ha^{-1}. The above data clearly indicate that a wide variability existed in the soil test values and cumin yield of treated and control plots, which is a pre-requisite for calculating the basic parameters and fertilizer adjustment equations for calibrating the fertilizer doses for specific yield targets.

Table 1. Range and mean values of available nutrients in the pre-sowing surface soil, yield and nutrient uptake of cumin

Parameters	Range	Mean
Soil test values		
$KMnO_4$-N	82.20 - 92.80	87.40
Olsen-P	22.50 - 35.50	29.87
NH_4OAc-K	160.50 -196.40	175.02
Wheat yield (q ha^{-1})		
Treated plots	3.12 - 11.12	6.83
Control plots	2.92 - 6.12	4.03
Nutrient uptake (kg ha^{-1})		
Treated plots		
N uptake	12.14 - 45.75	27.85
P uptake	9.31 - 33.05	18.51
K uptake	13.42 - 65.39	33.36
Control plots		
N uptake	11.10 - 22.65	14.82
P uptake	9.40 - 18.09	11.09
K uptake	14.59 - 35.12	20.13

Table 2. Nutrient requirement and per cent contribution from soil, fertilizer and FYM for cumin

Parameters	N	P_2O_5	K_2O
Nutrient requirement (kg q^{-1})	4.06	2.71	4.88
Soil nutrient utilization efficiency (%)	21.81	49.17	15.59
Fertilizer nutrient utilization efficiency (%)	27.43	23.11	50.93
Nutrient contribution from FYM (%)	7.43	11.22	27.71

Basic parameters

The basic data, *viz*, nutrient requirement for producing one quintal of cumin yield, the per cent nutrient utilization efficiency for soil, fertilizer and FYM have been calculated (table 2) and were used for formulating the fertilizer prescription equation under IPNS.

The nutrient requirements of N, P_2O_5 and K_2O were 4.06, 2.71 and 4.88 kg q^{-1} of cumin, respectively. The per cent nutrient utilization efficiencies from soil and fertilizer nutrients were found to be 21.81 and 27.43 for nitrogen, 49.17 and 23.11 for phosphorus and 15.59 and 50.93 for potassium. Similarly, the per cent contribution of N, P_2O_5 and K_2O from FYM were 7.43, 11.22 and 27.71, respectively. The data on C_s and C_f indicated that the per cent utilization efficiencies from fertilizer source were greater than that from soil in case of N and K_2O, whereas in P_2O_5 it was reverse.

The application of FYM also contributed for particular nutrients i.e nitrogen, phosphorus and potassium. The findings are in line with those reported by Reddy *et al.* (1994), Rao *et al.* (1997) and Santhi *et al.* (2002).

Fertilizer adjustment equations for desired yield targets of cumin

Soil test based on fertilizer models or equations for

Table 3. Soil based fertilizer equations for targeted yield of cumin

FN	=	14.80 T	-	0.79 SN	-	0.28 FYM
FP	=	11.73 T	-	2.13 SP	-	0.48 FYM
FK	=	9.58 T	-	0.31 SK	-	0.54 FYM

Note : FN, FP and FK- fertilizer N, P_2O_5 and K_2O in kg ha^{-1}, respectively, T- yield target in qha^{-1}, SN, SP and SK- $KMnO_4$-N, Olsen-P and NH_4OAc-K in kg ha^{-1}, respectively.

Table 4. Estimates of soil test based fertilizer recommendations for 8 q ha^{-1} grain yield target of cumin (kg ha^{-1})

Soil test values (kg ha^{-1})			Fertilizer required for grain yield target of 8 q ha^{-1} without FYM/compost			with FYM/compost @ 5 t ha^{-1}		
N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
80	20	160	55.20	51.24	27.04	53.80	48.84	24.34
85	25	170	51.25	40.59	23.94	49.85	38.19	21.24
90	30	180	47.30	29.94	20.84	45.90	27.54	18.14
95	35	190	43.35	19.29	17.74	41.95	16.89	15.04
100	40	200	39.40	8.64	14.64	38.00	6.24	11.94

targeted yield of cumin were formulated using the basic parameters and are furnished in table 3.

On the basis of these equations ready reckoner were prepared for range of soil test values and for yield target of 8.00 q ha^{-1} (Table 4) under different fertilization programmes. For producing 8.00 q ha^{-1} of cumin in Torripsamments, with an average soil test values of 90, 30 and 180 kg ha^{-1} N, P_2O_5 and K_2O, respectively, the required fertilizer doses were 45.90, 27.54 and 18.14 kg N, P_2O_5 and K_2O, respectively with 5 tonnes of FYM.

The findings of these studies indicated that in STCR-IPNS technology, the fertilizer doses could be tailored to the requirement of specific yield target of cumin taking into account the contribution from soil, fertilizers and organics. Hence, there will be a balanced supply of nutrients coupled with recycling of organic waste avoiding either under or over use of fertilizer inputs.

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Use pattern of agro-chemicals in ber based cropping system: ber grower's perceptions

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Abstract

The present study was conducted in Bikaner district of western Rajasthan. A total of 108 ber growers were selected for the study using purposive-cum-random sampling method. It was found that during kharif season, 8-36% ber growers grow various vegetables as intercrops in ber orchards on area ranging from 0.1-1.2 ha. During rabi season, 9-32% ber growers grow several Rabi vegetables/wheat/mustard/gram/green fodders/cumin/fenugreek (seeds) as intercrop in ber orchards on area ranging from 0.1-1.1 ha. Some of the ber growers grow some vegetables as intercrops in ber orchards during the summer season also.

It was also observed that 37-86%, 48-89% and 17-29% ber growers use various fungicides, insecticides and nematicides, respectively to control the insect pests and diseases in ber and vegetable intercrops grown in ber orchards. The chemical fertilizers (Urea, DAP, SSP) is used by 32-98% ber growers in ber based cropping system. However, the ber growers are unhappy with use of agro-chemical (Fungicides, insecticides, fertilizers, etc.) in their crop production. They perceive that the use of agro-chemicals in crop production leads to "poisoning and degradation of the soil quality/properties, degradation in quality and tests of the crop produces, crop produces become unhealthy and poisonous, induce the diseases and disorders in human being and animals body, reduce biodiversity, contaminate the ecological food chain, pollute the irrigation water, decrease the soil fertility, dangerous to crops and other economic plants, induce paralytic effect on human and animals limbs, increase soil drought and pollute the air, water bodies and ground water.

Key words: *Bikaner, ber, inter crop, insecticide, fungicide, fertilizer*

Introduction

Ber *(Ziziphus mauritiana* L.*)* is an important indigenous fruit of Indian subcontinent. It is grow to almost some extent in almost all the states of India. The tree is drought hardy and can grow under the most hazardous and harsh climatic conditions. Amongst the fruit trees, ber cultivation requires least input and care. It can give good yield with assured income even under rainfed and marginal growing conditions. It has been proved by the horticulturist that the arid environment of western Rajasthan is most suitable for production of high quality ber fruits. In recent years, the farmers of western Rajasthan have adopted various commercial improved verities of ber on large scale and as a conseqence of which area and production under ber crop is increasing day by day in this region. The farmers in these regions grow vegetables, pulses, legumes and oilseeds in ber orchards as inter crops to obtain extra income from per unit of land and better utilization of resources. Today, ber based cropping system is one of the most successful and emerging system of crop production in arid eco-system. However, the attack of pests and diseases on ber and ber based cropping system is a major problem before the ber growers. Low soil fertility level also have negative impact on progress of the above cropping system.

To manage the above problems in ber based cropping system, the farmers use various agro-chemical like chemical pesticides/ fungicides/insecticides and fertilizers. However, the farmers are not satisfy with the use of above agro-chemicals as they perceive that these chemicals are harmful from the ecological point of view. But there are no authentic data which can make clearly demarkate the present use pattern of agro-chemicals and farmers perception about bad impact of these chemicals on ecological/ environmental aspects. Keeping the above fact in mind, the present study was conducted in Bikaner district of western Rajasthan with the following objectives.

1. To evaluate the use pattern of agro-chemical in ber based cropping system.
2. To assess the farmer's perceptions about negative impact of agro-chemicals.

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Materials and methods

The present study was conducted in Bikaner district of western Rajasthan. The Bikaner district consist of eight revenue Tehsil. Out these, three Tehsils namely Bikaner, Nokha and Kolayat Tehsil were selected purposively for the study. Ber growing villages of each Tehsils were identified and listed (with the help of secondary information available at each Tehsil headquarter and consultation with extension agents/ state Govt. deptt. of horticulture/ agriculture). Twelve villages were selected randomly from above so listed ber growing villages of each Tehsil. Thus, a total of 36 ber growing villages were selected from the above three Tehsils. Further, all the ber growers of selected 36 villages were listed one by one and out of these, three ber growers were selected from each villages for the study. Thus, a total of 108 (total sample size) ber growers were selected amongst all three selected Tehils of the district for the study using purposive-cum-random methods of sampling. The selected respondents (ber growers) were personally contacted, interviewed and their response were recorded on semi-structured interview schedule.

The perception of ber grower's (respondents) about impact of agro-chemicals on ecological/environmental aspects were recorded on a five continuum scale i.e. strongly agree, agree, undecided, disagree and strongly disagree. The scoring 5,4,3,2 and 1 was allotted to response strongly agree, agree, undecided, disagree and strongly disagree, respectively. The statistical tools like scores, percentage, ranks etc. were used for statistical analysis of data and drawing the conclusion and inferences of the study.

Results and discussion

The socio-economic status of the farmers play very important role in adoption of any improved technology and capacity building of them for crop production. During the present study, the socio-economic status of the ber growers (respondents) was also assessed which is described below.

Socio-economic status of the ber growers.

The socio-economic status of the ber growers is presented in Table 1. From the table it could be seen that the majority (53.70%) of the ber growers were middle age group while few were of old age group. The educational status of the ber growers was very poor. The majority of them were have primary and middle standard education, only a few (17.60%) ber growers were graduate and postgraduate level. Majority (48.15%) of the ber growers belonged to other backward caste (OBC) and second majority of ber growers belonged to general caste. None of the ber growers belonged to schedule tribe category. It was also observed that about fifty per cent (47.22%) ber growers were of high income group who could earn more than one lakh annually from all the sources. There were ber growers which had large size (>9 ha) of land holding and second majority was of medium farmers. It was also observed that the majority (46.30%) of the ber growers had low extension orientation i.e. their participation in extension programme was low. There were only 25.0% ber growers who had high extension orientation. Thus, it may be said that the overall socio-economic status of the ber growers was not good.

Table 1. Socio-economic status of ber growers (respondents)

Variable	Total Sample size (ber growers)=108 Frequency of ber growers	ber growers (in%)
A. Age:		
1. Young (18-35 yrs)	29	26.85
2. Middle age (36-50 yrs)	58	53.70
3. Old (>= 51 yrs)	21	19.45
B. Education:		
1. Illiterate	07	06.48
2. Functional literate	15	13.88
3. Primary School	28	25.93
4. Middle School	22	20.37
5. High School	17	15.74
6. Graduate	13	12.04
7. Post Graduate	06	05.56
C. Caste:		
1. SC	19	17.59
2. ST	00	00.00
3. OBC	52	48.15
4. GEN	37	34.26
D. Annual income:		
1. Low (20000-50000)	20	18.52
2. Middle (51000-100000)	37	34.26
3. High (>= 10,0000)	51	47.22
E. Size of land holding:		
1. Small (1.1-2.0 ha)	14	12.96
2. Medium (4.1-9.0 ha)	41	37.96
3. Big (>9.0 ha)	53	49.08
F. Extension Orientation:		
1. Low (Score up to 33)	50	46.30

Intercrops grown in ber orchards.

The ber based cropping system in arid environment of western Rajashtan is one of the most important emerging system of crop production. The area under this system is increasing day by day and various vegetable and other crops are grown in the interspace of ber orchards as intercrops.

Table 2, reveals that during kharif season, 8-36 per cent of the ber growers grow mateera, snap melon, kachri, bottle gourd/round melon/ridge gourd/ brinjal / chilli /tomato /onion/ Indian aloe/cluster bean/groundnut/moth bean, in an area ranging from 0.1-1.2 ha. as intercrops for generating extra income and for better utilization of available natural and human (family labour) resources. Similar findings have

been reported by Sharma and Khurana (2000), that majority of the farmer grow pulses (moong, mash, cowpea), vegetables, oilseeds as intercrops in mango orchards in Gurdaspur district of Punjab.

Table 2. Intercrops grown by ber growers in ber orchards.

Season		Intercrops in ber Orchards	Area (in ha.)	Percentage of growers
(a) Kharif	(i)	Mateera/Snap melon/Kachri	0.2-1.0	12-23
	(ii)	Bottle gourd/ roundmelon/ ridgegourd	0.1-0.4	8-18
	(iii)	Brinjal / chilli/tomato /onion/Indian aloe	0.1-0.7	14-22
	(iv)	Cluster bean/groundnut /moth bean	0.5-1.2	19-36
(b) Rabi	(i)	Brinjal/onion(green) /tomato/Indian aloe	0.1-0.5	12-20
	(ii)	Cauliflower/cabbage	0.1-0.3	9-16
	(iii)	Spinach/fenugreek (leaves)/coriander (green)	0.1-0.3	18-26
	(iv)	Cumin(seeds)/ fenugreek(seeds)	0.5-1.1	14-32
	(v)	Radish/carrot/Pea	0.2-0.4	13-23
	(vi)	Wheat/mustard/gram /green fodders	0.2-1.0	11-16
(c) Zaid (summer season)	(i)	Mateera/snap melon /kachri/Tar kakadi	0.3-0.7	14-26
	(ii)	Bottle gourd/ridge gourd/round melon	0.1-0.4	10-18
	(iii)	Brinjal/ tomato /chilli/cluster beam (veg.)/cowpea	0.1-0.6	12-19
	(iv)	Spinach/Amaranthus /onion(green)	0.1-0.2	7-15

Similarly, during Rabi season 9-32 per cent ber growers, grow cauliflower/cabbage/spinach/fenugreek (green)/ Indian aloe/radish/carrot /pea/wheat/mustard/ gram/green fodders/cumin (seeds)/ fenugreek (seeds) in an area ranging from 0.1-1.1 ha. as intercrop in ber orchards.

It was also reported that the farmers who had irrigation facilities, grow vegetable crops in ber orchards during summer (zaid) and 7-26 percent ber growers, grow spinach/ round melon/ brinjal/ tomato/ chilli/ cluster bean (Vege.)/ cow pea, Mateera/ snap melon/ kachri as intercrop in ber orchards during the same season on a small scale (0.1-0.7 ha) to get extra income and multi-utilization of available resources.

However, the severe attack of insect-pests and diseases and low fertility status of soil of the region affect the ber based cropping system of the farmers negatively. Therefore, the farmers (ber growers) use various agro-chemicals to manage the above problems.

Agro-Chemicals used in ber based cropping system

The major agro-chemicals (fungicides/bactericides, insecticides/ fumigants, nematicides, chemical fertilizers, etc.) used by the ber growers to protect their ber and component intercrops from the attack of insect-pests and diseases and to manage the soil fertility are presented in Table-3.

The Table 3, reveals that 37-86 per cent ber growers use various fungicides/bactericides like bavastin, benomyl, thirum, mancozeb, ridomil MZ, Karathene, topsin, streptomycin/agrimycin, zineb, chlorneb, etc. to control the various diseases like powdery mildew/downy mildew, bight, root rot, fruit rot, leaf spot/anthracnose in intercrop vegetables, mustard, ber, pomegranate, etc. grown in ber orchards. The ber growers, purchase these fungicides/ bactericides from local markets, shopkeepers, pesticide agencies and use them on their crops in uncontrolled manner through seed treatment or foliar spray or soil treatment.

Further Table 3 reveals that majority (48-89%) of the ber growers use excess of insecticides/fumigents to control the attack of insect-pests either on ber or intercropped vegetables. The major insecticides/fumigants used by the ber growers are cholropyrifos, acephate, quinalphos, endosulfan, methylparathion, themate, roger, phosphamidon, monocrotophos, fenvalerate, malathion, dimethoate, carbaryl, phorate, etc. These insecticides are used through foliar spray or applied in soil in granular or powder form or with irrigation water to control different insect-pests. Shaik, and Bhal (2000) also stated similar findings in their study conducted in Delhi state. They reported that 27-63% vegetable growers used endosulfan, malathion and cypermethrin chemicals pesticides to protect their raddish, turnip, brinjal, tomato and cucumber crops from the attack of pests and diseases.

The attack of nematode in vegetable crops like brinjal, chilli, tomato, etc. is a very serious problem in arid regions as reported by the farmers. About 17-29 per cent ber growers use some nematicides/ fumigants to control the attack of nematodes. The major nematicides/funigants used by ber growers were: nemagon, vapam, carbofuram, aldicarb, phenumiphos, etc. to avoid the attack of nematodes in their intercrop vegetables. Some of the Vegetable growers use zinc phosphide in the form of bait to control the attack of rodents/ rats in their vegetable fields. But due to the religious aspects, the rodenticides were used by a few farmers only.

The soil of the arid regions are sandy and very much poor in fertility. Therefore, 32-98% of the farmers use chemical fertilizer like urea, diammonium phosphate (DAP), single super phosphate (SSP) murate of potash (MOP), etc. in the cropping system. Majority of the ber growers use urea and DAP in growing ber itself and vegetable, groundnut, mothbean, wheat, mustard, cumin, fenugreek, etc. in ber orchards for higher and quality of production.

Table 3. Agro-chemicals used by ber growers in ber based inter-cropping system.

Group of agro-chemical used	agro-chemicals used	Mode of application	Percentage of adopters (ber growers)
(i) Fungicides/ Bacteriocides	Bavistin, Benomyl (Benlate), Thiram, Mancozeb, Ridomil MZ, Karathene, Topsin, Streptomycin, Agrimycin, Dithane Z-78 (Zineb), dichlone, etc.	Through seed treatment, foliar spray and soil treatment to control diseases	37-86
(ii) Insecticides	Chlorpyriphos, Acephate, quinalphos, Endosulfan, Methylparathion, Themate, Roger, Phosphamidon, monocrotophos, fenvalerate, malathion, Dimethoate, Carbaryl, Phorate, etc.	Through dusting, foliar spray and soil treatment to control insect pests.	48-89
(iii) Nematicides/ fumigents	Nemagon, Vapam, carbofuran, Aldicarb, Phenumiphous	Through fumigation/ drenching/soil treatment to control nematodes and other insects.	17-29
(iv) Rodenticide /Raticide	Zinc Phosphide	Through baiting to control the rats in vegetable fields.	18-32
(v) Chemical Fertilizers	Urea,/Diamonium phosphate/Single super phosphate/Murat of potash, etc.	Through soil and foliar application to increase soil fertility and productivity	32-98

Table 4. Perceptions of ber growers regarding mischievous impacts of agro-chemical's

Perceptions	Sectional Ranking (PMS*=540) Scores	Rank	Overall Ranking
Section-A: Impact on Soil System/components			
1. Poisoning and degradation of soil quality/properties	356	1	1
2. Death of soil micro flora and fauna	232	3	11
3. Increase the soil droughtness	181	4	16
4. Affact water and nutrient availability	146	5	19
5. Decrease the soil fertility	264	2	8
Section-B: Impact on water quality/requirement			
1. Pollution of irrigation water	277	1	7
2. Pollution of water bodies and ground water	209	2	13
3. Increase the demand of irrigation	167	3	18
Section-C: Impact on plant growth, yield & quality			
1. Dangerous for crops and other economic plants	244	3	9
2. Degradation of the quality and test of produces	346	1	2
3. Crop produces become unhealthy/ poisonous	333	2	3
4. Induce localized deformities in plant system	189	4	15
Section-D: Impact on human and animals health			
1. Induce the diseases and disorders	329	1	4
2 Induce Paralytic effect on human and animals limbs	242	2	10
3. Reduce the working capacity and productivity of human being/animals.	133	4	20
4. Reduce resistance power of animal/human body	179	3	17
Section-E: Impact on other environ-ecological aspects:			
1. Reduction of the biodiversity	321	1	5
2. contamination of ecological foodchains(food,feed and fodder sources)	308	2	6
3. Pollution of the air	202	4	14
4. Dangerous for existence of wild life	219	3	12

***PMS= Possible Maximum Scores.**

However, the ber growers are not happy with use of different agro-chemicals in growing their crops. The farmers apprehend that the agro- chemicals are dangerous and have bad impact on their crop fields, irrigation water, quality of products, human health and other environmental/ ecological aspects. The farmers perceive that the use of agro-chemical in crop production are harmful and very risky from the ecological point of view.

Perceptions of ber growers regarding negative impact of agro- chemical's used.

Perception of ber growers regarding negative impact of agro-chemicals used in crop production was evaluated under different sections.

Table 4, reveals that amongst the impact of agro-chemicals on soil system/ components as perceived by the ber growers were "poisoning and degradation of soil quality/ properties, decrease the soil fertility, death of soil micro flora and fauna and increase the soil drought," which were ranked first, second, third, and fourth with score 356, 264, 232 and 181, respectively. Amongst the impact of agro-chemicals on water quality/requirement as observed by ber growers were "pollution of irrigation water, pollution (Poisoning) of water bodies and ground water and increase the demand of irrigation," which were rank 1st, 2nd,and 3rd with score 277, 209 and 167 respectively. "The degradation of the quality and test of the produces, produces become unhealthy/poisonous, dangerous for crops and other economic plants and induce localized determities in plant system," were major bad impact of agro-chemicals on plant growth, yield and quality of produces as reported by the ber growers. These findings are on the line of the findings as reported by Rao, (1994).

Amongst the impacts of agro-chemicals on human and animal health's as perceived by the ber growers were that they "induce the disease and disorders, induce the paralytic effect on human and animal limbs, reduce the resistant power of human being and animals and reduce the working capacity and productivity of human being and animals which were ranked by the ber growers as first, second, third and fourth bad impact of agro-chemical with scores 329, 242, 179 and 133, respectively. Nair, (1996) reported that the pesticides are fatal to environment and human health. The pesticides have chronic effect on human being like inducing cancer, genetic mutations, damage to immune system, kidney, liver etc.

The impact of agro-chemicals on environmental/ ecological aspect as viewed by the ber growers, were "reduction of the bio-diversity, contamination of ecological food chain (food, feed and fodder sources), dangerous for existence of wild life and pollution of air which were ranked 1st, 2nd, 3rd, and 4th with score 321, 308, 219 and 202 respectively. These are supported by the findings of Potter (1965) and Piementel *et. al.* (1992). They reported that the heavy use of pesticides had poisoning impact on food stuff and contaminate the environment. They disturb the ecological processes and affect the normal life of domestic animals, vegetation, flora and fauna and wife life, etc.

The conclusion of this study is that about 1/3 population of ber growers grow various vegetables as intercrops in ber orchards during kharif, rabi and zaid (summer) season of the year. Majority of ber growers use several agro-chemicals (fungicides, insecticides, nematicides, rodenticides and chemical fertilizers) in their ber based cropping system. However, they were not satisfied with the use of agro-chemicals in their crop production system. They apprehended that these agro-chemical have bad impact on environmental/ecological aspects. They have ill effect on biodiversity, ecological food chain, soil fertility and soil micro- organism. Hence, the farmers should be trained and guided for scientific and environmental safe use of agro-chemicals in their crop production. They should be motivated for adoption of organic farming system in horticultural crop production. The organic farming system, integrated nutrient management, integrated pests and diseases management, biopesticides, organic manures, etc. should be popularized amongst the farmers/ber growers of arid region so that they may adopt these practices for better horticultural crop production with minimum environmental risk.

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Biological control of arid fruit diseases

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Abstract

Area of plantation of arid fruits is increasing every year under arid and semi-arid regions of the country. Fruit crops like ber; pomegranate, aonla, date palm and other minor fruits are mostly grown in water deficit areas. Among different production constraints in these crops, diseases are also concerned with yield and quality of fruits. For example, powdery mildew of ber can devastate whole orchards and fruit rots can trim down yield and quality of fruits. Leaf and fruit spots in pomegranate affect the foreign trade; rust in aonla results in poor quality of fruits in the absence of proper management practices in these crops. Low establishment of new plantation in date palm is mainly because of sucker rot in addition to fruit rot incited by common saprophytes. Despite, advancements in plant pathology and molecular plant pathology, much attempts have not been focused on etiology and management of arid zone fruits and therefore, presently a comprehensive information on biological control is discussed herewith.

Key words: *Ambient temperature, physiological loss in weight, spoilage loss, economic life and respiration rate*

Introduction

The control efficacy of various fungicides for the management of most of the diseases of arid zone fruits has been worked out by many workers. Biological control is gaining importance for management of crop diseases. Particularly, bacterial antagonists are also useful for post harvest treatments for the control of fruits diseases (Pusey and Wilson, 1984). The important diseases in different fruit crops along with their control measure is discussed.

Biological control of ber diseases

Indian jujube (*Ziziphus mauritiana* Lam) belongs to the Order Rhamnales, Family Rhamnaceae and Genus *Ziziphus*. This crop is relatively free from diseases wherein the dry, hot weather coupled with very less relative humidity prevails. However, diseases like powdery mildew and leaf spots in humid region, fruit rots in arid region and post harvest diseases due to common saprophytic fungi in all marketing locations of ber fruits are economically important and concern with yield and quality of fruits. Ber being one of the major under utilized fruits, systematic research has not been carried out even on major diseases However, after the establishment CIAH, Bikaner, much progress has been made with regard to ber diseases and their management with reference to biological control. Verma *et al.* (2000) has conducted a survey and observed the diversity of ground flora, soil micro flora and fauna under plantations of *Ziziphus mauritiana* in Mohan Bhata land (Bilaspur), Madhya Pradesh, India. The populations of fungi, bacteria, nematodes and vesicular-arbuscular mycorrhizal (VAM) fungi were more diverse in soils under plantations.

Ber powdery mildew is a major disease causing great loss up to cent per cent in production and quality of ber fruits. Disease caused by *Oidium erysiphoides* f.sp. *Ziziphi* was first reported from Allahabad. Kumar *et al.* (1978) noted the occurrence of powdery mildew of ber (*Ziziphus* spp.) in Indian arid zone. Nallathambi and Thakore, 2003 have worked out this method for the first time under field experiments on management of powdery mildew using the native isolates of *Trichoderma* (CIAH-240) and *Pseudomonas fluorescens* (CIAH-196) with 50% less concentration than recommended dose of fungicide (karathane). Spray of bioagents on susceptible ber cultivars (Gola and Umran) at pea stage at monthly interval results maximum of 90% control. Spraying 5% culture filtrate of *Trichoderma* (CIAH-240) followed by conidial suspension of *Trichoderma* (5 and 10%) spray resulted in 82.19 and 83.2% control, respectively. In case of cv.Gola per cent control efficacy was 95.81 by combined application of *P.fluorescens* and 0.05% karathane (Nallathambi and Umamaheswari, 2003 and Nallathambi *et al.*, 2003a and 2003b). Therefore, the bioagnets are of great importance and an alternative component in integrated management formulations. The mode of action revealed mostly disruption of conidia, which is important of for the dissemination and subsequent infection. In some cases, mycelia strands were

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also disrupted after exposing to the antagonists. However, detail investigations are under progress.

Ber fruit rots are not a major problem in other regions of the country. However, in western parts particularly in arid regions of Rajasthan, it is a major problem than powdery mildew in ber. Nalathambi (2001) have studied in details about different kinds of rots due to various fungal pathogens. In almost all the major varieties of ber growing in arid regions of Rajasthan, different types of fruit rots were recorded. Diseases caused by *Alternaria* species have also been successfully managed by bio control agents like *Trichoderma harzianum* and *Bacillus* sp (Mercer and Papadopolous,1990). Different native isolates of *Trichoderma* were evaluated for *in vitro* inhibition of *A. alternata*. Nallathambi and Thakore (2002b) has tested various isolates of bio agents against *A. alternata*. Out of 16 isolates, 9 isolates could check more than 50% growth of pathogen. Native isolate CIAH-240 (5% level) was significantly superior to rest of the isolates. Isolates viz., CIAH-142; CIAH-150, CIAH-161, CIAH-165a and CIAH-259 resulted less than 50% checks. It is well-established fact that *Trichoderma* species suppress plant pathogens by competition, antibiosis and mycoparasitison. Different native isolates of *Trichoderma* inhibit the pathogen by different mechanisms. The superior isolate CIAH-240 was mycoparasitic as well as secreted toxic metabolites. Isolates CIAH-142 and 165a can be used as mycoparasitic while rest of isolates are merely competitive. Isolate CIAH-149 and SBI-48 can secrete antifungal metabolites in growth medium to suppress *A.alternata*. Out of 14 native isolates of *P. fluorescens*, CIAH-196 inhibited the maximum mycelial growth. Production of toxic metabolites like phenazine, pyocyanin and pyrrolnitrin and lytic enzymes are the characteristic features in virulent strains of *P. fluorescens*. Interestingly, sporulation of test pathogen was suppressed by some of the native isolates. *P. fluorescens* isolates viz., CIAH-226, SBI-48 and SBI-62175 could secrete the siderophores (yellowish pink), which checked the mycelial growth of the pathogen (Nallathambi and Thakore 2002a). However, sporulation of test fungus was not arrested. Microscopic observations also revealed severe distortion in pathogen hyphae at the juncture of hyphal tip and bacterial colonies.

Alternaria rot

Generally post harvest infection due to microbial organisms results into severe losses particularly in fruits due to high perishability. Fruits are ready-made food with high carbohydrates and other nutrients thereby utilization is easy for fungal colonization. In order to find some post harvest treatments for combating *A. alternata* infection which also was found to spoil fruits in transit and storage experiments were conducted under laboratory conditions using biocontrol agents, fungicides and combination of these two methods to reduce the infection. Nallathambi (2001) has identified some of the effective isolates of *P. fluorescens* under *in vivo*. All native isolates of *P. fluorescens* are effective with more than 60% control efficiency after 7 days of treatment. In addition, physical properties like texture and colour of ber fruits are better in bacteria treated fruits. Isolates of bioagents i.e. CIAH-240 (*Trichoderma*) and CIAH-196 (*P. fluorescens*) were found to be better than rest of the biocontrol agents tested and therefore, these two effective isolates have been taken for further experiments. Dinocap and copper oxychloride at 50 ppm 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 resulted 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. Fungicidal solution (50 and 100 ppm a.i.) and conidial suspension of *Trichoderma* (CIAH-240) may be prepared in concentrated form first and slowly dispensed into fungicides solution upto 10^6 conidia per ml. Mixing of *Trichoderma* certainly improved the efficiency of the treatment, as there was marked efficiency 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). 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 can be effective to control the Alternaria rot of ber at 100 ppm; the PEDC being 82.68, 78.33 and 77.58, respectively (Nallathambi and Thakore, 2003). 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 fungicide (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 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,

Chhuhara, Bagwadi, Chuhara, Bagwadi, Reshmi and Ponda showed immune response to fruit rot pathogen.

Biological control of pomegranate diseases

Pomegranate (*Punica granatum* L.) is a popular fruit of arid and semi arid regions. Apart from other biotic and abiotic stresses, diseases are major threat to this crop particularly in southern states. In earlier days, much attention was given on post harvest disease. However, leaf and fruit spots are the major diseases in Maharastra, Karnataka some parts of Gujarat and Rajasthan. Wherever humid conditions prevail, much incidence of fruit and leaf spots could be seen. Leaf spots can indirectly reduce the yield and fruit spots affect the physical appearance of fruits and thereby market value of the fruit is reduced. There are various other diseases at post harvest stages but those are easily manageable. Aril necrosis or blackening of aril and pomegranate wilt are important concern in productivity and quality of fruits. There are suitable fungicides for the management of these diseases however, being a export oriented crop and considering the residual effect and quality of fruits for international trade, use of chemicals is not appropriate. In order to manage wilt disease, different approaches were attempted and it was noted that the soil application of bacterial culture, *Bacillus subtilis* was effective in field condition in reducing pomegranate wilt incidence (Somasekhara, 2002). The antagonism of 56 rhizobacteria, isolated from healthy and diseased plants of pomegranate against *F. oxysporum* was evaluated *in vitro* by dual culture technique. Of the 10 isolates antagonistic to *F. oxysporum*, PHRB-13 and PHRB-32 showed the greatest inhibition (65.39%) of mycelial growth. Based on morphological and cultural characteristics, PHRB-5, PHRB-6, PHRB-9, PDRB-20, PHRB-41, and PHRB-54 were identified as non-fluorescent Pseudomonas, PHRB-13 as fluorescent Pseudomonas, and PHRB-32 and PDRB-45 were *Bacillus* sp (Chavan and Dake, 2001). Laboratory experiments were conducted to determine the effect of airborne antagonist *B. thermophillus* (*Bacillus thermophilus*) on *A. alternata* and *Drechslera rostrata* (*Setosphaeria rostrata*) of leaf spot of pomegranate. Conidial germination and mycelial growth of the three fungi were inhibited by *B. thermophillus* at 2.2 x 109 and 2.2 x 10^8 cfu/ml respectively. Under ordinary conditions, the bacterium was able to survive for more than 20 months *in vitro*. However, its population declined after 34 days of spray on pomegranate leaves. *B. thermophillus* produced a thermo-labile metabolite toxic to *A. alternata* and *D. rostrata*. *B. thermophillus* restricted the fungal growth and invasion in host plants, and caused morphological changes in the germ tubes or mycelia of these pathogens (Mandhare and Suryawanshi, 2003). Most of the 149 strains of bacteria tested were antagonistic to *Sphaeropsis malorum* from *Phoma punicae* from pomegranate. *Bacillus mesentericus* and *B. subtilis* strains were the most active antagonists (Oganyan,1977). Therefore, there is lot of scope for the exploitation of biological control of pomegranate diseases and it needs more research on basic aspects before moving to field experiments and commercial formulations of specific antagonists against target pathogens.

Biological control of date palm diseases

In India, date palm is grown in very limited areas mostly confined to water deficit areas of Gujarat and Rajasthan. There are different diseases in this hardy fruit crop but only few diseases are common in India. The Graphiloa leaf spot is major one followed by fruit rots. Recently it was observed that the failure in establishment of off shoots or newly planted suckers of date palm attributed with Diplodia rot. Sporadic incidence of wilt was also noticed in established plants. The other diseases reported in this crop are not common and therefore this text is restricted with the major diseases of India. In order to manage the soil borne diseases of date palm, the knowledge on the soil microflora and their potential use for the biological control is essentially required. In this regard, some of the basic research has been carried out in other countries. Atika *et al.* (1977) observed the rhizosphere of date palm cultivars of susceptible and resistant to *F. oxysporum* f.sp. *albedinis* showed that the microflora varied with seasonal changes, the nature of root exudates, plant health and genome. Nitrogen fixation, ammonification, nitrification, denitrification, starch, hemicellulose and cellulose degradation were also studied. Actinomycetes constituted a large part of the microflora of soil from the rhizospheres of susceptible and resistant cvs.of date palm. Of 271 actinomycetes tested against the pathogen, 50% were antagonistic (Sabaou *et al.*, 1980). The qualitative and quantitative distributions of bacterial populations in the rhizosphere of 2 date-palm cultivars, 1 sensitive and 1 resistant to fusariosis, and with the antagonistic capacity of these bacteria against the pathogen *Fusarium oxysporum* f.sp. *albedinis* were reported by Lamari and Sabaou (1993). In the external zones of young roots, bacterial growth was stimulated more by the sensitive cultivar than by the resistant one. A survey of 665 isolates permitted the bacteria to be grouped in 2 main genera, Pseudomonas and Bacillus, and in a coryneform group composed of *Arthrobacter*, *Brevibacterium* and *Pimelobacter*. The generic and specific composition differed between the 2 cultivars and varied with root age (young or old) and the root zones considered (internal or external). In external zones, Pseudomonas caryophylli and Pseudomonas gladioli were the most abundant for the sensitive cultivar. In the endorhizosphere, *Bacillus firmus* was more abundant in the resistant cultivar, and *Pseudomonas fluorescens* biovar II in the sensitive one. Differences were also noted in the percentages of antagonistic bacteria against *F. o.* f. sp. *albedinis*. It was concluded that plants can influence their own rhizosphere bacterial populations. Benjama (1994) observed bacterial contaminants on date palm in culture test tubes and the

investigations revealed that the contaminants were introduced with date palm hearts selected in the field for seedling multiplication. A Gram negative, flagellate type of *Bacillus*, represented by *B. pumilus* and *B. sphaericus* was identified from date palm, and a Gram positive type, represented by *B. brevis*, *B. laterosporus* and *B. circulans* was identified from date palm. The effect of filtrates from 9 microorganisms on *in vitro* germination and mycelial growth of *F. oxysporum* f.sp. *albedinis* was investigated by Sedra and Maslouhy (1995). Of the microorganisms tested, 6 were antagonists isolated from Marrakech date palm grove soils, 4 *Pseudomonas fluorescens* isolates, *Stachybotrys* sp. and an unidentified actinomycete. In the presence of the filtrates from the 6 antagonistic microorganisms, inhibition rate varied with the antagonists from 26.6 to 69% for spore germination and from 43.6 to 80.7% for mycelial growth. The inhibitory action of the filtrates was related to the antagonistic capacity of the microorganisms and to the chemical nature of antibiotic substances they produce.

Biological control of aonla diseases

Indian gooseberry (*Emblica officinalis Gaertn.*) is used as fruit and medicine. Area under cultivation is increasing rapidly not only in tropical and subtropical areas of India but also under arid region. In India, though there is limited effect of diseases on in its production. However, aonla rust and post harvest diseases are major constraints. In other countries like China, the brown spot (*Phyllostica emblica*), false anthracnose (*Kabatiella emblica*), Pestalotiopsis leaf spot (*P. heterocornis*) and powdery mildew (*Oidium* sp) have been reported. It is imperative to know about these diseases and nature of pathogen so that appropriate strategies could be formulated for the better management. Not much attempts have been made on the biological management of the diseases. Mamatha *et al.* (2000) have screened Seeds of *E. officinalis* for mycoflora incidence. Dominant mycoflora were isolated and their effects were studied on quality aspects like germination and vigour. Seeds inoculated with dominant fungi showed significant decrease in germination and seedling vigour. Seed samples were subjected to four different pre-treatments. Treatment with *Trichoderma* spp. was most effective both in reducing the incidence of mycoflora and enhancing the germination and vigor. However, this method can be well exploited for post harvest diseases since majority of the pathogens are saprophytic on injured fruits. In rare cases, colonization of antagonistic fungi like *Trichoderma* could be seen.

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Short communication

Performance of mango varieties for growth, flowering and yield under agro climatic condition of Chhattisgarh plains

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Mango is one of the important fruit crops of Chattisgarh and is grown in an area of 8880 ha (excluding forest trees) with production of 79920 tonnes (Patil, 2002). The crop takes about three to four months from the time of fruit set to maturity and ripening. In northern India, mango is harvested during end of May to July-August, while in Chhattisgarh, mango fruits mature one month earlier than north India which offers immense scope for the local as well as for export market. Therefore, the study was conducted to find out appropriate varieties/hybrids suitable for the region to obtain maximum benefit from the mango orchards.

The investigation was carried out at Horticultural Research Farm of Department of Horticulture, Indira Gandhi Agricultural University, Raipur, during the year 2002-03. Thirteen year old mango plants laid out in randomized block design in three replications with eleven treatments (varieties/hybrids) were taken for study. The varieties/ hybrids selected for study were Langra, Sunderja, Amrapali, Mallika, Pairi, Totapari Red Small, Krishnabhog, Amin, Neeleshwari, Kesar and Dashehari. Recommended package of practices were followed during the experimental period. The canopy volume of the tree was calculated by the formula, Volume $=p r^2h$, where $p = 3.14159$, r = spread (N-S+E-W)/ 4, h = canopy height. For complete information regarding fruiting behaviour of individual varieties, the date of first flower bud appearence, date of flower opening and date of full bloom were recorded.

Growth characters

The tree height of different varieties / hybrids showed significant differences. Maximum plant height were recorded in Amin (6.08 m), Langra (5.61 m) and Mallika (5.58 m), whereas, the varieties Neeleshwari (4.27 m), Pairi (4.40 m), Kesar (4.46 m) and Totapari Red Small (4.50 m) were found significantly shorter/dwarf. The canopy height was found to be maximum in Amin (4.98 m) followed by Mallika (4.57 m) and Langra (4.52 m), which were at par whereas, minimum canopy was observed in Amrapali (3.33 m) and Neeleshwari (3.33 m) which were at par with Pairi (3.37 m), Kesar (3.52 m), Totapari Red Small (3.56 m), Dashehari (3.67 m) and Krishnabhog (3.88 m). The trunk girth was maximum in Amin (112.33 cm) followed by Langra

Table 1. Vegetative growth characters of different mango varieties /hybrids

S.No.	Varieties	Tree height (m)	Tree canopy height (m)	Trunk girth of tree (cm)	Tree spread (m) (N-S)	Tree spread (m) (E-W)	Tree canopy volume (m^3)
1.	Langra	5.61	4.52	108.67	5.41	5.45	104.78
2.	Sunderja	5.00	4.07	74.67	4.75	4.73	73.54
3.	Amrapali	4.54	3.33	88.66	4.27	4.19	46.96
4.	Mallika	5.58	4.57	78.33	5.11	5.03	92.83
5.	Pairi	4.40	3.37	73.67	4.27	4.33	48.86
6.	Totapari Red Small	4.50	3.56	72.33	4.55	4.59	58.46
7.	Krishnabhog	5.00	3.88	83.66	4.88	4.73	69.52
8.	Amin	6.08	4.98	112.33	5.57	5.57	121.64
9.	Neeleshwari	4.27	3.33	70.33	4.86	4.85	61.39
10.	Kesar	4.46	3.52	87.00	5.10	4.87	69.51
11.	Dashehari	4.53	3.67	68.67	4.68	4.73	63.51
	C D at 5%	0.73	0.72	18.73	0.56	0.63	23.14

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Table2. Flowering and fruiting behaviour of different mango varieties/hybrids

S.No.	Varieties	Flowering behaviour (Date)			Fruiting behaviour			
		Flower bud initiation	Flowering	Full bloom	Fruit setting	No. of fruits /tree	Fruit weight (g)	Yield /tree (kg)
1.	Langra	27 Jan.	24 Feb.	6 Mar.	14 Mar.	182.67	136.67	24.89
2.	Sunderja	30 Jan.	20 Feb.	2 Mar.	12 Mar.	267.33	174.66	45.55
3.	Amrapali	3 Jan.	28 Jan.	12 Feb.	18 Feb.	583.33	84.00	48.76
4.	Mallika	28 Jan.	20 Feb.	4 Mar.	10 Mar.	261.33	164.67	42.90
5.	Pairi	7 Jan.	2 Feb.	12 Feb.	19 Feb.	107.66	159.33	17.03
6.	Totapari Red Small	15 Jan.	12 Feb.	24 Feb.	4 Mar.	498.00	76.67	37.92
7.	Krishnabhog	28 Jan.	24 Feb.	4Mar.	12 Mar.	127.33	166.66	21.13
8.	Amin	17 Jan.	10 Feb.	22 Feb.	3 Mar.	359.33	137.00	49.15
9.	Neeleshwari	5 Jan.	21 Jan.	16 Feb.	22 Feb.	219.00	133.33	29.25
10.	Kesar	21 Jan.	15 Feb.	28 Feb.	5 Mar.	173.33	145.67	25.20
11.	Dashehari	20 Jan.	5 Feb.	22 Feb.	1 Mar.	386.00	137.67	52.88
	C D at 5%	-	-	-	-	82.78	11.77	8.00

(108.67 cm). The spread of tree (N-S and E-W) was also noted maximum in Amin (5.57 m and 5.57 m) followed by Langra and Mallika. The variety Amin showed maximum tree canopy volume (121.64 m^3), which was at par with Langra (104.78 m^3) followed by Mallika (92.83 m^3)and significantly superior to other varieties. The minimum canopy volume was noted under Amrapali (46.96 m^3). Krishnamurthi *et al.* (1961) also reported high variability within the varieties for vegetative growth. Based on vegetative growth parameters, Amin, Langra, and Mallika appeared to be vegetatively vigorous after 13 years of plantation under Raipur plains.

Flowering

In mango, time of full bloom is demarcated as early, mid and late. The early blooming cultivars were Amrapali, Pairi and Neeleshwari, mid-bloomed cultivars were Amin, Dashehari and Totapari Red Small and late-blooming cultivars were Langra, Mallika, Sunderja, Krishnabhog and Kesar (Table-2). The varietal difference in flowering behaviour might be due to the different genetic make up of the varieties.

Fruiting behaviour

Early fruit setting was observed in Amrapali closely followed by Pairi and Neeleshwari while, late fruit set was observed in Langra, Sunderja and Krishanabhog. Fruit setting in all the varieties were observed between 18th February to 14th March. Similarly, Gangwar and Moti (1974) found stretched fruit setting in late mango varieties during last two weeks of March in north India. Maximum number of fruits per tree were noted in Amrapali followed by Totapari Red Small and Dashehari, whereas minimum number of fruits were observed in Pairi, Krishnabhog and Kesar. The maximum fruit weight was recorded with Sunderja followed by Krishnabhog while lowest fruit weight was noted in Totapari Red Small which was at par with Amrapali.

The high-yielding varieties were Dashehari followed by Amin and Amrapali. Poor-yield in cv. Pairi was due to the lesser number of fruits per tree while in Langra it may be due to the sudden upsurge in temperature, low R.H. (<30%) and hot air during the year under observation. However cv. Dasehari was not much affected. Hoda and Yadav (1987) also reported significant variation in fruit yield/ tree.

The varieties Amin, Langra and Hybrid Mallika were found vigorous. On the basis of flowering behaviour hybrids Neeleshwari and Amrapali appeared to be earlier, whereas, Mallika, Langra and Krishnabhog appeared late. The varieties Dashehari, Amin and hybrid Amrapali were found to be high-yielding.

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Short communication

Value added products in aonla

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Aonla (*Emblica officinalis* Gaertn.) known as Indian gooseberry is one of the important non-traditional fruit of Indian origin having immense potentiality of cultivation on marginal lands. The fruit is good source of Ascorbic acid. It contains chemical substances called leucoanthocyanin and polyphenols which retard the oxidation of Ascorbic acid. However, the fruit cannot be consumed afresh due to its highly acidic and astringent taste. Value addition through processing may be a suitable alternative for its economic utilization. Thus the present investigation was carried out to develop processing techniques for making different value added aonla products which can be used at home scale as well as commercial level.

Fresh aonla fruit (cv. NA. 6) was procured from the Central Institute for Arid Horticulture (CIAH), Bikaner in the month of December 2004. Seven value added aonla based products viz., aonla candy, chutney, jam, squashes, preserve, mouth freshener and pickle were prepared and standardized in the laboratory of Dept. of Food and Nutrition, college of Home science, Rajasthan Agricultural University, Bikaner following standard procedure for preparation and sensory evaluation. Samples of aonla fruit and their products were chemically analyzed as the method described by AOAC (1990) for its moisture, protein, fat, fiber, total ash, carbohydrate, energy and ascorbic acid content. The shelf life of all the products was assessed on the basis of their sensory attributes (on nine point hedonic ranking scale), ascorbic acid retention and microbial load (total viable count) during the recorded storage period of 60 days at the interval of each 15 days. The total cost of each developed product was estimated on the basis of food cost (60%) which included the raw material cost.

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The data recorded on nutritional analysis of developed aonla products ascertained that 100 gm of sample provides moderate amount of protein (0.2 to 0.3 g), crude fat (0.1 to 3.5 g), fiber (0.01 to 8.3 g), ash (0.1 to 1.2 g). The carbohydrate and energy content of the sample were recorded to be high after processing (Table 1). The moisture and ascorbic acid recorded as 3.3 to 70.8 g and 150 to 210 mg /100 g on fresh wt. basis is the indicator of moderate to low perishability of the products.

Gradual changes were recorded in ascorbic contents of aonla products during storage. After 60 days of storage ascorbic acid retention in different products varied between 40.7 to 68.9 mg of ascorbic acid per 100 g on the fresh wt. basis (Table 2). The reduction in ascorbic acid may be due to oxidation by light and trapped oxygen in glass bottle resulting in the formation of dehydroascorbic acid. Similar, reduction in ascorbic acid content during storage has been reported by Mehta and Rahotre (1976). Minimum loss was observed in aonla mouth freshener which could be due to dry state of the product. Singh *et. al.* (2001) stated that the greater stability of the ascorbic acid in dried products is assigned to the presence of polyphenols.

The effect of microbial quality on shelf life of the products 60 days after storage is presented in Table 2. The total viable count of all the developed products was found to be negligible. This could be due to compositional

Table 1. Nutritional composition of developed aonla products

Aonla Products	Moisture (g)	Crude protein (g)	Crude fat (g)	Crude fiber (g)	Total ash (g)	Carbohydrate (g)	Energy (Kcal)	Ascorbic acid (mg)
Candy	6.0	0.3	0.2	8.3	1.2	98.8	398	210.0
Chutney	25.3	0.3	0.1	1.2	0.9	99.0	399	186
Jam	3.3	0.2	0.3	0.8	0.1	99.8	403	150
Squash	70.8	0.2	0.1	0.1	0.2	99.7	400	211
Preserve	3.0	0.3	0.1	9.0	1.1	98.8	397	199
Mouth freshener	8.0	0.3	0.2	11.0	1.2	79.2	320	299
Pickle	26.0	0.5	3.5	11.1	5.4	23.5	397	180

Table 2. Ascorbic acid retention, microbial load and over all acceptability at 60 days of storage.

Aonla Products	Ascorbic acid (mg/100g)	Microbial load	Over all acceptability
Candy	40.7	0.5×10^3	7.79
Chutney	42.6	0.9×10^3	8.23
Jam	51.9	0.8×10^3	8.29
Squash	68.9	Nil	8.32
Preserve	44.25	0.8×10^3	8.20
Mouth freshener	72.0	Nil	7.20
Pickle	44.9	Nil	7.90

components like presence of sugar and use of preservative in the products during preparations. The hygienic condition during storage was found effective in retaining the good quality of the products through out the period.

The acceptability of the products were assessed on the basis of maximum mean over all acceptability score obtained on nine point hedonic ranking scale. The observations (Table 2) reveled that aonla candy followed by aonla chutney and aonla jam scored highest. The variation in the scores due to storage was tested statistically and the differences were found to be non significant, thus indicating good acceptability of the products during the storage of 60 days.

The developed aonla products under the study were found to be reasonable in cost (Rs 20 to 60) then other preserve products such as apple, tomato , mango, etc. available in the local market during the month of Feb.2005

Results of the present study clearly indicate that there is a greater scope of value added processed aonla products. Inclusion of these products in diet will definetely help in improving the nutritional value of Indian meal. Low cost of the products and good sensory, nutritional and shelf life qualities establish that the value added processed aonla products are appropriate for consumption and commercialization.

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Short communication

Effect of growth regulators on growth and yield of tomato

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Tomato (*Lycopersicon esculentum* Mill.) is one of the popular and important commercial vegetable crop of India. It is available through out the year and in Rajasthan's vegetable scenario, it ranks second in production (54,490 MT) after onion (Anonymous, 2005). The main tomato growing districts of Rajasthan are Jaipur, Alwar, Tonk, Sirohi, Pali and Udaipur. Tomato is a good source of Vitamin A, B, and C, possess medicinal properties and is said to be an excellent purifier of blood (Aykrod, 1963).

Growth regulators play an important role in increasing, reducing or modifying the physiological processes within plant which ultimately affects the growth and flowering in majority of cultivars. The beneficial effects of foliar application of growth regulators have been reported in tomato by several workers (Sengupta, 1996 and Sharma and Tiwari, 1995). Hence, field investigations were carried out to study the effect of plant growth regulators on growth and yield of tomato cv. Pusa Ruby at Horticulture Farm, RCA-Campus, Udaipur during autumn-winter season of tomato crop. Healthy uniform seedlings were transplanted on 28th July in a bed size 3 m x 3 m at a 60 cm x 60 cm spacing. The treatment comprised of two growth regulators with four levels each of IAA (50, 100, 150 and 200 mg l^{-1}) and 4-CPA (20, 40, 60 and 80 ppm) with distilled water as control. The experiment was conducted in randomised block design having 17 treatments, replicated thrice. Two successive foliar sprays of plant growth regulators were applied at 20 and 40 days after transplanting (DAT) of seedlings in

Table 1. Effect of IAA, 4-CPA and spray times on growth, flowering and yield of Tomato cv. Pusa Ruby

Time (DAT)	Treatments	Plant height (cm)	Plant spread (cm^2)	Clusters per plant	Percent fruit set/plant	Number of fruit harvested per plant	Fruit weight (g)	Yield per ha. (q)
	Control	42.06	34.32	10.46	39.90	13.90	35.20	135.38
20 days	IAA 50	52.26	45.30	12.00	56.90	23.50	39.80	261.38
"	"100	59.06	47.60	15.20	59.23	30.80	42.70	364.79
"	"150	47.93	42.56	13.80	47.40	22.90	38.60	246.79
"	"200	48.73	39.60	13.20	47.26	20.80	38.00	220.78
"	4-CPA20	49.40	40.86	12.00	51.40	21.90	39.20	237.23
"	"40	52.73	41.63	13.40	54.13	23.40	41.80	270.53
"	"60	50.20	38.36	15.40	57.26	31.50	43.90	383.56
"	"80	49.73	36.33	12.50	49.23	23.20	40.90	251.67
	C.D. at 5%	3.87	4.41	2.84	3.74	3.47	3.84	45.70
	Control	42.06	34.32	10.46	39.90	13.90	35.20	135.38
40 days	IAA 50	52.70	42.86	13.90	53.93	23.80	40.00	264.78
"	"100	55.53	43.86	16.80	60.90	33.50	43.63	406.67
"	"150	46.86	40.50	14.80	47.06	23.60	40.50	265.55
"	"200	45.53	38.30	14.40	46.96	22.30	39.90	246.47
"	4-CPA 20	48.06	39.60	13.60	51.76	22.90	41.20	262.35
"	"40	51.73	40.93	15.30	56.23	25.50	43.50	308.33
"	"60	49.60	37.86	17.40	61.83	35.70	45.00	444.57
"	"80	49.13	36.06	14.73	53.30	23.90	41.50	276.03
	C D at 5%	2.92	4.11	2.41	3.47	3.16	3.52	43.55

DAT = Days after transplanting.

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all the treatments. Observations were recorded on various growth, flowering and yield attributes.

The perusal of data revealed that growth attributes (plant height and plant spread) were influenced significantly at IAA 100 mg l^{-1}, whereas, flowering and yield attributes (per cent fruit set, cluster per plant, fruits number per plant, fruit weight and yield per hectare) were significantly superior with the spray of 4-CPA 60 mg l^{-1} followed by IAA 100 mg l^{-1}. The results summarized in Table-1 revealed that maximum plant height (59.06 cm) and plant spread (47.60 cm^2) were recorded under 100 mg l^{-1} IAA at 20 DAT. Whereas, number of cluster per plant (17.40), per cent fruit set (61.83%), number of harvested fruits $plant^{-1}$ (35.70), fruit weight (45.0g) and yield ha^{-1} (444.57 q) were recorded under 4-CPA, 60 mg l^{-1} at 40 DAT, followed by IAA 100 mg l^{-1} at 40 DAT. These results are in close agreement with the findings of Arora *et al.* (1982), Pandita *et al.* (1994), Sengupta *et al.* (1996) and Phookan *et al.* (1991). Increase in yield by 4-CPA application might be due to better fruit setting, fruit retention and gaining good fruit weight. It can thus be concluded that foliar application of 4-CPA 60 mg l^{-1} at 40 DAT provides maximum fruit yield of tomato cv. Pusa Ruby under Udaipur condition.

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Short communication

Effect of integrated use of nitrogen on growth and seed yield of bottle gourd

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Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] is gaining importance due to it's high yield potential, steady market price throughout the season and export potential. It is also a rich source of minerals, protein, carbohydrate and vitamins. It also has a wide medicinal properties such as laxative, digestive and to prevent constipation. Application of nitrogen through inorganic fertilizer can enhance the growth and yield to considerable extent but soil fertility and productivity cannot be retained for a longer period. Integration of chemical fertilizers with organic manures maintains long-term fertility and sustains higher productivity (Pillai *et al.*, 1985). Use of organic manures is not only the liable way for obtaining high productivity with sustainable fertilizer economy but is also a concept of ecological soundness leading to sustainable agriculture (Swaminathan, 1987). Vermicompost is a good organic source of nitrogen and by application of nitrogen through a combination of urea with vermicompost can increase the seed and fruit yield. With this point in view, the present investigations was undertaken to find out the suitable combination of urea and vermicompost in bottle gourd.

Field experiment was carried out during kharif 2004 and 2005 at Agricultural Research Station, Durgapura, Jaipur. The soil of experimental field was sandy loam having available N (149.9 kg ha^{-1}), P (27.4 kg ha^{-1}), K (190.5 kg ha^{-1}) and pH of 7.7. Five different combinations of nitrogen i.e., 100 % through urea (N_1), 75 % through urea + 25 % through vermicompost (N_2), 50 % through urea + 50 % through vermicompost (N_3), 25 % through urea + 75 % through vermicompost (N_4) and 100 % through vermicompost (N_5). were replicated thrice in a randomized block design. The seeds of cv. Pusa Naveen was sown in the rows spaced at 2.50 m maintaining a plant-to-plant distance of 0.75 m in 6.75 m x 2.5 m plot size. The recommended dose of NPK for bottle gourd is 80:40:60 kg ha^{-1}. Nitrogen was supplied through urea and vermicompost in different combinations as per the treatments. Phosphorus and potash were applied uniformly through single super phosphate and muriate of potash, respectively at the time of field preparation in individual plots. The whole quantity of vermicompost was uniformly spread at the time of bed preparation below and around the ridges and then thoroughly mixed. The required quantity of urea as per nitrogen treatments was supplied in three splits i.e. one-third at the time of sowing and remaining quantity in two splits. The first dose of urea was top dressed 30 days after sowing and remaining dose at 50 days after sowing. The nitrogen was estimated by Nesseler's reagent (Snell and Snell, 1939). The pooled data of two years on various growth and yield attributes were recorded and subjected to statistical analysis.

The data revealed that different nitrogen sources influenced the growth parameters of bottle gourd as presented in Table 1. It is evident from the data that the highest vine length (526 cm), maximum number of primary branches (11.29), fruit length (41.60 cm) and fruit girth (25.71 cm) were recorded under N_3 treatment where nitrogen was supplied through 50% urea and 50% through vermicompost. However, the effect of treatments N_4 and N_5 on these attributes was at par with N_3 treatment. It might be due to better nutritional environment in root zone as well as in plant system. Improved growth parameters with combination of vermicompost might be due to better moisture holding capacity, supply, and availability of major and minor nutrients due to favourable soil condition. These results are in close conformity with Reddy *et al.* (1998) in garden pea and Yadav *et al.* (2006) in okra.

Application of nitrogen 50 per cent through urea and 50 per cent through vermicompost was found best for yield and yield attributing characters . It might be due to profused vegetative growth which must have provided more sites for translocation of photosynthates with ultimately increased yield attributes. The findings of present investigation are being supported by Sreeniwas *et al.* (2000b) in Ridge gourd and Anon (2006) in cucumber.

Nitrogen content of seed and nitrogen uptake (kg ha^{-1}) by seed were observed highest in treatment N_3 where nitrogen was given 50 per cent through urea and 50 per cent through vermicompost. This might be due to improved growth and photosynthetic activities in plants. These

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Table 1. Effect of integrated use of nitrogen on vine length, number of primary branches per vine, fruit length and fruit girth.

Treatments	Vine length (cm)	No. of primary branches /plant	Fruit length (cm)	Fruit girth (cm)	No. of fruits per vine	No. of seeds/ fruit	Seed yield/ plot (g)	Seed index	N uptake by seed (kg ha^{-1})	N content (%)	B:C ratio
Nitrogen											
N_1	456.3	9.22	37.25	23.43	2.28	429.98	1242.20	12.69	21.09	3.03	2.46
N_2	461.8	9.48	38.37	23.70	2.58	444.29	1473.03	12.84	25.24	3.06	2.61
N_3	526.0	11.29	41.60	25.71	2.99	464.32	1808.07	12.98	31.64	3.12	2.96
N_4	496.0	10.56	40.72	25.09	2.83	451.05	1656.84	12.94	28.63	3.08	2.28
N_5	442.4	8.90	39.70	24.47	2.50	442.48	1425.86	13.18	24.58	2.99	1.64
C D at 5%	16.7	0.42	1.92	1.04	0.11	14.82	90.05	NS	0.87	0.04	0.21

results also confirms the findings of Sreeniwas *et al.* (2000b) in ridge gourd and Patil *et al.* (1998) in tomato. The nitrogen supplied through 50 per cent urea and 50 per cent vermicompost was found superior over the other sources on B: C ratio where it was observed 2.96.

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Short communication

Effect of integrated nutrient management on content and uptake of N, P, K and S of onion

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Onion is being cultivated in an area of about 0.42 million ha with a production of 4.21 million tonnes (Anonymous, 2004). The productivity of onion in India is, however, quite low compared to many other countries. Application of fertilizers is imperative to maintain the desired pace of crop production. Continuous use of inorganic fertilizers has depleted soil organic matter, resulting into inherent loss of native soil N, available P, available K and ultimately lowered the productions. Balanced fertilization has to be made for different crops based on soil testing for attaining maximum yield and nutrient content of crop. The balanced use of chemical fertilizers with FYM and biofertilizers for onion crop improve the nutrient availability and uptake to the plants.

The investigation was carried out at Horticulture Farm, S.K.N. College of Agriculture, Jobner during rabi season 2002-03 and 2003-04 to study the effect of integrated nutrient management on content and uptake of N, P, K and S of onion. The treatments consisted of four levels of NPK (control, 50% of recommended dose of NPK, 75% of recommended dose of NPK and 100% of recommended dose of NPK), two levels of FYM (without FYM and with FYM @ 25 t ha^{-1}) and four levels of biofertilizers (no inoculation, N_2 fixer *Azatobactor,* PSB inoculation and N_2 fixer *Azatobactor* + PSB inoculation) making thereby 32 treatment combinations, which were replicated three times in the split plot design. Levels of fertilizers and FYM were taken in main plots and levels of biofertilizers in sub-plots. Plot size was kept 3.0 m x 1.5 m with a row to row and plant to plant distance of 15 cm x 10 cm. Recommended dose of NPK for onion in this zone is 100:50:100 kg ha^{-1}. Nitrogen was applied as per treatment through urea, half as basal dose and remaining half in two equal splits at 30 and 50 days after transplanting. Phosphorus and potassium was applied through single super phosphate and muriate of potash, respectively just before transplanting. Well rotten farm yard manure was incorporated in the soil at the time of field preparation as per treatment @ 25 t ha^{-1}. *Azatobactor* and PSB @ 2 kg ha^{-1} were mixed with 20 kg FYM ha^{-1}. This mixture was applied in soil after the transplanting of seedling.

Nitrogen was estimated by digesting plant samples with sulphuric acid using hydrogen peroxide for removing black colour. Estimation of nitrogen was done by colorimeteric method using Spectronic-20 after development of colour with Nesseler's reagent (Snell and Snell, 1939). Nitrogen was calculated and expressed in percentage. Phosphorus was estimated by digesting plant sample with Tri-acid mixture of HNO_3 : H_2SO_4 : $HClO_4$ and was estimated by Vanadomolybdo phosphate yellow colour method (Jackson, 1967). Potassium was determined by digesting plant samples with tri-acid mixture of HNO_3 : H_2SO_4 : $HClO_4$ and was estimated by flame photometric method (Jackson, 1967).Sulphur was estimated by turbidmetric method (Tabatabi and Bremner, 1970). Plant samples were digested with tri-acid mixture (Nitric acid, perchloric acid and hydrochloric acid) using gelatin barium chloride solution for development of turbidity. The resultant turbidity was measured by colorimeter and sulphur content was expressed in percentage on dry weight basis.

Uptake of nitrogen, phosphorus, potassium and sulphur was computed from nitrogen, phosphorus, potassium and sulphur content in bulb and leaves and yield of bulb and leaves by using the following relationship.

$$\text{Total uptake of NPKS (kg ha}^{-1}\text{)} = \frac{\text{\% NPKS content in bulb x Bulb yield (kg ha}^{-1}\text{)} + \text{\% NPKS content in leaves x Leaves yield (kg ha}^{-1}\text{)}}{100}$$

The data revealed that there was clear cut effect of different levels of fertility. FYM and biofertilizers significantly influenced the content of N, P, K and S (Table 1), yield and uptake of nutrients (Table 2). Progressive increase in levels of fertility from control to 100 % RDF brought about significant improvement in nutrient content of onion over preceding levels. The significant increase in N, P, K and S uptake in onion with the increasing levels of fertility was due to the effect of higher yield along with higher N, P, K and S content in bulb. The content and

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Table 1. Effect of N, P, K, FYM and bio-fertilizers on N, P, K and S nutrient content in onion bulbs

Treatment	N (%)	P (%)	K (%)	S (%)
Fertilizers				
F_0 = Control	0.703	0.212	1.033	0.635
F_1 = 50 % RDF	0.799	0.267	1.075	0.665
F_2 = 75 % RDF	0.876	0.310	1.092	0.690
F_3 = 100 % RDF	0.910	0.336	1.103	0.693
C D at 5%	0.025	0.011	0.028	0.015
Manures				
M_0 = Control	0.775	0.273	1.057	0.659
M_1 = 25 t ha^{-1}	0.870	0.290	1.095	0.682
SEm±	0.006	0.003	0.007	0.004
CD (p=0.05)	0.018	0.008	0.020	0.011
Biofertilizers				
B_0 = Control	0.737	0.264	1.051	0.654
B_1 = *Azatobactor*	0.842	0.278	1.077	0.673
B_2 = PSB	0.833	0.282	1.075	0.670
B_3 = *Azatobactor* + PSB	0.877	0.302	1.100	0.686
C D at 5%	0.019	0.011	0.023	0.014

RDF= Recommended dose of fertilizers

uptake of any nutrient in the plant is directly related to the availability in the feeding zone and growth of plant. The increased uptake of nutrient with increasing fertility level was due to added supply of nutrients and an account of proliferous root system developed under balanced nutrient application which resulted in better absorption of water and nutrients. Thus, increasing doses of N, P, K and S might have resulted in higher content and uptake of these nutrients in onion. The result were in close agreement with the findings of Patel *et al.* (1992) and Soni (2005) in onion crops. Miller *et al.* (1987) also reported significant improvement in the uptake of nitrogen with the application of mineral nutrient in conjunction with FYM under different soils, crops and climatic conditions. Yadav *et al.* (2002) reported an increase in potassium uptake in kharif onion with increase in number of nutrient in a mineral mixture. Further, the application of 100% fertility level significantly increase N, P and K availability in soil. The probable explanation of this result is better utilization of N, P and K with increase in rate of fertility levels (Table 3).

Addition of 25 t ha^{-1} FYM increased the N, P, K and S uptake by onion. The favorable and significant influence of organic manure (FYM) might be due to enhanced growth characters, increasing rate of NPK and micro nutrient availability. Application of organic manure not only increased the uptake of nutrients through mineralization but also reduced the loses of N which other wise occurs through leaching and volatilization (Shanmugam and Veeraputtiram, 2000 and Shreelatha *et al.*, 2000). The increase in uptake of N, P and K due to application of organic matter could be attributed to higher availability of these nutrients and increased utilization of native P due to organic acids produced during decomposition of organic matter, Vachhani and Patel (1993).

Inoculation with biofertilizers (*Azatobactor* and PSB) significantly increased the NPK and S uptake by onion whether alone or in combination. Inoculation significantly increased the uptake of nutrients by crop, which could be

Table 2. Effect of NPK, FYM and bio-fertilizers on nutrient uptake of N, P, K and S and yield of onion

Treatment	Bulb yield (q ha-1)	Nitrogen uptake (kg ha-1)	Phosphorus uptake (kg ha-1)	Potassium uptake (kg ha-1)	Sulphur uptake (kg ha-1)
Fertilizers					
F_0 = Control	153.75	109.38	32.80	159.41	97.98
F_1 = 50 % RDF	200.14	161.83	53.86	215.91	133.55
F_2 = 75 % RDF	236.02	209.31	73.63	258.55	163.32
F_3 = 100 % RDF	244.21	224.81	82.67	270.31	169.82
CD at 5%	7.69	9.30	4.00	9.77	6.56
Manures					
M_0 = Control	173.61	136.98	48.74	184.32	115.18
M_1 = 25 t ha^{-1}	243.45	215.68	72.73	267.77	167.16
SEm±	1.88	2.27	0.98	2.38	1.60
CD (p=0.05)	5.44	6.58	2.83	6.91	4.64
Biofertilizers					
B_0 = Control	196.45	148.59	53.50	207.96	129.62
B_1 = *Azatobactor*	211.54	182.68	60.80	229.46	143.62
B_2 = PSB	208.88	178.44	60.91	226.06	141.18
B_3 = *Azatobactor* + PSB	217.25	195.61	67.75	240.71	150.25
C D at 5%	4.91	7.85	2.78	6.82	3.42

RDF= Recommended dose of fertilizers

Table 3. Effect of NPK, FYM and bio-fertilizers on post harvest available N, P, and K (kg ha^{-1})

Treatment	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
Fertilizers			
F_0 = Control	102.88	14.50	113.74
F_1 = 50 % RDF	14.48	15.99	125.23
F_2 = 75 % RDF	124.64	16.49	132.53
F_3 = 100 % RDF	130.20	17.34	137.18
C D at 5%	6.74	0.73	5.71
Manures			
M_0 = Control	112.49	15.27	124.57
M_1 = 25 t ha^{-1}	123.62	16.90	129.77
C D at 5%	4.77	0.51	4.04
Biofertilizers			
B_0 = Control	114.44	15.36	123.08
B_1 = *Azatobactor*	117.85	16.02	127.12
B_2 = PSB	117.10	16.04	126.91
B_3 = *Azatobactor + PSB*	122.82	16.90	131.58
C D at 5%	3.74	0.52	2.80

RDF= Recommended dose of fertilizers

attributed to the fixation of nitrogen, better root growth due to increased availability of P by PSB besides secretion of growth promoting substances especially by *Azatobactor* (Totawat *et al.*, 2000).

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Short communication

Salinity, alkalinity and fertility indices of cultivated soils of Bikaner district of Rajasthan

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The salinity and alkalinity indices for cultivated soils of Bikaner district were 1.06, 2.96 and 1.04, 3.00 for surface and subsurface soils, respectively. The fertility index for organic carbon, available nitrogen, phosphorus and potassium were 1.00, 1.09,1.51 and 2.01 for surface and 1.00,1.04,1.50 and 1.96 for subsurface soils. Soils have slight salinity and moderate alkalinity problem and found to be low in organic carbon and available nitrogen, low to medium in available phosphorus and medium in available potassium.

Saline and alkali soils usually occur in association with the normal soils of the arid and semi-arid regions of Rajasthan. Salt affected soils occur to a lesser or greater extent in all the districts of the state, however, their nature is location specific. At present about 11.22 lakh hectares of land is affected by salinity and sodicity in the state (Sharma, 1998). In addition to this, considerable part of cultivated land is subjected to secondary and seasonal salinization due to poor quality of ground water. The periodically diagnosis and subsequent management of salinity, alkalinity and fertility status of the soil is of vital significance. Detailed systematic information are not yet available about salinity, alkalinity and fertility status of soils of the study area, which is essential for sustainable natural resource management. Therefore, an urgent need was felt for extensive and well planned investigation both in the field and laboratory for suggesting guidelines towards better utilization of soils of the tract.

A field survey was conducted to evaluate salinity, alkalinity and fertility indices of cultivated soils of Bikaner district of Rajasthan during 2004. One hundred seventeen composite soil samples from each depth (0-15 and 15-30 cm depth) were collected from cultivated fields during the months of April-May, 2004. The soil samples were processed and analyzed for soil pH, EC (1:2 soil water suspension), organic carbon, available nitrogen, phosphorus and potassium by using standard methods. Salinity, alkalinity and fertility indices of soils were calculated by the methods suggested by Muhr *et al.* (1965) and Seth (1967). The study area are irrigated by tubewell waters. The main crops grown are pearlmillet, cluster bean, groundnut, cotton, mung, moth and sesame in kharif and wheat, mustard, barley and gram in rabi.

Data presented in Table 1 revealed that the pH value of Bikaner district soils varied between 7.75 to 9.21 with an average value of 8.72 and 7.80 to 9.28 with an average value of 8.78 for surface and subsurface soils, respectively. Thus, the pH of study area varied from normal to alkaline. Accumulation of bases especially Na^+ under low rainfall conditions seem to be the primary reason for alkalinity. Similar result was also reported by Sharma *et al.* (2004). The electrical conductivity of surface soils ranged between 0.10 to 1.39 dS m^{-1} with an average value of 0.33 dS m^{-1}, while electrical conductivity of subsurface soils varied from 0.08 to 1.12 with an average value of 0.27 dS m^{-1}. The EC values of surface soils were slightly higher as compared to subsurface soils. The higher values of EC of surface soils might be due to high evaporation demand of the arid-ecosystem due to prevailing high temperature, low rainfall and irrigating soils with poor quality underground waters. Similar findings were also reported by Sharma *et al.* (2004). It is seen from the data (Table 1) that organic carbon, available nitrogen, phosphorus and potassium content of surface soils were varied from 0.03 – 0.42% with mean value of 0.16%, 62.76-370.65 with mean value of 152.82, 3.25- 62.31 with mean value of 17.51 and 108.78-372.54 with the mean value of 209.99 kg/ha while for subsurface soils it were varied from 0.01-0.38% with average value of 0.13 %, 56.95-307.40 with average value of 127.75, 2.20 - 53.13 with average value of 15.16 and 100.79-357.50 with the average value of 189.26 kg/ha. The organic carbon and available nitrogen of both surfaces had been found low. The low organic carbon and nitrogen content of these soils could be ascribed to occasional addition of organic material, scanty natural vegetations and poor decomposition due to low rainfall and rapid oxidation due to high summer temperature and wind erosion. The soils of the study area were found to be low to medium in available phosphorus and medium in available potassium content.

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Table 1. Chemical and fertility parameters of soils of Bikaner district

Characters	Depth (cm)	EC (dSm^{-1})	pH	Organic carbon (%)	available nitrogen (kg/ha)	available phosphorus (kg/ha)	available potassium (kg/ha)
Range	0-15	0.10-1.39	7.75-9.21	0.03-0.42	62.76-370.85	3.25-62.31	108.78-372.54
	15-30	0.08-1.12	7.80-9.28	0.01-0.38	56.95-307.40	2.00-53.13	100.79-357.50
Mean	0-15	0.33	8.72	0.16	152.82	17.51	209.99
	15-30	0.27	8.78	0.13	127.75	15.16	189.26
C.V.	0-15	74.38	2.12	48.23	39.40	55.51	23.62
	15-30	77.97	2.05	54.18	42.15	59.28	24.27

The calculated values of salinity and alkalinity indices for surface soils were 1.06 and 2.96, respectively. On the other hand, the calculated values of these indices for subsurface soils were 1.04 and 3.00, respectively (Table 2). From these indices it can be inferred that both surface and subsurface soils were moderate sodic in nature. On the basis of EC and pH of surface and subsurface soils of Bikaner district were classified into three salinity and sodicity groups as suggested by Sehgal *et al.* (1987). The majority of surface (93.16%) and subsurface (92.31%) soil samples fell under the VsM group (very slight salinity and moderate sodicity), whereas, only 3.42 and 1.71% under VsS group (very slight salinity and slight to negligible sodicity) and 3.42 and 5.98 % soil samples under VsS_1 (very slight salinity and strong sodicity) groups , respectively. The fertility index for organic carbon, available nitrogen , phosphorus and potassium were 1.00 ,1.09,1.51 and 2.01 for surface and 1.00 ,1.04,1.50 and 1.96 for sub surface soils. Therefore , soils of the study area were found to be low in organic carbon and available nitrogen , low to medium in available phosphorus and medium in available potassium (Table 3) . Based on the grouping of data according to fertility groups, surface soils of studied area were classified into seven fertility groups (1.71%) samples low in organic carbon , available nitrogen , phosphorus and potassium , 47.86% samples low in organic carbon , available nitrogen , phosphorus and medium in available potassium , 39.33% samples low in organic carbon , available nitrogen and medium in available phosphorus and potassium , 1.71% samples low in organic carbon , available nitrogen , medium in available phosphorus and high in available potassium , 0.85% samples low in organic carbon,

Table 2. Frequency distribution and salinity and alkalinity indices of soils

Parameters	Number of samples under each category	
	D_1	D_2
EC ($dS\ m^{-1}$)		
<1	110.0	112.0
1-2	7.0	5.0
2-3	-	-
>3	-	-
salinity index	1.06	1.04
pH		
<8.0	1.0	1.0
8.0-8.5	7.0	5.0
8.5-9.0	105.0	104.0
>9.0	4.0	7.0
Alkalinity index	2.96	3.00

D_1 = 0-15 cm soil depth D_2=15-30 cm soil depth

Table 3. Frequency distribution (n) and fertility index (f_i)of soils

Parameters	Number of samples under each category (n)							
	Low		Medium		High		f_i	
	D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2
SOC (%)	117.0	117.0	-	-	-	-	(100)	(100)
		1.00	1.00					
Available nitrogen (Kg/ha)	107.0	112.0	10.0	5.0	-	-	1.09	1.04
	(91.45)	(95.73)	(8.55)	(4.27)				
Available phosphorus(Kg/ha)	58.0	59.0	58.0	57.0	1.0	1.0	1.51	1.50
	(49.57)	(50.43)	(49.57)	(48.72)	(0.85)	(0.85)		
Available potassium(Kg/ha)	3.0	6.0	110.0	110.0	4.0	1.0	2.01	1.96
	(2.56)	(5.13)	(94.02)	(94.02)	(3.42)	(0.85)		

Figures in parenthesis represent per cent samples under each categories : D_1 = 0-15 cm soil depth D_2 = 15-30 cm soil depth

available nitrogen and potassium and high in available phosphorus , 7.69% samples low in organic carbon and medium in available nitrogen , phosphorus and potassium and 0.85% samples low in organic carbon, medium in available nitrogen, phosphorus and high in available potassium), while , subsurface soils classified into six fertility groups (4.28%) samples low in organic carbon, available nitrogen , phosphorus and potassium , 46.15% samples low in organic carbon, available nitrogen, phosphorus and medium in available potassium, 43.59% samples low in organic carbon, available nitrogen and medium in available phosphorus and potassium, 0.85% samples low in organic carbon , available nitrogen , medium in available phosphorus and high in available potassium, 0.85% samples low in organic carbon, available nitrogen and potassium and high in available phosphorus and 4.28% samples low in organic carbon and medium in available nitrogen , phosphorus and potassium. In nut cell majority of soils both of surface (87.19%) sub surface (89.74%) were grouped into two fertility groups soils low in organic carbon available nitrogen , phosphorus and medium in available, potassium and soils low in organic carbon , available nitrogen and medium in available phosphorus and potassium .

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Short communication

Physiological studies on mycelial growth and sporulation causing alternaria leaf spot of date palm

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Date palm (*Phoenix dactylifera* Linn.) is an important arid fruit plant. Datepalm fruits have high nutritive value as it has high calorific value 60-65 per cent sugar (3150 calories/ kg of fresh fruits) and fair amount of fibre (2.5%), protein (2.0 %), fat (upto 2.0 %) and minerals (upto 2.0 %) Pectic substances (less than 2.0%) and vitamins (Vitamin A, Vitamin B_1 and Vitamin B_2). The date palm tree plantation in arid regions of Rajasthan can improve the ecology of the arid region by providing green cover to the barren land and by improving the micro climate of the region.

Alternaria leaf spot is a serious disease of datepalm caused by a fungal pathogen *Alternaria alternata (Fr.)* Keissler. This disease was first reported by Elarosi *et al.* (1982) from Saudia-Arabia. It causes great losses to the date industries in both quality and quantity of production. It has been found in severe form at Datepalm Research Centre, Bikaner, Rajasthan since last several years. Once established, the pathogen can cause severe losses and drastically reduce fruit yield. No detailed physiological studies have been carried out on this serious pathogen. Studies on the optimum conditions for disease initiation and establishment are important for evolving suitable management strategies. Hence, detailed studies were carried out *in-vitro* to find out the suitable medium, carbon, nitrogen sources and temperature for mycelial growth and sporulation of *Alternaria alternata.*

In vitro effect of various media on mycelial growth and sporulation of _Alternaria alternata_

To ascertain the mycelial growth and sporulation on media, a 6 mm actively growing culture disc of *Alternaria alternata* from PDA was placed at the centre of respective medium into sterilized Petri dishes aseptically. The inoculated plates were incubated at 25 ± 1°C for 7 days. The diameter of mycelial growth was recorded and sporulation of the fungus was counted with the help of haemocytometer. The media viz, Brown's medium, Czapek's Dox, oat meal, potato dextrose agar and Richard's medium were used in this experiment.

Alternaria alternata grew well on all the solid media tested. The best mycelial growth was observed on potato dextrose agar medium (81.2 mm) which was significantly different (P=0.05) from oat meal medium (75.3 mm), Czapek's dox medium (63.0 mm) and Richard's medium (45.8 mm). Least growth was observed on Brown's medium (41.2 mm). *Alternaria alternata* sporulated on all the solid media. The best sporulation was observed on potato dextrose agar medium followed by Czapek's dox medium, Richard's medium and Brown's medium. Least sporulation was observed on oat meal medium. Similary Ionnsidis and Main (1973), Toor *et al.*, (1987) and Maheshwari *et al.*, (2001) reported that PDA was best for growth and sporulation of *Alternaria alternata* followed by oat meal agar.

In vitro effect of carbon sources on growth of _Alternaria alternata_

Carbon is required by fungi as a main structural and functional element. To find out the effect of various carbon sources on mycelial growth of *Alternaria alternata*, Czapek's-dox agar was used as basal medium and sucrose was substituted by adding different sources of carbon. Each Petri dish was inoculated with 6 mm disc of 7 day old culture. Three replications for each treatment were maintained. The inoculated dishes were incubated at 25 ± 1°C for 7 days and the diameter of mycelial growth was measured. Carbon sources used were Dextrose, D-Fructose, Maltose, Mannitol and Sucrose.

Maltose (82.4 mm) was the best source of carbon for the growth of the pathogen, which was significantly (P=0.05) better than dextrose (80.7 mm). Moderate growth was obtained on mannitol (62.1 mm) and sucrose (61.0 mm), when used as carbon source. Poor growth was observed on D-fructose (47.8 mm). Growth was comparatively less in the medium without carbon sources (15.7 mm). The above results indicate that the carbon is required essentially for growth of the pathogen. Kumar (2004) reported that maltose was the best source of carbon for growth of the pathogen

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Alternaria burnsii followed by sucrose and dextrose. However, Gupta (1993) reported that glucose and sucrose were the best sources of carbon for growth of the pathogen *Alternaria alternata* causal agent of leaf blight of henbane followed by fructose, maltose and galactose.

In vitro* effect of nitrogen sources on growth of *Alternaria alternata

Nitrogen is another essential element used by fungi for structural and functional purposes. To find out the effect of various nitrogen sources on mycelial growth of *Alternaria alternata,* Czapek's-dox agar was used as basal medium and sodium nitrate was substituted by adding various nitrogen sources. To ascertain the mycelial growth on media, a 6 mm actively growing culture disc of *Alternaria alternata* was placed at the centre of respective medium into the sterilized Petri plates aseptically. The inoculated plates were incubated at 25 ± 1°C for 7 days and the diameter of mycelial growth was measured. Each treatment was replicated thrice. Nitrogen sources used were Ammonium sulphate, Ammonium nitrate, Sodium nitrate, Potassium nitrate and L- asparagine.

L-asparagine (71.6 mm) was the best source of nitrogen for the growth of the fungus, which was significantly (P=0.05) better than ammonium nitrate (64.3 mm). Good growth was also recorded both on sodium nitrate (60.0 mm) and potassium nitrate (58.2 mm). Poor growth was obtained on ammonium sulphate (51.7 mm). Scanty growth of the fungus was observed in control (without nitrogen) (21.3 mm). The above results indicated that the nitrogen is required essentially for growth of the pathogen. Hackaylo *et al.* (1954) reported that many *Alternaria* spp. gave good mycelial growth on L-asparagine followed by ammonium nitrate. Orynbaev and Ermekova (1972) found that best growth of five different species of *Alternaria* on L-asparagine and tryptophane. However, Hasija (1970) reported that best growth of *Alternaria tenuis* on potassium nitrate, ammonium nitrate and other organic nitrogen sources.

In vitro* effect of temperature on growth of *Alternaria alternata

The effect of temperature on mycelial growth of *Alternaria alternata* was studied in this experiment. six mm actively growing culture disc of *Alternaria alternata* was placed at the centre of PDA medium into the sterilized Petri plates aseptically and incubated at 20°C, 25°C, 30°C, 35°C and 40°C in a growth chamber. The diameter of mycelial growth was measured after 7 days. Each treatment was replicated thrice.

Temperature is an important factor influencing the growth of the pathogen. *Alternaria alternata* grows fairly well within a range of 20 to 30°C but optimum temperature for growth (79.3 mm) of the fungus was found to be 25°C and with increase and lowering of temperature, growth decreased. Gupta (1993) found that *Alternaria alternata* causing leaf blight of henbane could grow fairly well within a range of 20°C to 30°C but optimum growth was found at 25°C temperature. Kumar (2002) found that severity of *Alternaria alternata* causing fruit rot of ber was significantly higher at 25°C temperature. Jakhar (2003) also found that 25°C and 30°C temperature were more congenial for *Alternaria alternata* causing ripe fruit rot of tomato.

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