Haryana J. hortic. Sci., **41** (3 & 4) : 89-104 (2012)

Post-harvest Handling of Ber (*Zizyphus mauritiana* Lamk.)

S. SIDDIQUI AND R. K. SHARMA[1]
Centre of Food Science and Technology, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India

Ber is one of the most ancient and common fruits of India. It belongs to genus *Zizyphus* of the family Rhamnaceae. The *Z. jujuba* Mill. and *Z. mauritiana* Lamk. are the two most important species. *Z. jujube* Mill. is cultivated in China, Korea and in parts of south-east Africa. It is also known by names Jujube, Chinese date, Chinese Fig. *Z. mauritiana* Lamk. is commercially most important in India, and is known by several names : *ber* in Hindi and Punjabi, *bor* in Marathi, *bogari* in Assamese, *boroi* or *kool* in Bengali and *regu* in Telgu. It is also referred as Indian jujube. In India, 90,000 ha land area is under cultivation of improved ber cultivars and the average productivity is 8.34 t/ha (8). It is grown widely in the plains of the Punjab, Uttar Pradesh, Haryana, Rajasthan, Madhya Pradesh, Bihar, Maharashtra, Assam, Andhra Pradesh, Tamil Nadu and West Bengal.

The fruits of different species of ber are round or oval or oblong in shape and yellow, green, reddish or purple/dark brown in colour. Wild fruits are 1.5-2.5 cm in length and 1-2 cm in diameter, however, commercial cultivars can be up to 5 cm in length. The ripe fruit (drupe) consists of juicy, hard or soft sweet-tasting pulp.

Several cultivars of ber are grown commercially in India. The popular cultivars grown in various states are mentioned in Tables 1 and 2, and Fig. 1.

Nutritional Value

The belief that ber fruit is nutritionally poor has no basis (25). It is richer than apple and mango in vitamin C, protein and minerals, and contains higher phosphorus and iron than orange (51, 86). The nutritional value of ber is given in Table 3.

Bal *et al.* (14) and Bal (9) reported that ripe fruits of Sanaur-2 and Umran cultivars contained sucrose, glucose and fructose in the ratio of 3 : 1 : 1 and its mesocarp had abundant amino acid arginine followed by aspartic acid, L-alanine, glutamic acid and threonine. Jain *et al.* (42) and Sharma (83) reported that starch was absent in ripe fruits.

MATURITY

Ber fruits exhibit predominantly the climacteric nature of ripening, the details of which are discussed later in this chapter. Maturity of fruit at harvest is one of the most important factors that determine storage life and quality. Immature fruits are more susceptible to shrivelling, mechanical damage and are not able to ripe properly after harvest. Overripe fruits become soft and

Table 1. The commercial ber cultivars grown in various states of India

State	Cultivars		
	Early season	Mid season	Late season
Haryana	Gola, Safeda, Selected, Safeda, Sandhura Narnaul, Seo, Chonchal, Seb	Kaithli, Sanaur-5, Muria Muhrara, Banarsi Karaka	Umran, Illaichi, Kathaphal
Maharashtra	Shamber, Badami, Manuki, Guli	Mehrun, Darakhi, Kharki	-
Punjab	Nazuk, Noki, Seo, Rohtaki Gola, Selected Safeda, Sandhura Narnaul	Banarsi, Dandan, Kaithli, Sanaur-2, Walaiti, Thornless	Umran, Illaichi, Pathani, ZG-2, ZG-3
Rajasthan	Gola, Seb, Seo	Jogia, Mundia, Tikadi	Katha (Umran), Maharwali, Bagwadi
Uttar Pradesh	Narma Varanasi, Delhi Gola, Banarsi Gola	Banarsi Karaka, Muthiya, Muriya, Pawandi	Jogia, Aliganj
Gujarat	Gola	-	Umran, Ajmeri, Chameli, Randeri
Andhra Pradesh	-	Banarsi, Dudhia	-

[1]Department of Horticulture.

Table 2. Ripening time, colour, average size and weight of ripe fruits of various cultivars/forms of *Ziziphus* spp. under north Indian conditions

Name of cultivar/form/ species	Approximate time of ripening	Colour at maturity	Fruit size (cm)	Fruit weight (g)	Pulp to stone ratio
Ziziphus mauritiana					
Early-season varieties					
Gola	January 7-25	Bright yellow	3.8 x 3.5	21.4	14.3
Mundia	January 10-30	Yellowish green	5.7 x 3.5	39.5	23.8
Seb	January 14-Feb. 10	Yellowish green	3.6 x 3.3	34.6	14.4
Sanaur-2	January 25-Feb. 13	Golden yellow	4.0 x 3.0	24.0	17.6
Kaithli	January 26-Feb. 15	Yellowish green	4.7 x 3.4	29.5	32.1
Dandan	Jan. 28-Feb. 12	Yellowish green	5.7 x 3.5	27.6	17.4
Banarsi Kadaka	January 27-Feb. 12	Light yellow	4.9 x 3.1	25.0	31.0
Chonchal	January 28-Feb. 12	Light yellow	5.3 x 3.2	24.9	19.0
Mid-season varieties					
Kakrola Gola	Feb. 4-March 1	Golden yellow	3.4 x 3.3	25.5	25.6
Sua	Feb. 5-Feb. 25	Yellowish green	4.6 x 3.1	21.6	30.0
Gola Gudgaon No. 3	Feb. 6-Feb. 28	Golden yellow	3.3 x 2.8	13.7	10.8
Ponda	Feb. 16-March 3	Greenish yellow	4.6 x 4.2	37.0	28.0
ZG-3	Feb. 17-March 3	Greenish yellow	3.8 x 3.1	18.6	14.5
Meharun	Feb. 21-March 3	Light yellow	2.2 x 1.7	3.5	7.9
Late-season varieties					
Umran	March 12-April 4	Golden yellow	4.7 x 3.4	33.6	25.2
Illaichi	March 8-March 28	Golden yellow	2..2 x 2.2	5.4	19.3
Kathaphal	March 16-April 6	Light green with coffee colour patch	3.2 x 2.8	10.8	7.42
Ziziphus spp.					
Desi-1	Feb. 16-March 16	Golden yellow with coffee colour patch	2.41	7.31	7.28
Desi-2	Feb. 4-March 2	Yellowish with brown patch	2.03	5.80	7.03
Desi-3	No ripening	Light green with coffee colour patch	1.30	1.42	2.58
Ziziphus nummularia					
Jharber	Sept. 28-Oct. 12	Dark brown/coffee colour	1.17x1.4	0.81	4.00

Source : Pareek (70).

Fig. 1. Extreme variations in fruit size and colour of different species of ber.

mealy with insipid flavour soon after harvest. Fruits harvested too early to too late have a shorter storage life than fruits picked at the proper maturity. Ber fruits that ripen on tree normally have a shorter shelf-life than fruits picked before the onset of ripening.

The development of fruit skin colour is one of the most reliable maturity indices (Fig. 2). Singh *et al.* (96) reported that fruits of cv. Umran should be picked at golden yellow stage for good eating quality and better shelf life. Similarly, Siddiqui and Gupta (89) reported

Table 3. Nutritional value (per 100 g fresh fruit) of Indian jujube

Energy	24.76 kJ (5.92 kcal)
Carbohydrates	17 g
Sugars	5.4-10.5 g
Dietary fibre	0.60 g
Fat	0.07 g
Protein	0.8 g
Water	81.6-83.0 g
Thiamine (Vit. B_1)	0.02-0.024 mg
Riboflavin (Vit. B_2)	0.02-0.038 mg
Niacin (Vit. B_3)	0.7-0.873 mg
Carotene	0.021 mg
Ascorbic acid	65.8-76.0 mg
Fluoride	0.1-0.2 ppm
Pectin (dry basis)	2.2-3.4%
Citric acid	0.2-1.1 mg
pH	4.68-4.71
Titrable acidity	0.1-0.5%
Calcium	25.6 mg
Iron	0.76-1.8 mg
Phosphorus	26.8 mg

Source : Morton (64).

Fig. 2. Various ripening stages in ber cv. Umran (Stage I–Green mature; Stage VI–Over-ripe).

that if fruits are to be transported, fruits of cv. Kaithli cultivar should be harvested up to greenish yellow (GY) stage of maturity because of retention of high fruit wall pressure. However, if fruits are to be stored, the fruits of cv. Gola can be harvested at green mature stage because of lower ethylene evolution and ripening rates. It was suggested by Kadam *et al.* (47) that ber fruits should be harvested at half yellow to full yellow stage for fresh marketing or store green mature fruits for 4-5 days and then utilize them for processing or marketing.

The time required for ber fruits to develop from fruit set to maturity is dependent on cultivar and location (Table 4). In general, ber fruits require about 150-154 days from fruit set to maturity. The degree day heat unit (above base 7.2°C) requirements for maturity of early (Gola), mid season (Kaithli) and late (Umran) cultivars were 1980-2236, 2236-2566 and 2516-2920, respectively. In general, the harvest period in north India is February 14-March 13 for Gola, 13-27 March for Kaithli and March 27-April 18 for Umran (20, 21). In Punjab, the cultivars ZG-2 and Kaithli ripened in 180 and 170 days, respectively, after fruit set, whereas in south India, cvs. Gola, Umran and Kaithli ripened in 195, 180 and 165 days, respectively. Since these differences are because of climatic conditions, therefore, degree days required for ripening should be computed for different regions, and can then be used to predict the harvest date of fruits in that region.

Meel *et al*. (60) reported that length, weight, volume of fruit, pulp weight, pulp : stone ratio and chlorophyll content could be used to judge maturity. Similarly, it was reported by other workers that TSS, acidity, ascorbic acid, phenols, firmness, specific gravity, etc. could also be promising indices (Table 5) in determining maturity of ber fruits (1, 21, 70, 89).

Specific gravity is also considered a reliable harvest indicator. Specific gravity values at harvest maturity in Kaithli, Gola and Umran cultivars have been observed to be 0.88, 0.93 and 0.81, respectively, with corresponding fruit wall pressure values of 2.07, 2.52 and 2.80 (21). Meel *et al*. (60) recommended that fruits of cultivar Sandhura Narnaul should have a specific gravity less than 1 for harvest maturity. Sharma (83) reported no definite pattern of changes in specific gravity in fruits of cv. Umran ripening on tree, while a gradual decrease was observed when the fruits ripened in storage.

Table 4. Time taken by various cultivars of ber to reach maturity

Cultivar	Days after fruit set	Location in India
Banarsi Karaka	135	Faizabad
Jogia	150	Jodhpur
Kaithli and *Z. rotundifolia*	65	Coimbatore
Banarsi	180	Coimbatore
Gola	195	Coimbatore
Gola	150	Delhi
Sanaur-2	180	Ludhiana
Umran	180-190	Ludhiana
	160	Hisar

Source : Sharma *et al.* (84).

Table 5. Physico-chemical characteristics of ripe ber fruits

Ber varieties	Characteristics			
	TSS (%)	Acidity (%)	Ascorbic acid (mg/100 g)	Moisture (%)
***Z. mauritiana* Lamk.**				
Katha	21.4	0.10	97	74.3
Bagwari	18.0	0.11	126	77.9
Umran	22.7	0.29	151	77.8
Chhuhara	17.2	0.35	146	76.4
Illaichi	34.7	0.22	129	73.9
Karaka	11.8	0.31	103	86.6
Mundia Murhara	13.0	0.22	174	88.1
Narma	16.8	0.25	146	79.3
***Z. spina-christi* L. Wild**				
Babbawi	15.0	0.34	139	74.6
Mallasey	17.5	0.24	160	68.3
Zaytoni	12.5	0.25	131	79.3

Source : Abbas *et al.* (1) and Pareek (70).

POST-HARVEST HANDLING AND PACKAGING

The cost and returns analysis shows that ber growing is very remunerative (70, 71). However, being highly perishable, different varieties show shelf life of 2-6 days at room temperature (28). It also requires proper post-harvest handling operations like packaging, transportation, storage, etc. The growth and developmental pattern, physiology, mineral constituents, and biochemical changes in ber fruits during ripening and storage are reviewed elsewhere (72, 87). Some of the important pre-harvest applications and post-harvest handling operations to improve the quality of fruit at harvest and to enhance the shelf life of ber are discussed in the following section.

1. Pre-harvest Applications

Cui *et al.* (24) reported that low water deficit in ber during the fruit growth stage and low, moderate and severe water deficits during the fruit maturation stage shortened the fruit maturation period by 10-15 days and raised the market price of the fruit. The decreased fruit water content reduced the rotten fruit percentage during the post-harvest storage period. It thus suggests that regulated deficit irrigation (RDI) should be adopted as a beneficial agricultural practice in the production of jujube fruit to have better quality, early maturation and higher market price.

Pre-harvest sprays of gibberellic acid and NAA improved the quality of fruit in terms of weight, size, TSS, acidity, reducing sugar, total sugar and pulp percentage (29, 50). Bal and Chauhan (12) reported advanced ripening by 8-12 days in Sandhura Narnaul, Umran and Gola with pre-harvest application of 150 ppm ethephon. The TSS and ascorbic acid contents and colour development were higher in ethephon treated fruits. Pre-harvest spray of 400 ppm of ethephon resulted also in uniform ripening and improved fruit colour to golden yellow in ber cv. Umran (13, 59). Later, Bal (11) reported that pre-harvest spray of 500 ppm ethephon resulted in minimum total phenolic, maximum total sugar and higher organoleptic rating of fruits during storage. Increased TSS and vitamin C and decreased acidity in Umran ber fruits by pre-harvest spray of ethephon were reported by other workers also (23, 78).

The post-harvest decay losses can also be reduced by various pre-harvest applications of fungicides and other chemicals. The pre-harvest spray with 500 ppm of captaf and TBZ each and 1% calcium nitrate solution on cv. Kaithli of ber improved the shelf life of fruits. The highest reduction in weight loss was observed by captaf, however, decay was reduced maximum by TBZ and over ripe percentage by calcium nitrate (36). Similarly, Mukherjee *et al.* (65) observed that ber cv. Umran trees sprayed three times at 10 days intervals with 0.1% bavistin (carbendazim), 0.2% difolatan (captafol), and 0.2% copper oxychloride produced fruits showing lower physiological weight loss and decay loss, and resulted in higher total soluble

solids and ascorbic acid content compared with the control when stored at room temperature for six days. Saran *et al.* (81) reported that pre-harvest sprays of bavistin (carbendazim) (500 ppm), dithane M-45 (mancozeb) (500 ppm), topsin M (thiophanate methyl) (500 ppm), captan (500 ppm), cuman L (ziram) (500 ppm) and ridomil MZ (mancozeb+metalaxyl) (500 ppm) enhanced the shelf life and quality of ber cv. Gola. Maximum shelf life (10 days) was recorded under dithane M-45.

2. Harvesting

Fully mature fruits are picked several times during the extended ripening period. The harvesting is generally done manually by shaking the trees or beating of the tree branches to induce fall of mature fruits. Sometimes, a cloth sheet is spread below the tree canopy to facilitate collection of fruits. Manually plucking individual fruits by hand by riding on ladders and collecting the fruits in a bag tied to shoulders results in best harvest. A worker can harvest manually about 50 kg ber fruits per day. Fruits can also be harvested by use of a clipper (a bamboo stick having iron hook attached to it). Harvesting by shaking the tree though is easier and faster but was not found desirable as it caused considerable spoilage. In a study on cv. Kaithli, it was observed that plucking resulted in harvesting of very small quantity (1.3%) of small and immature fruits, but by use of clipper led to 7.6% immature, 12.1% overripe and 1.8% damaged fruits. Shaking resulted in harvest consisting of 25% immature and 22.5% injured fruits (6).

Although the fruit can be harvested with or without the pedicel but attached pedicel increases storage life. Attached pedicel had no significant effect on shelf life of Kaithli fruits when stored up to four days at ambient temperature (32±3°C) but was beneficial when stored up to eight days (92). Time of harvest greatly affects quality and storage life of fruits. Usually, morning time is preferred since at that time the fruits are having lesser field heat and higher turgidity, thus can comfortably be disposed off or processed during rest of the day. It was reported by Fageria *et al.* (27) that ber fruits cv. Mundia harvested in the morning could be stored fresh with minimum physiological weight loss and percentage spoilage, and showed better quality attributes as compared to the noon and evening harvested fruits. Contradictorily, it has also been reported that ber fruits harvested at noon had better quality and storage life as compared to those harvested in morning or evening (5). It may be due to higher loss of water from fruit harvested in morning or evening time, due to their higher water content as compared to the noon harvested fruits.

Fully mature or ripe fruits are picked several times since the fruits do not attain harvest maturity at one time. In one season, 4-5 pickings are usually made. After harvest, the fruits are brought to a packing house or under shade for cleaning, packing or for post-harvest treatments with certain chemicals with a view to extend their shelf life.

3. Post-harvest Treatments

Post-harvest dipping treatments in various Generally Regarded Aas Safe (GRAS) chemicals have been reported to enhance the shelf life of ber fruits.

Calcium : Storage life of ZG-3 fruits was also improved by dipping in 1% $CaCl_2$ solution (62). Kumar *et al.* (52) reported that fruits dipped in 2-4% $CaCl_2$ solution showed improved shelf life of ber cv. Banarsi Pewandi. It was reported that post-harvest dipping of fruits in 0.17% Ca salt solutions extended the shelf life of Umran and Kadaka ber by three days. Similarly, Singh *et al.* (99) reported that post-harvest treatment of ber fruits cvs. Gola and Goma Kirti with calcium nitrate (1.5%) and packing in perforated polyethylene (PPE) bag showed shelf life of 5 and 9 days, while the untreated control under ambient conditions had 3 and 5 days economic life for cvs. Gola and Goma Kirti, respectively.

Growth regulators : Siddiqui *et al.* (93) observed that treatment with 100 ppm benzyl adenine reduced the per cent weight loss but increased ethylene evolution in Umran fruits during storage. Dipping in 500 ppm cycocel for 15 min (91) and at 1000 and 2000 ppm for 10 min (42) improved the shelf life of ber fruits. Post-harvest dip treatment in 10 ppm GA_3 and benzyl adenine (BA) solution and storage at room conditions have been shown to improve the marketability of ber cv. Umran fruits (77). Similarly, Ramkishan and Godara (76) reported that ber fruits of cv. Gola dipped in 25 ppm cytokinin and 1000 ppm GA_3 showed improved shelf life. Jawanda *et al.* (45) reported that post-harvest dipping treatment of cv. Umran fruits for 5 min in 60 ppm GA_3 and 2% $CaCl_2$ reduced the browning of fruits during storage at low temperature.

Antioxidants : Dipping ber fruits in 150 and 300 ppm ascorbic acid solution reduced over- ripening,

increased TSS but had no effect on acidity and ascorbic acid during storage (89). It was further reported by Siddiqui and Gupta (91) that ascorbic acid dip treatment (300 ppm) resulted in reduced respiration, enhanced ethylene evolution and higher decay loss during storage. Zhao *et al.* (108) observed that fresh fruits of *Ziziphus jujuba* Mill. 'Linyilizao' when soaked in 0.5-1.5% citric acid for 3 h and then stored in refrigerator at 4°C, showed higher retention of vitamin C, soluble sugars and titratable acidity during storage.

Fungicides : Use of various fungicides and other chemicals has also been tried to reduce post-harvest decay losses, however, as they are not GRAS, their use should be avoided. Dipping Gola fruits in 500 ppm TBZ, captaf and dithane M-45 improved the shelf life by reducing decay loss and rate of respiration (33). Dipping of Umran fruits in 0.05 and 0.1% $KMnO_4$ also reduced the decay loss during storage (89).

4. Use of Irradiations

Mature green jujube fruits of Z. *spina-christi* L. Wild cv. Zaytoni were subjected to gamma radiation and stored at 20°C and 85-90% R. H. It was observed that fruits subjected to 30 krad were firmer and greener than unirradiated control fruits after six days of storage. Irradiation delayed ripening by three days with no significant loss in the nutritive value (2).

Exposure of ber cv. Umran fruits to UV-C radiations so as to receive energy of 10-40 KJ/m^2, resulted in reduced ripening and decay losses, thereby improving the shelf life at ambient conditions (94).

5. Heat Treatment

Heat treatment has been reported to influence the shelf life of fruits and vegetables. Siddiqui *et al*. (95) reported that dipping green-mature fruits of ber cv. Umran for 10 min in hot water at 40°C, enhanced their shelf life at room temperature by reducing PLW and influencing the respiration and ethylene evolution rate. The growth of surface moulds was also reduced resulting in reduced decay loss. Nallathambi *et al*. (68) reported that ber fruits stored at low temperature (7°C) after treatment with hot water (50°C for 10 min) containing 0.5% calcium chloride significantly reduced fungal infections. Lal *et al.* (55) reported that dipping of fresh fruits of cv. Umran in hot water (50°C) for 5 min followed by packaging in sealed polythene bags resulted in shelf life of eight days at room temperature, as against four days in control. The enhancement in shelf life was because of retarded metabolic activities and reduced growth of post-harvest pathogens.

6. Grading

After harvesting, the under ripe, over ripe, damaged and misshapen ber fruits are sorted out. The grading is generally done for local marketing; however, there are no export standards available for grading of ber fruits. Some growers do sorting in three or more grades based on size or maturity or colour to get better returns. The grading is done generally manually, which is, however, more of subjective nature. Size grading can also be done through standard sieves/rings. Pareek and Gupta (71) suggested the following three grades viz., A, B and C for ber (Table 6).

7. Pre-cooling

Pre-cooling is generally not done for ber fruits but air- or hydro-cooling technique can be successfully adopted. It has been reported by Gupta and Mehta (33) that pre-cooling Gola ber for 2 h in cold water at 2°C or keeping them exposed to cold air for 4 h extended the shelf life by reducing respiratory rate. Nallathambi *et al*. (68) reported that ber fruits stored at low temperature (7°C) after treatment with cold water (30 min) or fruits stored at room temperature (28±2°C) after treatment with cold water (15 min) had significantly reduced decay losses.

Table 6. Various grades of ber

Grade	Standards
A	Shining yellow, large to medium size fruits of uniform shape with no blemishes
B	Uneven yellow or yellow red, large to medium size fruits of uniform shape with some blemishes
C	Red, large to small fruits. Uneven yellow, small fruits

Source : Pareek and Gupta (71).

8. Waxing

Jain *et al.* (42) reported that coating of ber cv. Umran fruits with waxol-W-12 reduced PLW but had poor organoleptic rating. In Umran and Sanauri-2, wax emulsion W-O-12 decreased per cent spoilage, did not help in retention of ascorbic acid content, enhanced shelf life by reducing PLW and maintained organoleptic quality of fruits during storage (43, 44). Siddiqui *et al*. (93) observed that waxol-O-12 decreased decay loss and increased TSS of Umran fruits. Waxol at 6% was more effective than at 12%. However, it has been suggested that ber fruit coated with waxol should be eaten after washing. Baviskar *et al.* (16) reported that mature fruits of ber cv. Umran treated with 6% Waxol-O-12 when packed in 2% perforated polythene bags improved the shelf life. Banik *et al.* (15) had reported that ber cv. Gola fruits coated with 2% paraffin wax remained acceptable up to 18 days as against untreated control fruits getting spoiled by 9th day when stored at 10-12°C. Similarly, Bhadra *et al.* (18) reported that green mature fruits of ber cv. Narikeli, coated with liquid paraffin, could be stored up to 12 days under ambient temperature conditions.

RIPENING REQUIREMENT

Fruits of ber are considered to have a climacteric type of ripening (4, 72). The detailed studies on respiration, ethylene evolution, starch, sugar and colour development patterns of ber cv. Umran fruits ripening on tree or after harvest in stores, also revealed climacteric nature (39, 87). Contradictorily, fresh jujube (*Ziziphus jujube*) cv. Dapingding fruits have been reported to show non-climacteric nature of ripening (104, 107).

Kader *et al.* (48) reported that fruits of Chinese jujube picked green stage do not ripen satisfactorily off the tree. However, if picked at the whitish green stage, they continue to ripen. Brown spots develop on these fruits and increase in size until the entire skin becomes reddish brown. The rate of colour development increases with temperature and is optimum at 20-25°C. Jujube fruits produce very little ethylene (less than 0.3 µl/kg/h) at 20°C, but they respond to treatments with ethylene (applied as gas or from ethephon).

To permit once-over harvest, or at least fewer harvests, when a large percentage of the fruits has reached this stage or more advanced stages of ripeness, artificial ripening can be induced in Chinese jujube by exposing fruits picked at the whitish green stage to 100 ppm ethylene for four days at 20°C (Fig. 3). Similar results were obtained when whitish green jujubes were dipped for 2 min in 2000 ppm ethephon solution. These treatments resulted in faster and more uniform ripening (48). Similarly, Bal (10) reported that ethephon not only induced a nearly uniform fruit ripening, but also produced attractive, better quality ber fruits. However, Gupta and Mehta (33) reported that post-harvest dip application with 500 ppm ethrel had no beneficial effect on shelf life of ber cv. Gola fruits.

Since ripening of ber can be hastened by ethylene, it is conceivable that fruit ripening can also be delayed or prevented by controlling ethylene production or ethylene perception. 1-MCP is a relatively newly introduced non-toxic compound which blocks ethylene binding at the receptor level. Sankhla *et al*. (79) reported that exposing harvested ber cvs. Seb and Gola fruits to 1-MCP (100-400 nl/l) delayed fruit ripening and extending the shelf life. Jiang *et al.* (46) earlier had reported that rates of respiration and ethylene production of the fruit were reduced by 1 methylcyclopropene (1-MCP). In addition, treatment

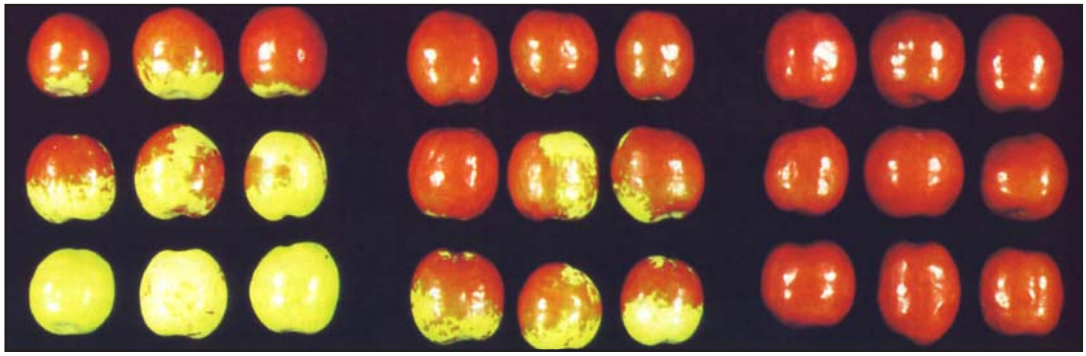

Fig. 3. Two weeks after being picked at greenish white stage, Chinese jujube stored at 20°C shows typical uneven ripening (left). Exposure to 100 ppm ethylene for four days promoted faster, more uniform ripening (right). Fruits in center were treated for two days (*Source* : Kader *et al.*, 48).

with GA+1-MCP resulted in additive beneficial effects on ripening inhibition of the fruit.

Nitric oxide (NO) also influences the ripening behaviour of ber fruits. It has been reported by Zhu *et al*. (109) that the fruits of Chinese winter jujube (*Zizyphus jujuba* Mill. cv. Dongzao) when fumigated for 3 h with 20 µl/l NO, significantly delayed ripening, slowed the increase in red index, inhibited changes of polyphenol oxidase (PPO) and phenylalanine ammonia lyase (PAL) activities. It maintained a low total anthocyanin content, high total phenol content besides delaying the increase of soluble solids and decrease of vitamin C during storage.

The ripening of fruits while attached on tree and after harvest in storage was compared. The per cent decrease in total chlorophyll and chlorophyll 'a' and 'b' contents in the peel with increase in the ripening of fruit cv. Umran was more in storage than on tree. There was no significant change in the content of carotenoids during ripening, both on tree as well as in storage (87). The loss of firmness during ripening showed higher correlation with degradation of celluloses and hemicelluloses while ripened on tree, whereas the correlation was higher with pectin degradation when ripened in storage (85). The best temperature for the maintenance of highly acceptable organoleptic quality during storage was found to be 7.5°C for cv. Umran. At this temperature, the fruits developed attractive colour and acceptable quality, and can be stored up to two weeks (58).

PACKAGING

Packaging is done for proper storage and safe transport. The storage behaviour of Umran, Gola and Kaithli fruits in different packages has been extensively studied (69, 98). Fruits of Umran and Kaithli packed in hard board corrugated boxes retained better quality for longer period than in wooden crates, bamboo baskets and gunny bags (38). Paper cuttings proved a better cushioning material than *doob* grass. Use of bleaching powder fumigant in the packages reduced the incidence and extent of decay loss (98). Diphenyl impregnated paper lining in boxes improved the shelf life of Umran and Gola fruits (33, 88).

An experiment was conducted by Radder *et al.* (73) to find out the influence of packages (gunny bag, woven basket, corrugated paper box, corrugated paper box with mesh and wooden box) and storage conditions (room temperature, modified atmosphere and zero energy cool chamber) on the biochemical parameters of ber fruits after transport. Among the different packages, corrugated paper box with mesh recorded lower total soluble solids (TSS) and non-reducing sugars with higher titratable acidity, ascorbic acid, total sugars and reducing sugars compared to the wooden boxes.

Four types of packages and two cushioning material were evaluated by Singh and Gupta (97) for their effect on microbial decay during storage of Umran and Kaithli cvs. of ber. Gunny bags and wooden boxes were better in reducing spoilage than bamboo basket and cardboard boxes. Paper cuttings were better cushioning material than grass hay as lesser decay loss was observed with it. The frequency of incidence of various fungi was reported and it was observed that *Ulocladium chartarum*, *Phonia hissarensis* and *Botryodiplodia theobromae* caused decay losses more frequently in the packages (Table 7).

Consumer Packs

These days consumer packs of half or one kg of ber fruits packed in nylon mesh bags are available. These

Table 7. Fungi associated with decay of ber fruits in different packs during storage

Fungi	Frequency of occurrence of fungi						
	Wooden box		Bamboo basket		Card board		Gunny bag
Alternaria solani	0	1	0	1	0	1	0
Botryodiploida theobromae	1	1	1	2	1	3	1
Fusarium roseum	0	0	0	1	0	1	0
Penicillium crysogenum	1	0	1	1	1	0	1
Phoma hissarensis	1	2	2	3	2	3	2
Ulocladium chariarum	2	3	2	3	2	2	2
Unidentified (black mycelium)	0	1	1	0	0	1	0

0 = nil, 1 = rare, 2 = common and 3 = very common.
Source : Singh and Gupta (97).

consumer packs are just acting as convenient handling units and are not able to provide any cushioning effect or protection, hence, several consumer packs are together repacked in CFB or plastic trays.

STORAGE

The choice of variety of ber and its storage conditions is of paramount importance for its shelf life. The differences in storage life may also be owing to variations in years, regions, floor management practices, irrigation geometry, maturity stages, locations of the fruits on the tree, time of harvesting, post-harvest applications, etc. The storage environment and its associated components like temperature, humidity, gaseous composition, etc. also exercise great influence on the shelf life. Ber fruits from harvest until their consumption are usually stored at ambient/room temperature (25-35°C). Zero energy cool chambers (ZECC) can also be used to enhance the shelf life by lowering the temperature and increasing the relative humidity inside the chambers via passive evaporative cooling. The maximum enhancement of shelf life, however, is obtained by storing the fruits at low temperature.

Storage Environment

(i) Temperature : Jain *et al.* (42) reported that ber cv. Umran fruits could be stored at room temperature with less than 10% weight loss up to three days in open baskets and up to six days in earthen pots. Siddiqui and Gupta (89) could store fruits up to three days in wooden boxes at room temperature and up to six days in zero energy chambers. Similarly, Gupta and Kadam (32) reported that ber fruits stored at ambient temperature had a short life of three days only. Banarsi Karaka fruits could be stored in straw up to eight days at room temperature, in leaves up to seven days and for only four days in open basket. Gupta and Siddiqui (35) observed that the shelf life at room temperature was the longest in Sanaur-5, followed by Ponda, Reshmi and Umran cultivars. Pareek and Gupta (71) observed the shelf life of Gola and Kaithli cultivars at ambient temperature up to 7 and 10 days, respectively. Jawanda *et al.* (43) observed that Umran and Sanaur-2 could be stored up to 10 and 12 days at room temperature. *Z. spina-christi* cv. Zaytoni fruits could be stored for six days at room temperature (3). The fruits of cultivar Gola were suitable for eating up to eight days of storage (75). The shelf life of 10 cultivars of ber at room temperature growing under West Bengal conditions was found to be 2-6 days by Ghosh and Mitra (28).

Meena *et al*. (61) reported that shelf life of ber cv. Umran fruits was extremely short, hardly 2-4 days at ambient conditions and it can be increased up to 12 days in zero energy cool chambers (ZECC). Earlier, Siddiqui and Gupta (90) stored ber fruits in ZECC and reported that fruits of cultivar Gola remained in acceptable condition up to 12 days of storage. A comparison of shelf life of ber fruits presented in Table 8, indicated that contrary to the general belief, Gola fruits had longer shelf life than Umran at room temperature and even better when kept in zero energy chamber or in cold storage.

Several studies have examined the effect of low temperature on post-harvest changes in the chemical constituents of ber fruits. Jawanda *et al*. (44) observed that Umran and Sanaur-2 fruits could be stored up to 30 and 40 days, respectively, in commercial cold storage (0-3.3°C). Jain *et al*. (41) reported that fruits stored in perforated polythene bags and baskets at 13°C remained at acceptable organoleptic quality up to three weeks. Panwar (69) stored Umran and Kaithli ber up to 42 days at 10°C. The shelf life of Gola and Kaithli cultivars of ber at 17°C was found to be 42 and 28 days, respectively (71). In cold storage (10°C, 79% relative humidity), fruits of cultivars Gola, Kaithii and Umran remained acceptable up to 42, 28 and 35 days, respectively (6). The golden yellow coloured ripe fruits of Umran could be stored for about three weeks at

Table 8. Storage life (days) of some ber cultivars

Storage conditions	Gola	Kaithli	Umran	Temp. (°C)		Relative humidity (%)
				Min.	Max.	
Room temperature	9	7	10	17.8	28.8	64
Zero energy chamber	18	14	15	11.6	20.0	95
Cold storage	42	28	35	10.0	-	79

Source : Anonymous (6).

low temperatures ranging from 0-4°C (7). Monthira (63) reported that Bombay jujube fruits could be stored in perforated polythene bags for 8, 16 and 24 days at 15°C, 10°C and 5°C, respectively. Kumar (53) evaluated shelf life of various cultivars of ber (*Z. mauritiana*) at 10, 20 and 25°C. It was observed that the shelf life of ber fruits was maximum for cv. Umran followed by cvs. Sanaur-5, Kaithli and Sandhura Narnaul, and it was minimum for Narma followed by Chonchal and Illaichi. The differences in storage temperature gave the same trend except that the average shelf life at 25°C was eight days and at 10°C, it was 20 days. Tembo *et al*. (101) reported that weight loss in ber (*Z. mauritiana*) fruits under Zimbabwe conditions after three weeks of storage at 22°C was 40%, while at low storage temperature of 5°C, loss was just 3%, thereby showing prolonged shelf life of ber fruits under cold storage conditions.

(ii) Humidcool technology : Liu *et al.* (57) reported that the humidicool technology and sterilization with ozone can increase the storage life of winter jujube (*Ziziphus jujube*) effectively, thus improving the economic benefits of the winter jujube industry.

(iii) Modified atmosphere storage in polybags : Siddiqui *et al.* (95) reported that packing of ber cv. Umran in sealed polythene bags (150 gauge) (modified atmosphere) along with $KMnO_4$ impregnated chalk sticks enhanced the shelf life of fruits under ambient conditions. For 2 kg package, 20 g of chalk sticks impregnated with saturated $KMnO_4$ solution was found to be optimum. Studies were conducted by Naik and Rokhade (66) to know the effect of polythene packing on the storage behaviour of 11 commercial cultivars of ber at room temperature in the month of November under Dharwad (Karnataka) conditions. It was observed that polythene packing (100 gauge thickness with 0.5% area of vents) was effective in reducing PLW and maintaining TSS, acidity and vitamin C. Fruits were acceptable up to 12 days for cvs. Umran, Gola and Mehrun. However, fruits of Sanaur-2 were acceptable even up to 15 days. The fruits of Yishui Daxuezao, a late jujube variety, can be stored in plastic bags for 90 days without losing their freshness (31). Bal (11) observed that ber fruits kept in paper bags retained higher TSS and total sugars and lower acidity, starch content and PME activity than those kept in polythene bags. Bhaskar *et al*. (19) reported that perforated polyethylene bag as packing material under zero energy cool chamber and paper bags under ambient storage conditions were effective in maintaining better quality of the fruit throughout the storage period in term of retention of acidity, ascorbic acid and total sugar.

Due to the build-up of high humidity inside the polybags, higher decay losses have been reported in ber fruits packed in polyethylene bags (61, 106). However, Baviskar *et al*. (17) reported that packing of ber cv. Umran in PE bags and CFB resulted in elimination of decay loss during storage at low temperature.

(iv) UHP and hypobaric storages : Fresh-cut jujube treated with ultra high pressure (UHP) of 600 MPa for 10 min and then stored at 4°C for nine days showed higher retention of flesh firmness due to decreased hydrolyzation of non-water soluble pectin (110).

Shelf life of ber cv. Umran was studied under various hypobaric conditions. The fruits remained acceptable up to 12 and 20 days under 100% hypobaric conditions, as against 4 and 8 days in control, at room and low temperature storage conditions, respectively (26).

The effect of hypobaric storage on the physiological and biochemical changes in Dong jujube (*Ziziphus jujube*) fruits was studied during cold storage by Xue *et al*. (105). Hypobaric storage significantly maintained the firmness and vitamin C content, decreased acetaldehyde and alcohol contents in pulp and respiratory intensity of fruits, and slowed down the rate of ethylene production in fruits. Chang and Hu (22) earlier reported that hypobaric storage of 50.663 and 20.265 kPa (as against 101.325 kPa, control) were the best conditions for storage of Chinese jujube cv. Lizao.

Changes during Storage

During storage, respiration and ethylene evolution rates and TSS increased or showed little change initially but decreased later, while vitamin C content decreased progressively (34, 43). The acidity of Umran and Kaithli fruits progressively decreased in storage (37, 42), while in Gola, acidity decreased initially but on prolonged storage increased significantly (33). This contradiction might be due to varietal differences. Antioxidant capacity and phenolic content, which are important indicators to evaluate the quality, were two times higher in fresh than three months stored fruits

of *Z. jujuba* cv. Dongzao (56).

Rate of Respiration

The rate of respiration is an indicator of heat evolution during storage and thus is helpful in determining the cooling efficiency and design of the cold room. Singh *et al*. (96) observed that the average rate of respiration of various cultivars of ber was 52.4 mg CO_2/kg/h at the green stage and reached up to 127.64 mg CO_2/kg/h at the red ripe stage. The rate of respiration among various cultivars was found to be 119.72, 131.54, 137.32, 132.32 and 133.33 mg CO_2/kg/h in Umran, Rashmi, Kaithli, ZG-3 and Ponda cultivars, respectively, at red-ripe stage. The lowest rate of respiration was observed in cultivar Umran while the highest rate was observed in cultivar Ponda. Similarly, Kader *et al*. (48) reported for Chinese jujube that respiration rate fluctuated between 15 and 20 ml CO_2/kg/h and remained within this range, while fruit was held at 20°C.

Storage Rot and its Biocontrol

During harvest, transit and storage, the fruits may get spoiled by various decay causing microflora. Some of the predominant organisms observed on freshly harvested fruits were *Aspergillus niger, A. sydowii, Rhizopus oryzae, Penicillium chryspgenum, Alternaria tenuisima, Phoma* sp., *Gurvularia* sp. of which *A. niger* and *R. oryzae* caused the maximum spoilage *in vitro* (49). *Alternaria* spp., *Aspergillus* spp., *Fusarium* spp., *Rhizopus* spp. and *Penicillium* spp. were identified causing spoilage during storage (80). Similarly, Yadav *et al.* (106) reported that population of *Penicillium expansum, A. niger* and *Rhizoctonia stolonifer* increased with storage period, particularly under polyethylene bags, plastic bags and wooden boxes with paper lining. Gola had a higher spoilage than Kaithli. Singh and Gupta (97) earlier reported lower decay loss in cv. Umran as compared to cv. Kaithli.

Use of various fungicides/irradiations/hot water treatment to control storage rot of ber has already been discussed earlier. Biocontrol of storage rot has also been reported. A mycological survey was carried out on the Lingwu Changzao changzao (*Ziziphus jujuba* Mill.) fruits in storage and the efficacy of bioantifungal agent against the decay *in vivo* was evaluated at room temperature by Guo *et al.* (30). Five fungi were isolated by tissue separation technique, artificial inoculations with the fungi were also performed in fruits as typical storage decay. The results on bio-efficacy indicated that oligochitosan concentrations ≥0.75 mg/ml significantly decreased black mould and gray mould disease caused by *A. alternata* and *B. cinerea* in jujube fruit stored at 25°C, combining natamycin with oligochitosan (KD-2) resulted in more effective control of disease. Only 19.96% of the fruits showed decay, while in the control decay incidence was 60.12%. Similar biocontrol of storage pathogens in ber by isolates of *Trichoderma* species (67) and yeasts (*Cryptococcus laurentii* and *Rhodotorula glutinis*) combined with silicon (102) has also been reported.

TRANSPORTATION

For long distance transport (800 km), card board containers and mulberry baskets with straw as cushioning material proved the best packaging material (40). For short distance transport (200 km) of Umran fruits, card board boxes proved the best giving the least per cent loss in weight, the highest being in gunny bags. Transport by rail resulted in lower PLW than by truck (5). However, the TSS, acidity and ascorbic acid were not affected by the mode of transport or packaging material. Singh and Gupta (98) observed that corrugated hard board cartons were better in reducing weight losses and in maintaining fruit quality during long distance (600 km) transport of Gola fruits during 19 h of rail journey. Also for storage after transportation corrugated hard board cartons were found to be the best. Radder *et al*. (74) compared the composition and quality of ber cv. Umran fruits transported using various packaging materials (gunny bag, woven basket, corrugated paper box with or without mesh and wooden box). Fruits packed in a corrugated paper box with mesh recorded the least mechanical damage (7.52%) and physiological weight loss (0.55%), and were superior with regard to firmness, colour, taste, flavour and overall acceptability.

Lal and Fageria (54) evaluated the performance of various packages and CFB boxes were found to be best for transportation and storage of ber cv. Umran fruits. The fruits packed in CFB boxes remained acceptable for six days of storage, whereas in bamboo baskets or wooden boxes or gunny bags with or without polythene lining, the fruits remained acceptable only for 3-4 days. Similarly, Yadav *et al.* (106) conducted a study to determine the most suitable packaging material for long distance transportation and subsequent storage of ber fruits of cvs. Gola and Kaithli. Immediately after transportation (at zero day of storage), minimum PLW was observed in sealed

polyethylene and plastic bags (0.9%), followed by perforated polyethylene bags (1.80%). Maximum PLW in Gola (6.30%) and in Kaithli (5.70%) was observed in bamboo baskets without cushioning.

POST-HARVEST STORAGE DISORDERS

Chilling Injury

Green mature fruits of cv. Umran stored at 5°C or at lower temperatures developed chilling injury symptoms**,** such as surface pitting and brown streaks, and bland taste on the 5th day of storage, while those stored at 10°C developed softening and browning at the neck, which progressed to the distal end with further storage (58). Similarly, Wang *et al*. (104) reported that fresh fruit of jujube (*Ziziphus jujuba*) cv. Dapingding was not suitable for storage below 0°C. Sandhbohr *et al*. (77) reported that fruits stored up to 10°C low temperature did not show any chilling injury symptoms during marketing. Earlier, Kader *et al*. (48) reported that fresh Chinese jujube fruits appeared to be susceptible to chilling injury if held at 0°C. The primary symptom is sheet pitting, or large sunken areas on the skin (Fig. 4). To avoid this injury, fruits should not be exposed to temperatures below 2.2°C during post-harvest handling. Fresh fruits (70 to 75% moisture) can be held at 10 °C for 70 days or at 20 °C for 30 days without significant quality deterioration or decay.

Injury due to MA

Inappropriate atmosphere in the storage package/ rooms also leads to development of disorders during storage. Sun *et al*. (100) reported that high concentration of CO_2 and low concentration of O_2 led to fresh fruit injury of *Ziziphus jujuba* cv. Dongzao. O_2/CO_2 ratio should be maintained at a certain level (approximately 19 : 0.2) in long-term storage. It is recommended that the fresh fruit may be stored in polyethylene bag with holes for air exchange and CO_2 absorbent in the bag in order to keep a balance of O_2 and CO_2.

MARKETING

In India, ber fruits, as any other fruits, are marketed through a marketing channel depending upon quantity of produce, distance from market and available storage and marketing infrastructure. Retailers purchase fruits

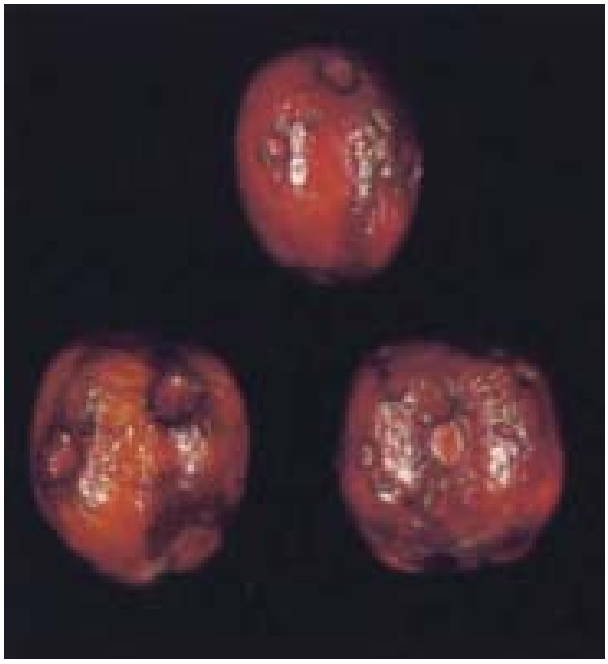

Fig. 4. Chilling to 0°C for 26 days caused sheet pitting, or large sunken areas in jujube fruits (Source : Kader *et al*., 48).

in the *mandi* (market) from producers or pre-harvest contractors through the commission agent or from a wholesaler and sell them in a local market or oustside areas.

An analysis of the marketing costs of ber in Rajasthan, India by Verma and Gujjar (103) revealed that getting the produce into the market involved considerable effort and cost for transportation, packing and loading/ unloading by the producer. In addition, marketing of the perishable produce is risk prone to spoilage. The harvesting season may coincide with other farm activities and the local market infrastructure may be inadequate and lack managerial assistance. The producer also has to deal with several market functionaries such as commission agents and wholesalers, which is a cumbersome process. Thus, the producers often prefer to sell their produce by pre-harvest auction to contractors, just before fruit maturity. The contracts are fixed either on the basis of a share of the accruing income or on the basis of a lump sum to be paid by the contractor in instalments. In the first case, the contractor takes care of overseeing the fruit development and picking and grading, but the marketing is done jointly with the grower. In the second case, which is mot common, the contractor picks the fruit according to his convenience and sells it in local or distant markets.

Ber has remained almost unknown in the export market

and nearly all the produce is sold in local markets. However, demand of the fruit is growing. Fresh ber bruits are now being exported from India and Pakistan to countries such as South Africa, Bangladesh, Malaysia, Saudi Arabia, Bahrain, UAE and UK, for use by ethnic communities. Chinese jujube are exported by China to Thailand, Hongkong and Taiwan. However, for all the exporting countries, the export is restricted to few months in a year except Thailand, which exports ber on a year-round-basis.

CONCLUSION

Ber fruits are highly nutritious and are regarded as one of the fruits of future. The cost and return analysis shows that ber growing is very remunerative. The variations in taste and appeal of fresh fruits make it very popular among large section of peoples. However, since the shelf life of most of the commercial cultivars of ber is hardly 2-6 days at room temperature, proper post-harvest handling operations are required to reduce its post-harvest losses and to have better returns. The information available on post-harvest management and practices of fresh ber fruits has been discussed in this chapter, which indicates that some more work needs to be done to make ber growing still more remunerative and to boost its domestic as well as export potential. Further studies should be done to characterise the physiology of ber fruits. The cultural practices could be modified to stagger the maturity period to match with the market demand. Reliable maturity indices and international standards with respect to quality should be developed to boost its export. Low temperature storage methods and commercial recommendations should be standardized for its different cultivars. The possibilities and economics of controlled and modified atmosphere storage of ber should be worked out. Alternative treatments used during pre- and post-harvest stages should be developed to replace any chemical treatments currently in use that are questionable for human safety.

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Effect of Levels of Adoption of Package of Practices on Fruit Yield and Quality of Kinnow

J. S. GORA, SULTAN SINGH, S. K. SEHRAWAT, M. DAHIYA AND JAGAT SINGH
Department of Horticulture, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India

ABSTRACT : The present study was undertaken with an objective ''effect on fruit yield and quality of kinnow with their adoption level of package of practices'' in the blocks of Hisar, Sirsa and Fatehabad districts of Haryana during the year 2010-11. The fruit yield per plant was recorded maximum in the kinnow orchard of Manohar Lal (70.00 kg) and minimum with Vineet (20.00 kg). The fruit weight was recorded maximum in the kinnow orchard of Manohar Lal (194.71 g) and minimum with Manphool (86.85 g). The correlation coefficient and regression coefficient increased with the adoption level of package of practices viz., fruit weight, fruit length, fruit breadth, juice per cent, T. S. S. but decreased with acidity of all fruit yield and quality parameters of kinnow.

Key words : Adoption level, package of practices, yield, quality, kinnow

Citrus is the most important fruit of tropical and sub-tropical region of the world. It was developed by Dr. H. B. Frost with the crossing of *(Citrus nobilis* Lour x *Citrus deliciosa* Tan.). The mandarin is the average nutritive value of vitamins and minerals so citrus is known as protective fruit.

The special feature of citrus fruit is the presence of juice sac in them. Unlike most other fruits, they lack a firm pulp and are either sucked or made into beverages. There is hardly anything to replace a glass of orange juice on a hot June afternoon or the appeal of an orange after a meal. They are rich source of vitamin C. The citrus fruits also contain vitamin P, which keeps the small blood vessel in our bodies in a healthy condition and helps in the assimilation of vitamin C. Tablets of vitamin C prescribed by the physicians are, therefore, not as effective in relieving the deficiency of this vitamin as much as a fresh citrus fruits (5). Therefore, its fruit quality and yield should be maintained by adoption of recommended package of practices.

MATERIALS AND METHODS

The study was carried out at Department of Horticulture, CCS Haryana Agricultural University during the year 2010-11. Thus, a total number of 20 farmers were selected for fruit yield and quality analysed based on their adoption level of package of practices from Hisar, Sirsa and Fatehabad districts of Haryana. For record of fruit yield and quality parameters, five trees were selected randomly in each orchard. Five fruits were randomly selected from the lot of harvested fruits for recording the data. Fruit size was recorded by measuring length and diameter of fruits. Total numbers of fruits were counted in November on randomly selected five trees before harvesting, whereas a sample of five randomly selected fruits from each tree was weighed and the average fruit weight was expressed in grams per fruit. Length and breadth of five randomly picked fruits from each tree were recorded with digital vernier callipers and the average expressed in centimetres. Yield per tree was calculated by multiplying the number of fruits per tree with the average fruit weight. The T. S. S. of pulp was determined with the help of refrectometer (0-32% range).

The titratable acidity was determined by the method given by A. O. A. C. (1). Two ml of freshly extracted juice was titrated against N/10 NaOH using phenolpthlein (1%) as an indicator. The appearance of the light pink colour was taken as the end point. The acidity of the fruit was expressed in terms of citric acid per 100 ml of juice. Ascorbic acid was estimated as per the method given by A. O. A. C. (1). Two ml of fruit juice was mixed with about 2 ml of 3% metaphosphoric acid as buffer. It was titrated with 2, 6-dichlorophenol indophenol dye till the light pink colour appeared. The results were expressed as mg of ascorbic acid per 100 ml of juice. However, fruit juice was extracted with the help of mechanical hand extractor and passed through a 20 mesh sieve and expressed as percentage of fruit juice.

$$\text{Juice (\%)} = \frac{\text{Total weight of fruit extracts juice}}{\text{Total fruit weight}} \times 100$$

The statistical analyses of data were carried out by two sampled t-test. The correlation and regression analyses were also done to find out the relationship between fruit quality, yield and soil-plant nutrients (3).

RESULTS AND DISCUSSION

The fruit yield and quality were affected by the adoption level of package of practices followed by farmers (Table 1). The fruit yield per plant was recorded maximum in the kinnow orchard of Manohar Lal (70.00 kg), followed by Vivekanand (64.00 kg) and Subash (62.00 kg) who had high level of adoption of package of practices. The numbers of fruits per plant were recorded maximum in the orchard of Gaurav, followed by Jagdeesh and Manphool. The fruit weight was recorded maximum in the kinnow orchard of Manohar Lal (194.71 g) followed by Subash (192.60 g) and Karam Chand (191.70 g). The juice per cent was observed highest in the orchard of Atmram (57.60%), followed by Vikas (57.18%) and Subash (55.90%). The low juice per cent was observed on the orchard of Hetram (36.39%) who had a low adoption level of package of practices. T. S. S. (8.92 °Brix) and ascorbic acid (29.40%) were recorded maximum in fruits obtained from Manohar Lal's orchard. Acidity (0.80%) was recorded maximum in fruits obtained from Atma Ram's orchard. The fruit yield was maximum where adoption level of package of practices was highest. Since these orchards were better managed and followed recommended package of practices, it resulted in higher fruit yield. On the contrary, the farmers adopting few package of practices recorded lower yield. The fruit quality of T. S. S., ascorbic acid, acidity and juice per cent was also better in kinnow orchards which had adopted package of practices. Karunadasa and Garforth (4) also obtained good quality tea leaves with higher adoption level of POP.

The correlation coefficient was worked out to know the relationship between fruit yield and quality parameters viz., fruit weight, fruit length, fruit breadth, juice %, T. S. S., ascorbic acid, acidity, number of fruits per plant and fruit yield per plant (kg) with adoption of package of practices of kinnow (Table 2). The fruit weight, fruit length, fruit breadth and fruit yield per plant showed significant correlation with adoption level of package of practices for kinnow cultivation. The maximum correlation coefficient was observed for fruit yield (0.92) followed by fruit weight (0.87). The rest of the fruit quality parameters viz., juice per cent, T. S. S., ascorbic acid, acidity and number of fruit per plant exhibited non-significant correlation with adoption level of package of practices. However, acidity and number of fruits per plant showed comparatively lowest correlation coefficient.

The parameters affecting its fruit yield and quality of kinnow had a positive relationship with increasing shown level of adoption. A critical examination of various management practices evaluated that few

Table 1. Fruit yield and quality parameters as affected by level of adoption of package of practices

Name of the farmer	Adoption level (%)	No. of fruits/ plant	Fruit yield/plant (kg)	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Juice (%)	T. S. S. (°Brix)
Karam Chand	72.50	315	60.00	191.70	6.30	6.62	43.82	7.56
Balram	54.70	400	53.00	133.90	5.85	7.10	47.91	8.22
Om Prakash	52.50	314	51.00	161.97	6.05	7.12	42.37	8.37
Atma Ram	50.00	325	47.00	145.75	5.95	7.38	54.81	7.10
Subash	75.00	322	62.00	192.60	6.22	7.42	55.90	8.55
Kuldeep	52.50	450	50.00	110.66	5.65	6.92	43.37	8.10
Manphool	45.00	460	40.00	86.85	5.97	6.27	39.05	8.27
Amardeep	47.50	420	43.00	103.20	5.67	6.10	48.60	6.67
Jagdeesh	54.76	472	52.00	110.27	5.75	6.07	44.14	8.90
Leeladhar	45.00	343	41.00	119.93	6.00	6.25	52.43	7.67
Harpal	32.50	280	25.00	89.40	5.65	5.97	46.48	7.20
Vineet	27.50	222	20.00	91.40	5.70	6.60	40.20	7.07
Vivekanand	77.50	365	64.00	178.49	6.07	6.92	52.40	8.87
Manoharlal	80.00	360	70.00	194.71	6.30	7.45	55.20	8.92
Gaurav	50.00	500	46.00	91.90	5.90	6.37	38.35	8.40
Hetram	42.50	367	38.00	103.42	6.04	6.15	36.39	7.46
Ram Kumar	47.50	400	42.00	105.06	6.05	6.66	55.50	7.97
Vikas	52.50	422	49.00	116.07	5.87	6.62	57.18	7.87
Atmram	60.00	435	55.00	127.17	5.60	6.52	57.60	7.70
Sriram	57.50	348	54.00	155.37	5.90	6.37	44.31	8.80
Average	53.80	375.75	48.10	130.50	5.92	6.64	48.30	8.07

Table 2. Association of fruit yield and quality parameters with their adoption level of package of practices

S. No.	Fruit quality parameters	Correlation coefficient
1.	Fruit weight	0.87*
2.	Fruit length	0.62*
3.	Fruit breadth	0.57*
4.	Juice (%)	0.31
5.	T. S. S.	0.41
6.	Ascorbic acid (mg/100 ml juice)	0.11
7.	Acidity	-0.10
8.	No. of fruits/plant	0.09
9.	Fruit yield/plant (kg)	0.92*

*Significant at P=0.05 level.

growers could not manage irrigation schedule and fertilizer application, whereas higher adopters of package of practices followed irrigation schedule and fertilizer application which provided soil moisture and nutrients throughout the growing season. Godara *et al.* (2009) reported that insufficient soil moisture during the period of fruit growth prevented attainment of normal fruit size and application of water after this period of growth will not enable the undersized fruits to grow and cause fruits cracking. According to Winkler (6) a severe shortage of readily available moisture during the ripening season delays maturity. This explains lower values of T. S. S. and higher acidity recorded in grape vineyard with a record of poor adoption.

The regression analysis was done by deleting acidity and number of fruits per plant due to their non-significant correlation coefficient values. Table 3 reveals that in case of adoption level of farmers, the regression coefficient of fruit weight, fruit length, fruit breadth and yield per plant were significant at 5% level of significance. This means that one unit change in fruit weight, fruit length, fruit breadth and yield per plant (kg) leads to a corresponding change of 2.31, 0.01, 0.02 and 0.82 units, respectively, on adoption of recommended practices. Regarding juice %, T. S. S., and ascorbic acid, it was observed that these variables

Table 3. Regression analysis of fruit yield and quality parameters with their adoption level of kinnow cultivation

S. No.	Fruit quality parameters	'a' value	Regression coefficient (b value)	't' value	R^2
1.	Fruit weight	5.60	2.31	7.56*	0.76
2.	Fruit length	5.41	0.01	3.36*	0.38
3.	Fruit breadth	5.60	0.02	2.94*	0.32
4.	Juice (%)	40.15	0.15	1.40^{NS}	0.10
5.	T. S. S.	7.08	0.02	1.95^{NS}	0.17
6.	Ascorbic acid (mg/100 ml juice)	21.99	0.01	0.49^{NS}	0.01
7.	Fruit yield/plant (kg)	2.59	0.82	10.71*	0.86

*Significant at P=0.05 level. NS–Not Significant.

had no significant impact on the variation of farmer's adoption level.

In the correlation coefficient, it was observed that fruit yield and fruit quality showed significant correlation with the adoption level of package of practices. On the basis of results obtained the regression coefficient of fruit weight and fruit yield per plant was found to be significant in relationship with the adoption because adoption of better input of package of practices in production resulted in better fruit yield and quality.

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Effect of Different Pulsing Solutions on Biochemical Changes of Chrysanthemum (*Chrysanthemum morifolium* Ramat.) Flowers cv. Shanti

SURESH KUMAR, B. S. BENIWAL, J. K. SANDOOJA AND MAHESH CHOUDHARY
Department of Horticulture, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India

ABSTRACT : An experiment was conducted to find out the effect of different pulsing solutions on biochemical changes of chrysanthemum (*Chrysanthemum morifolium* Ramat.) cv. Shanti at Department of Horticulture, CCS Haryana Agricultural University, Hisar during 2007-08. Two pulsing solutions (i) Sugar (0, 2, 4, 6 and 8) and (ii) 8-HQC (0 and 200 ppm) were used in different combinations i. e. T_1–Control, T_2–200 ppm 8-HQC, T_3–2% Sugar, T_4–4% Sugar, T_5–6% Sugar, T_6–8% Sugar, T_7–2% Sugar+200 ppm 8-HQC, T_8–4% Sugar+200 ppm 8-HQC, T_9–6% Sugar+200 ppm 8-HQC and T_{10}–8% Sugar+200 ppm 8-HQC. Among these treatments, pulsing solution of 2% Sugar+200 ppm 8-HQC was found the best for different biochemical changes viz., pH of vase solution, proximal end browning, total sugars (mg/g), reducing sugars (mg/g) and non-reducing sugars (mg/g).

Key words : Chrysanthemum, biochemical changes, 8-HQC, pulsing solution, sugar

Chrysanthemum, commonly known as *Guldaudi* or *Autumn Queen,* is cultivated world over for its commercial and aesthetic value. It belongs to the family Asteraceae. Chrysanthemum is popular having florets of varying forms and sizes, dazzling colours, which remain fresh for 7-10 days as cut flower and are ideal for indoor flower arrangements. Guldaudi is in great demand in international as well as domestic markets. In cut flower industry, most important aspect is post-harvest handling in order to maintain flower freshness and original colour for a long period after cutting from the mother plant for transportation to distant markets to fetch good prices. During the process of respiration, sugar stored in plant tissue gets burnt and consequently the life of cut flower depends upon the potential availability of sugars at the time of harvesting and lowering rate of respiration after harvesting. The vase life of cut flowers is influenced by constant water supply, checking of microbial growth, prevention of ethylene formation and energy source. So, several types of floral preservatives in the form of germicides, ethylene antagonists and sources of energy (sugar) are in use to preserve the flower quality and extending post-harvest longevity. The market losses of cut flowers due to inefficient post-harvest handling and packaging are estimated to be around 20 to 40% in our country. Devising appropriate post-harvest technology will minimize such losses considerably. Hence, the present investigation was carried out to know the best pulsing solution for extending the vase life of chrysanthemum.

MATERIALS AND METHODS

The study was conducted at the experimental orchard of the Department of Horticulture, CCS Haryana Agricultural University, Hisar in a completely randomized design (CRD) using two pulsing solutions (i) Sugar (0, 2, 4, 6 and 8%) and (ii) 8-HQC (0 and 200 ppm) in different combinations. The flowers were harvested at early morning and cut stems were dipped in different pulsing solutions, kept in flask i. e. T_1–Control, T_2–200 ppm 8-HQC, T_3–2% Sugar, T_4–4% Sugar, T_5–6% Sugar, T_6–8% Sugar, T_7–2% Sugar+200 ppm 8-HQC, T_8–4% Sugar+200 ppm 8-HQC, T_9–6% Sugar+200 ppm 8-HQC and T_{10}–8% sugar+200 ppm 8-HQC and were replicated three times. The cut stems were evaluated for some biochemical changes. The data recorded for various parameters were subjected to statistical analysis.

RESULTS AND DISCUSSION

pH of vase solution increased up to 4th day and then decreased up to 10 days in all the treatments (Table 1). Maximum pH of vase solution was observed on the first day of storage (4.80), whereas minimum pH of vase solution was observed on 10th day (4.72). This was mainly due to the reason that microbial growth in vase water which ultimately caused reduction in absorption of solution. These results are in conformity with results of Halevy and Mayak (3) who reported that 8-Hydroxyquinoline citrate was suggested for prolonging vase life of cut flower by inhibiting bacteria growth and stem blockage. Among the different treatments, minimum pH of vase solution was retained in 2% sugar solution with 200 ppm 8-Hydroxyquinoline citrate (4.48) followed by 4% sugar solution with 200 ppm 8-Hydroxyquinoline citrate (4.49). Maximum pH of vase solution was observed in the control pH (6.21). Among the interactions, minimum pH of vase solution was observed in flower kept in 2% sugar solution+200

Table 1. Effect of different pulsing solutions on pH of vase solution during storage of chrysanthemum cv. Shanti

Treatments/Pulsing solutions	Storage period (days)										
	1	2	3	4	5	6	7	8	9	10	Mean
T_1–Control	6.30	6.28	6.26	6.24	6.22	6.20	6.18	6.16	6.14	6.12	6.21
T_2–200 ppm 8-HQC	5.35	5.33	5.31	5.30	5.28	5.26	5.24	5.22	5.20	5.18	5.27
T_3–2% Sugar	4.58	4.58	4.59	4.60	4.59	4.58	4.56	4.54	4.52	4.50	4.56
T_4–4% Sugar	4.58	4.59	4.60	4.60	4.60	4.59	4.57	4.56	4.54	4.52	4.58
T_5–6% Sugar	4.58	4.58	4.59	4.60	4.59	4.58	4.56	4.55	4.54	4.53	4.57
T_6–8% Sugar	4.58	4.59	4.60	4.61	4.60	4.59	4.57	4.56	4.55	4.53	4.58
T_7–2% Sugar+200 ppm 8-HQC	4.50	4.50	4.51	4.52	4.51	4.50	4.48	4.46	4.44	4.42	4.48
T_8–4% Sugar+200 ppm 8-HQC	4.50	4.50	4.51	4.52	4.51	4.51	4.50	4.48	4.46	4.45	4.49
T_9–6% Sugar+200 ppm 8-HQC	4.50	4.50	4.51	4.52	4.51	4.51	4.50	4.48	4.46	4.45	4.49
T_{10}–8% Sugar+200 ppm 8-HQC	4.50	4.50	4.51	4.52	4.51	4.51	4.50	4.48	4.47	4.46	4.50
Mean	4.80	4.80	4.80	4.80	4.79	4.78	4.77	4.75	4.73	4.72	-
C. D. (P=0.05) : Treatment (T) : 0.05, Days (D) : 0.05, Treatment x Days (T x D) : 0.10											

ppm 8-Hydroxyquinoline citrate (4.50). However, the maximum pH of vase solution was observed in control (6.12) after 10 days of storage. Similar results were reported by Bhat *et al.* (1) in chrysanthemum.

The data presented in Table 2 depict that effect of different pulsing treatments on proximal end browning (visual basis) during storage at room temperature increased with increase in storage period up to 10 days in all the treatments. Minimum proximal end browning was observed on the first day of storage (1.2 marks), whereas maximum proximal end browning was observed on 10th day (5.3 marks) when considered irrespective of treatments.

Minimum proximal end browning was observed in flower kept in pulsing solution of 2% sugar +200 ppm 8-Hydroxyquinoline citrate. This was due to the reason that there were degradative processes which might have resulted in proximal end browning. These degradative processes slowed down in pulsing solution of 2% sugar+200 ppm 8-Hydroxyquinoline citrate. Maximum proximal end browning was observed in the control flower (5.7 marks).

Among the interactions, minimum proximal end browning was observed in flower kept in 2% sugar solution+200 ppm 8-Hydroxyquinoline citrate (0.3 marks). However, the maximum proximal end browning was observed in control (8.0 marks) after 10 days of storage.

The effect of different pulsing treatments on the total sugars during storage at room temperature has been presented in Table 3. Maximum total sugar was observed on the 5th day of storage (18.56 mg/g), whereas minimum total sugar was observed on 10th day (18.04 mg/g). This is obvious as with increase in storage period there was a decrease in carbohydrate content because respiration continued during storage thereby utilizing sugar which resulted in decrease in total sugar. Verma *et al.* (4) also reported that increase in storage period decreased total sugars.

Among the different treatments, maximum total sugar

Table 2. Effect of different pulsing solutions on proximal end browning (visibly) during storage of chrysanthemum cv. Shanti

Treatments/Pulsing solutions	Storage period (days)										
	1	2	3	4	5	6	7	8	9	10	Mean
T_1–Control	3.2	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	5.7
T_2–200 ppm 8-HQC	0.4	1.2	1.4	1.7	1.9	2.2	2.5	2.8	3.0	3.2	2.0
T_3–2% Sugar	1.2	2.0	2.2	2.5	3.0	3.5	3.7	4.5	5.0	6.0	3.4
T_4–4% Sugar	1.3	2.2	2.4	2.8	3.5	4.0	4.5	5.0	6.0	6.5	3.8
T_5–6% Sugar	1.3	2.4	2.6	3.0	3.8	4.5	5.0	5.5	6.5	7.0	4.2
T_6–8% Sugar	1.5	2.8	3.4	4.0	4.5	5.0	5.6	6.2	7.0	7.5	4.8
T_7–2% Sugar+200 ppm 8-HQC	0.3	1.0	1.1	1.4	1.5	1.7	2.1	2.2	2.4	2.8	1.7
T_8–4% Sugar+200 ppm 8-HQC	0.5	1.4	1.8	2.0	2.3	2.6	3.0	3.2	3.4	3.6	2.4
T_9–6% Sugar+200 ppm 8-HQC	0.5	1.6	1.9	2.1	2.4	2.8	3.2	3.5	3.8	4.1	2.6
T_{10}–8% Sugar+200 ppm 8-HQC	0.5	1.8	2.2	2.5	2.8	3.1	3.5	3.8	4.1	4.5	2.9
Mean	1.2	2.0	2.3	2.7	3.1	3.5	4.0	4.4	4.9	5.3	-

Table 3. Effect of different pulsing solutions on total sugars (mg/g) during storage of chrysanthemum cv. Shanti

Treatments/Pulsing solutions	Storage period (days)											
	0	1	2	3	4	5	6	7	8	9	10	Mean
T_1–Control	16.35	16.21	16.10	16.00	15.90	15.80	15.70	15.58	15.48	15.37	15.27	15.80
T_2–200 ppm 8-HQC	16.42	16.30	16.20	16.10	16.00	15.90	15.80	15.70	15.60	15.48	15.38	15.90
T_3–2% Sugar	20.28	20.41	20.52	20.62	20.71	20.82	20.71	20.61	20.51	20.41	20.30	20.54
T_4–4% Sugar	17.20	17.30	17.40	17.50	17.60	17.71	17.60	17.48	17.38	17.28	17.18	17.42
T_5–6% Sugar	18.08	18.16	18.26	18.36	18.46	18.58	18.48	18.38	18.28	18.10	18.02	18.29
T_6–8% Sugar	19.05	19.20	19.30	19.40	19.50	19.60	19.48	19.39	19.28	19.18	19.08	19.31
T_7–2% Sugar+200 ppm 8-HQC	21.00	21.10	21.20	21.30	21.40	21.50	21.40	21.29	21.19	21.09	20.98	21.22
T_8–4% Sugar+200 ppm 8-HQC	17.28	17.40	17.50	17.61	17.71	17.81	17.70	17.60	17.50	17.40	17.30	17.53
T_9–6% Sugar+200 ppm 8-HQC	18.00	18.10	18.20	18.30	18.41	18.45	18.40	18.30	18.20	18.10	18.02	18.22
T_{10}–8% Sugar+200 ppm 8-HQC	18.90	19.02	19.10	19.21	19.31	19.41	19.30	19.20	19.10	19.02	18.90	19.13
Mean	18.26	18.32	18.38	18.44	18.50	18.56	18.46	18.35	18.25	18.14	18.04	-
C. D. (P=0.05) : Treatment (T) : 0.03, Days (D) : 0.03, Treatment × Days (T × D) : 0.06												

was retained in 2% sugar solution with 200 ppm 8-Hydroxyquinoline citrate (21.22 mg/g) followed by 2% sugar solution (20.54 mg/g). This was due to the fact that pulsing with these chemicals also increased the content of total sugar in the petal which also might be associated with longer vase life.

Among the interactions, maximum total sugar was observed in flower kept in 2% sugar solution+200 ppm 8-Hydroxyquinoline citrate (21.50 mg/g). However, the minimum diameter was observed in control (15.27 mg/g) after 10 days of storage. These results are in conformity with the results of Vidhyasankar (5) who reported that pulsing with 8-Hydroxyquinoline citrate+fructose for 24 h resulted in highest total sugar content.

The data presented in Table 4 depict that maximum reducing sugar was observed on the 5th day of storage (12.38 mg/g), whereas minimum reducing sugar was observed on 10th day (12.02 mg/g) when considered irrespective of treatments. This is apparent as with increase in storage period there was a decrease in carbohydrate content because respiration kept on going during storage thereby utilizing sugar as substrate which resulted in decrease in reducing sugar. Similar results were also reported by Verma *et al.* (4) who reported that increase in storage period decreased reducing sugars.

Maximum reducing sugar was observed in flower kept in pulsing solution 2% sugar+200 ppm 8-Hydroxyquinoline citrate (Table 4). This was due to the fact that pulsing with these chemicals also increased the content of reducing sugar in the petal which also might be associated with longer vase life.

Among the interactions, maximum reducing sugar was observed in flower kept in 2% sugar solution+200 ppm 8-Hydroxyquinoline citrate (14.33 mg/g). However,

Table 4. Effect of different pulsing solutions on reducing sugars (mg/g) during storage of chrysanthemum cv. Shanti

Treatments/Pulsing solutions	Storage period (days)											
	0	1	2	3	4	5	6	7	8	9	10	Mean
T_1–Control	10.90	10.81	10.73	10.65	10.60	10.56	10.46	10.38	10.32	10.24	10.17	10.53
T_2–200 ppm 8-HQC	10.95	10.87	10.80	10.74	10.65	10.60	10.54	10.46	10.40	10.32	10.25	10.60
T_3–2% Sugar	13.52	13.61	13.68	13.74	13.81	13.88	13.80	13.74	13.67	13.61	13.53	13.69
T_4–4% Sugar	11.47	11.53	11.60	11.67	11.73	11.81	11.73	11.65	11.59	11.52	11.45	11.61
T_5–6% Sugar	12.03	12.14	12.17	12.24	12.31	12.39	12.32	12.25	12.19	12.07	12.00	12.19
T_6–8% Sugar	12.70	12.80	12.87	12.93	13.02	13.06	12.99	12.92	12.85	12.79	12.72	12.88
T_7–2% Sugar+200 ppm 8-HQC	14.00	14.07	14.13	14.20	14.27	14.33	14.27	14.19	14.13	14.06	13.99	14.15
T_8–4% Sugar+200 ppm 8-HQC	11.52	11.60	11.67	11.74	11.81	11.87	11.80	11.73	11.67	11.60	11.53	11.69
T_9–6% Sugar+200 ppm 8-HQC	12.00	12.07	12.13	12.20	12.27	12.35	12.27	12.20	12.13	12.06	12.00	12.15
T_{10}–8% Sugar+200 ppm 8-HQC	12.60	12.67	12.73	12.81	12.87	12.93	12.87	12.80	12.73	12.67	12.60	12.75
Mean	12.17	12.22	12.25	12.29	12.33	12.38	12.31	12.23	12.17	12.09	12.02	-
C. D. (P=0.05) : Treatment (T) : 0.08, Days (D) : 0.08, Treatment x Days (T x D) : 0.14												

the minimum reducing sugar was observed in control (10.17 mg/g) after 10 days of storage. These results are also in agreement with the results of Bhattacharjee (2) and Vidhyasankar (5) who reported that pulsing with 8-Hydroxyquinoline citrate+fructose for 24 h resulted in highest reducing sugar content.

The data presented in Table 5 predict that non-reducing sugars decreased with increase in storage periods up to 5th day and decreased thereafter up to 10 days in all the treatments. Maximum reducing sugar was observed on the 5th day of storage (6.19 mg/g). Among the different pulsing treatments, maximum non-reducing sugar was retained in flower kept in pulsing solution of 2% sugar+200 ppm 8-Hydroxyquinoline citrate. This may be due to the fact that pulsing with these chemicals increases the content of non-reducing sugar in the petal which also might be associated with longer vase life.

Among the interactions, maximum non-reducing sugar was observed in flower kept in 2% sugar solution+200 ppm 8-Hydroxyquinoline citrate (7.17 mg/g). However, the minimum non-reducing sugar was observed in control (5.10 mg/g) after 10 days of storage.

Table 5. Effect of different pulsing solutions on non-reducing sugars (mg/g) during storage of chrysanthemum cv. Shanti

Treatments/Pulsing solutions	Storage period (days)											
	0	1	2	3	4	5	6	7	8	9	10	Mean
T_1–Control	5.45	5.40	5.37	5.35	5.30	5.24	5.24	5.20	5.16	5.13	5.10	5.27
T_2–200ppm 8-HQC	5.47	5.43	5.40	5.36	5.35	5.30	5.26	5.24	5.20	5.16	5.13	5.30
T_3–2% Sugar	6.76	6.80	6.84	6.88	6.90	6.94	6.91	6.87	6.84	6.80	6.77	6.85
T_4–4% Sugar	5.73	5.77	5.80	5.83	5.87	5.90	5.87	5.83	5.79	5.76	5.73	5.81
T_5–6% Sugar	6.02	6.05	6.09	6.12	6.15	6.19	6.16	6.13	6.09	6.03	6.02	6.09
T_6–8% Sugar	6.35	6.40	6.43	6.47	6.48	6.54	6.49	6.46	6.43	6.39	6.36	6.44
T_7–2% Sugar+200 ppm 8-HQC	7.00	7.03	7.07	7.10	7.13	7.17	7.13	7.10	7.06	7.02	6.99	7.07
T_8–4% Sugar+200 ppm 8-HQC	5.76	5.80	5.83	5.87	5.90	5.94	5.90	5.87	5.83	5.80	5.77	5.84
T_9–6% Sugar+200 ppm 8-HQC	6.00	6.03	6.07	6.10	6.14	6.17	6.13	6.10	6.07	6.04	6.02	6.08
T_{10}–8% Sugar+200 ppm 8-HQC	6.30	6.35	6.37	6.40	6.44	6.48	6.43	6.40	6.37	6.35	6.30	6.38
Mean	6.08	6.11	6.13	6.15	6.17	6.19	6.15	6.12	6.08	6.05	6.02	
C. D. (P=0.05) : Treatment (T) : 0.01, Days (D) : 0.01, Treatment x Days (T x D) : 0.02												

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Haryana J. hortic. Sci., **41** (3 & 4) : 112-116 (2012)

Yield and Quality Parameters of Garland Chrysanthemum (*Chrysanthemum coronarium* L.) as Influenced by Growth Regulators/Chemicals

A. V. D. DORAJEERAO AND A. N. MOKASHI

Department of Horticulture, HC and RI, Dr. Y. S. R. Horticulture University, Venkataramannagudem (A. P.), India

ABSTRACT : The results on weight of flowers per plot showed that the maximum yield enhancing ability was shown by GA at 100 ppm. There was no addition in the yield of garland chrysanthemum by increasing the concentration of GA beyond 100 ppm. Foliar spray of cycocel at 3000 ppm recorded maximum number of flowers per plant, when compared to other concentrations. But their average weight being relatively lesser, they were making a gross weight of flowers/ha only next to gibberellic acid at 100 ppm. SA spray at 100 ppm resulted in significant increase in flower and seed yield when compared to other concentrations. Paclobutrazol at 40 ppm recorded a higher number of flowers per plant compared to other higher concentrations of 60 and 80 ppm. Flower quality in terms of average flower weight, flower diameter and seed quality in terms of test weight were also at maximum by the application of GA at 100 ppm.

Key words : Flower yield, garland chrysanthemum, growth regulators, quality

Garland chrysanthemum, botanically known as *Chrysanthemum coronarium* L., is an annual under the chrysanthemum group of flowers. It is different from plurannual or florist chrysanthemum in many aspects. The crop is relatively of short duration and less photosensitive; thus capable of coming up throughout the year. It is more hardy, vigorous and grows taller. Its flowers are in various shades of yellow, white, having single or double forms (3). They are hermaphrodite. The plant is self-fertile and seed propagated. In India, the crop is cultivated in localized spots and is becoming popular recently. However, there is no information about the use of growth regulators/ chemicals on the yield and quality parameters of this crop. Growth regulators have been found useful in overcoming the factors limiting the yield and quality of flowering annuals like marigold, China aster and daisy (8). Several positive and precise results were obtained in the past by the growth regulating chemicals on various flowering annuals. The response exhibited by plants to growth regulators varies with the species, varieties and on the concentration of the chemical used.

MATERIALS AND METHODS

The treatments included three chemicals viz., gibberellic acid-3 (GA), salicylic acid (SA), cycocel (CCC) and paclobutrazol and each at three different concentrations. Thus, there were 13 treatments including water spray as control. They were : 1. Gibberellic acid-3 at 50 ppm (GA 50), 2. Gibberellic acid-3 at 100 ppm (GA 100), 3. Gibberellic acid-3 at 150 ppm (GA 150), 4. Salicylic acid at 50 ppm, 5. Salicylic acid at 100 ppm (SA 100), 6. Salicylic acid at 100 ppm (SA 150), 7. Cycocel at 2000 ppm (CCC 2000), 8. Cycocel at 3000 ppm (CCC 3000), 9. Cycocel at 4000 ppm (CCC 4000), 10. Paclobutrazol at 40 ppm, 11. Paclobutrazol at 60 ppm, 12. Paclobutrazol at 80 ppm and 13. Water spray (Control).

The experiment was laid out in randomized block design with three replications. The gross plot size was 3.0 x 2.1 m and the net plot size was 2.7 x 1.8 m. The spacing adopted was 30 x 30 cm. The treatments were imposed in the form of foliar sprays with a spray fluid volume of 250 ml on 30 DAT.

RESULTS AND DISCUSSION

Flower yield per plot exhibited significant differences due to spray of growth regulators/chemicals during both the seasons (Table 1). In **kharif**, spray of CCC at 3000 ppm recorded the highest number of flowers per plot (1710.7) which was significantly superior to spray of GA at 100 ppm (1684.3), whereas a minimum of 1217.8 flowers per plot were recorded by control. In **rabi**, spray of CCC at 3000 ppm was the most productive with 2243.5 flowers per plot significantly superior to the spray of GA at 100 ppm (2202.7 flowers/plot).

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Table 1. Flower yield parameters as influenced by planting geometry in garland chrysanthemum during kharif and rabi

Treatment	No. of flowers/ plant			No. of flowers/ plot			Flower yield/ plot (kg)			Flower yield/ha (t)		
	Kharif	**Rabi**	Mean	**Kharif**	**Rabi**	Mean	**Kharif**	**Rabi**	Mean	**Kharif**	**Rabi**	Mean
GA 50	35.09	45.89	40.49	1684.3	2202.7	1943.5	3.01	4.56	3.79	6.21	7.51	6.86
GA 100	32.63	42.07	37.35	1566.2	2019.4	1792.8	2.78	4.18	3.48	5.71	6.88	6.30
GA 150	28.59	35.81	32.20	1372.3	1718.9	1545.6	1.88	2.78	2.33	3.86	4.57	4.22
SA 50	33.7	43.17	38.44	1617.6	2072.1	1844.9	2.92	4.42	3.67	6.01	7.26	6.64
SA 100	33.46	43.36	38.41	1606.1	2081.3	1843.7	2.69	4.07	3.38	5.56	6.69	6.13
SA 150	30.98	39.52	35.25	1487.0	1897.0	1692.0	1.88	2.8	2.34	3.89	4.61	4.25
CCC 2000	35.64	46.74	41.19	1710.7	2243.5	1977.1	2.57	3.88	3.23	5.31	6.38	5.85
CCC 3000	33.18	42.93	38.06	1592.6	2060.6	1826.6	2.20	3.28	2.74	4.52	5.4	4.96
CCC 4000	31.63	40.53	36.08	1518.2	1945.4	1731.8	1.98	2.94	2.46	4.07	4.83	4.45
Paclobutrazol 40	30.18	38.28	34.23	1448.6	1837.4	1643.0	1.79	2.64	2.22	3.67	4.34	4.01
Paclobutrazol 60	29.8	37.69	33.75	1430.4	1809.1	1619.8	1.74	2.56	2.15	3.57	4.21	3.89
Paclobutrazol 80	25.37	30.83	28.10	1217.8	1479.8	1348.8	1.24	1.8	1.52	2.57	2.96	2.77
Control	31.68	40.56	36.12	1520.5	1946.7	1733.6	2.25	3.36	2.81	4.63	5.54	5.09
Mean	0.14	0.21	0.18	6.69	10.3	8.50	0.03	0.04	0.04	0.06	0.07	0.07
S. Em	0.41	0.63	0.52	19.54	30.06	24.80	0.08	0.12	0.10	0.16	0.20	0.18
C. D. (P=0.05)	35.09	45.89	40.49	1684.3	2202.7	1943.5	3.01	4.56	3.79	6.21	7.51	6.86

There were significant differences with respect to weight of flowers per plot among the different treatments during both the seasons. During **kharif**, spray of GA at 100 ppm recorded the highest weight of flowers per plot (3.01 kg) which was significantly superior to spray of GA at 150 ppm (2.78 kg), whereas a minimum of 1.24 kg flowers per plot was recorded by control. In **rabi**, spray of GA at 100 ppm was the most productive with 4.56 kg flowers per plot significantly superior to GA at 150 ppm (5.71 kg flowers per plot), while minimum weight of flowers (1.80 kg) was recorded by control.

The flower yield/ha exhibited significant differences among the various growth regulators/chemical sprays during both the seasons. During **kharif** GA at 100 ppm recorded the highest weight of flowers/ha (6.21 t) which was significantly superior to spray of GA at 150 ppm (5.71 t), whereas a minimum flower yield of 2.57 t/ha was recorded by control. In **rabi**, spray of GA at 100 ppm was the most productive with 7.51 t/ha flower yield which was significantly superior to GA at 150 ppm (6.88 t/ha), while minimum weight of flowers (2.96 t/ha) was recorded by control.

The seed yield per flower exhibited significant differences among the different growth regulators/chemical treatments during both the seasons (Table 2). The maximum seed yield per flower (219 and 251.8 mg) was recorded by the spray of GA 100 ppm. It was at par with GA at 150 ppm which recorded seed yield per flower as 212.4 and 244.2 mg as well as SA at 100 ppm with 211.9 and 243.7 mg, respectively, during **kharif** and **rabi** seasons.

The seed yield per plant differed significantly among the different growth regulator treatments during both the seasons. The maximum seed yield per plant (2.88 and 3.31 g) was recorded by the spray of GA 100 ppm which was at par with GA at 150 ppm (2.79 and 3.21 g) as well as SA at 100 ppm (2.79 and 3.21 g) during **kharif** and **rabi** seasons.

There were significant differences with respect to seed yield per plot among the different treatments during both the seasons. The maximum seed yield per plot (201.70 and 231.95 g) was recorded by the spray of GA 100 ppm which was at par with GA at 150 ppm (195.60 and 224.94 g) as well as SA at 100 ppm (195.20 and 214.13 g) during **kharif** and **rabi** seasons.

The flower diameter exhibited significant differences among the various growth regulators/chemical sprays during both the seasons (Table 3). During **kharif**, spray of GA at 100 ppm recorded the highest size of flowers having a diameter of 5.51 cm which was significantly superior to spray of GA at 150 ppm (5.34 cm), whereas a minimum flower diameter of 2.84 cm was recorded by control. In **rabi**, spray of GA at 100 ppm had the largest flowers with 6.17 cm flower diameter which was significantly superior to GA at 150 ppm (5.98 cm), while minimum diameter of flowers (3.18 cm) was recorded by control.

Significant differences were recorded in 100-flower weight among the different growth regulators/chemical sprays during both the seasons. During **kharif**, the heavier flowers were obtained by the treatment GA at

Table 2. Seed yield parameters as influenced by planting geometry in garland chrysanthemum during kharif and rabi

Treatment	Seed yield/flower (mg)			Seed yield/plant (g)			Seed yield/plot (g)		
	Kharif	**Rabi**	Mean	**Kharif**	**Rabi**	Mean	**Kharif**	**Rabi**	Mean
GA 50	202.3	232.7	217.5	2.66	3.06	2.86	186.33	214.28	200.31
GA 100	219.0	251.8	235.4	2.88	3.31	3.10	201.70	231.95	216.83
GA 150	212.4	244.2	228.3	2.79	3.21	3.00	195.60	224.94	210.27
SA 50	157.0	180.6	168.8	2.07	2.38	2.23	144.62	166.31	155.47
SA 100	211.9	243.7	227.8	2.79	3.21	3.00	195.20	224.48	209.84
SA 150	202.2	232.5	217.3	2.66	3.06	2.86	186.20	214.13	200.17
CCC 2000	154.1	177.2	165.7	2.03	2.33	2.18	141.95	163.24	152.60
CCC 3000	188.3	216.6	202.4	2.48	2.85	2.67	173.44	199.46	186.45
CCC 4000	170.3	195.8	183.0	2.24	2.58	2.41	156.83	180.35	168.59
Paclobutrazol 40	158.9	182.7	170.8	2.09	2.40	2.25	146.33	168.28	157.31
Paclobutrazol 60	148.2	170.5	159.4	1.95	2.24	2.10	136.54	157.02	146.78
Paclobutrazol 80	145.4	167.2	156.3	1.91	2.20	2.06	133.93	154.02	143.98
Control	112.9	129.9	121.4	1.49	1.71	1.60	104.00	119.60	111.80
Mean	175.6	202.0	188.8	2.31	2.66	2.49	161.74	186.01	173.88
S. Em	4.11	6.13	5.12	0.05	0.08	0.07	3.79	3.32	3.56
C. D. (P=0.05)	12.00	13.06	12.53	0.16	0.24	0.20	11.05	9.82	10.44

100 ppm with a 100-flower weight of 180.42 g, which was at par with SA at 100 ppm (178.83 g) and GA at 100 ppm (180.42 g). During **rabi** the highest value of 100-flower weight (220 g) was recorded by GA at 100 ppm.

The differences recorded in 1000-seed weight among the different treatments with growth regulators/ chemicals were found significant during both the seasons. The maximum 1000-seed weight (1.37 and 1.58 g) was recorded by the spray of GA 100 ppm which was at par with GA at 150 ppm (1.34 and 1.53 g) as well as SA at 100 ppm (1.34 and 1.53 g) during **kharif** and **rabi** seasons.

There was an increase in the flower yield as well as seed yield per plant by the foliar application of growth regulating chemicals viz., GA, CCC, SA and paclobutrazol, when compared to control. The result on weight of flowers per plot showed that the maximum yield enhancing ability was shown by GA at 100 ppm. There was no addition in the yield of garland chrysanthemum by increasing the concentration of GA beyond 100 ppm. Chakradhar and Khiratkar (1) reported an increase in flower yield per plant by the application of GA on rose plants, which was attributed to better translocation of assimilates to the site of bud development, leading to maximum number of buds converting into flower buds. In the present study, GA at 100 ppm had not shown maximum number of flowers per plant but due to the maximum mean weight of flowers (Table 1), it recorded maximum yield in terms of weight of flowers per ha.

An increase in the concentration of CCC had increased the number of flowers per plant. Foliar spray of cycocel at 3000 ppm recorded a higher number of flowers per plant, when compared to other concentrations. But their average weight being relatively lesser, they were making a gross weight of flowers per ha only next to gibberellic acid at 100 ppm. Both increase and decrease in the concentration had not resulted in increase in either number of flowers per plant or mean flower weight. The increase in number of flowers per plant with the application of CCC was attributed to increased mobilization of bio-mass to flowers from sources in China aster. Enhancement of flower production in daisy due to the application of CCC was attributed to the retardation of vegetative growth (8).

SA spray at 100 ppm resulted in significant increase in flower and seed yield when compared to other concentrations. Though there was a slight increase in yield with SA at 150 ppm, it was not statistically significant. Foliar spray of SA increased the number of flowers per plant in chrysanthemum (7) and China aster (10).

Paclobutrazol at 40 ppm recorded a higher number of flowers per plant compared to other higher concentrations of 60 and 80 ppm. Increase in concentration of paclobutrazol spray reduced the number of flowers per plant in china aster as reported by Mishra and Mishra (6), who attributed that it was the increased number of branches that led to the improvement in the number of flowers per plant due to paclobutrazol spray at optimum concentration.

Table 3. Flower and seed quality parameters as influenced by planting geometry in garland chrysanthemum during kharif and rabi

Treatment	Flower diameter (cm)		100-flower weight (g)		1000-seed weight (g)	
	Kharif	**Rabi**	**Kharif**	**Rabi**	**Kharif**	**Rabi**
GA 50	5.09	5.70	169.46	198.32	1.27	1.46
GA 100	5.51	6.17	180.42	220.00	1.37	1.58
GA 150	5.34	5.98	177.25	206.85	1.34	1.53
SA 50	3.95	4.42	136.70	161.61	0.98	1.13
SA 100	5.33	5.97	178.83	200.49	1.34	1.53
SA 150	5.09	5.70	167.78	195.46	1.27	1.46
CCC 2000	3.88	4.34	126.72	147.43	0.97	1.11
CCC 3000	4.74	5.31	150.52	172.84	1.18	1.36
CCC 4000	4.28	4.80	137.87	159.02	1.07	1.23
Paclobutrazol 40	4.00	4.48	130.11	151.04	1.00	1.14
Paclobutrazol 60	3.73	4.18	123.35	143.56	0.93	1.07
Paclobutrazol 80	3.66	4.10	121.39	141.37	0.91	1.05
Control	2.84	3.18	102.16	121.44	0.71	0.81
Mean	4.42	4.95	146.35	170.73	1.10	1.27
S. Em	0.02	0.02	1.30	1.53	0.01	0.02
C. D. (P=005)	0.05	0.06	3.79	4.45	0.03	0.05

Swaminathan *et al.* (11) observed that paclobutrazol at higher dose resulted in lower flower production, whereas at lower doses, significantly increased flower yield in jasmine. Lower doses of paclobutrazol were thought to be enough in annual flowering plants like marigold for inhibition of gibberellin bio-synthesis and retardation of vegetative growth thereby redirecting the metabolites towards reproductive development.

Flower quality in terms of average flower weight, flower diameter and seed quality in terms of test weight was also at maximum by the application of GA at 100 ppm. Not only yield, but the quality parameters also did not show any increase by a higher concentration of GA more than 100 ppm. Thus, it can be assumed that the optimum concentration of GA for application through foliar spray is 100 ppm on garland chrysanthemum. Increase in weight of flower in treated plants may be attributed to the fact that GA promoted the efficacy of plants in terms of photosynthetic activity, enhanced the uptake of nutrients and their translocation, better partitioning of assimilates into reproductive parts. These results are in agreement with those reported by Rakesh *et al.* (9), Deotale *et al.* (2) and Dutta *et al.* (14) in chrysanthemum. Increase in cell size due to GA might have increased the diameter of flower as stated by Madhumita and Paswan (5). SA at 100 ppm significantly increased the flower diameter compared to lower level but further increase in the concentration did not show significant improvement in the diameter. In case of CCC, the concentration of 3000 ppm resulted in a higher mean flower weight but increased concentration resulted in a significant decrease in the mean flower weight. The other growth retarding chemical paclobutrazol also showed a decrease in flower weight due to increase in the concentration from 40 to 80 ppm. Thus, in the present study, the optimum concentrations found were 100 ppm both for GA and SA, 3000 ppm for CCC and 40 ppm for paclobutrazol. Though the number of flowers was higher with the foliar application of CCC and paclobutrazol, the gross weight of flowers per unit area was recorded at lower levels compared to GA and SA. Flower diameter and 1000-seed weight also followed the similar trends of being significantly higher at 100 ppm in case of GA and SA, 3000 and 40 ppm in case of CCC and paclobutrazol, respectively.

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Haryana J. hortic. Sci., **41** (3 & 4) : 117-120 (2012)

Effect of Modified Atmosphere on Physiology and Shelf Life of Guava (*Psidium guajava* L.) cv. Hisar Safeda and L-49 Fruits

C. BISHNOI, R. K. SHARMA AND S. SIDDIQUI[1]

Department of Horticulture, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India
(e-mail : chetak29@gmail.com)

ABSTRACT : The experiment was conducted to study the effect of different durations of modified atmosphere on the ripening behaviour of guava under ambient conditions. Uniform size fruits of guava cvs. Hisar Safeda and L-49 were harvested at green mature stage, packed in imperforated polyethylene bags to create modified atmosphere (MA) passively and stored at 8°C for 1-4 days. After respective durations of storage under MA, fruits were removed from MA and packed in corrugated fiber board (CFB) boxes and further stored at ambient temperature conditions (28±5°C, 85±5% RH) and sampled at regular intervals. It was observed that loss in weight and decay loss increased, whereas ripening percentage, fruit firmness and specific gravity decreased with the increase in storage in both the cvs. Hisar Safeda and L-49 (Sardar). Fruits stored in MA for > 3 days did not ripe and showed "Cricket ball" syndrome, where the fruits remained green but excessively hard. The fruits stored for two days under MA at 8°C and then under ambient conditions showed shelf life enhancement by two days.

Key words : Guava, modified atmosphere, shelf life, cricket ball syndrome

Guava 'Apple of tropics' [*Psidium guajava* L.] is a popular fruit, grown successfully throughout tropical and sub-tropical regions of India. In Haryana, area under guava cultivation is 5546 ha with an annual production of 57,000 t (1). It is a rich source of vitamin C and pectin. Being highly perishable, fruits have to be marketed immediately after harvest. Packing of fruits in sealed polybags is the simplest way to attain MA (9) and enhance shelf life of fruits. However, guava when packed in sealed polythene bags (LDPE) for longer durations at low temperature, does not ripen and results in cricket ball syndrome (2), where the fruits remain green, very hard and do not ripen. Therefore, a systematic study was conducted to find out the effect of various durations of MA on shelf life of rainy season guava cv. L-49 and Hisar Safeda to avoid development of cricket ball syndrome.

MATERIALS AND METHODS

The fruits of guava (*Psidium guajava* L.) cv. L-49 and Hisar Safeda were harvested from rainy season crop at green mature stage, packed in sealed unperforated polyethylene bags of thickness 300 gauge to create modified atmosphere passively (MA) and stored at 8°C in B. O. D. incubator for 1, 2, 3 and 4 days. After respective durations of storage under MA at 8°C, fruits were removed from MA and packed in corrugated fiber board (CFB) and stored at ambient temperature conditions (28±5°C, 85±5% RH). Control fruits were packed directly in CFB boxes. Fruits were sampled at every day for various parameters. Physiological loss in weight (PLW) was calculated on the basis of loss in weight over the initial weight. Flesh firmness was measured by pressure tester (Basic force gauge, England) fitted with a cylindrical plunger of 1.8 cm in diameter. Fruit ripening percentage was calculated on the basis of colour change. The fruits which turned yellow or light yellow were considered as ripened. Decay loss was recorded by counting the number of spoiled fruits out of the calculated number of fruits stored during initial day of experiment. The data were statistically designed using completely randomized design and critical differences (C. D.) were calculated at 5% level of significance.

RESULTS AND DISCUSSION

The physiological loss in weight (PLW) of fruits increased with progressive increase in storage period (Table 1). Lower PLW during storage at ambient conditions was observed in fruits stored for longer duration under modified atmosphere (MA) conditions. Control fruits exposed to 0-day MA maintained threshold value of PLW < 10% up to 2nd day of storage, while this was maintained up to 3rd and 4th day and 7th day in fruits exposed to MA for 1, 2 and 3 days, respectively. Overall PLW throughout the storage period was higher in cv. Hisar Safeda as compared to cv. Lucknow-49. The increase in PLW of guava during storage was reported by other worker also (11). After MA storage, the lower magnitude of PLW during storage under ambient conditions could be due to the persistence of reduced respiration rate of the fruit

[1]Centre of Food Science and Technology.

Table 1. Effect of modified atmosphere (MA) on PLW (%) of different cultivars of guava fruits during storage

MA (days)	Total period of storage (days)*							
	1	2	3	4	5	6	7	8
				Hisar Safeda				
0	1.30	7.55	13.28	18.35	25.45	28.98	34.35	39.93
1	-	2.15	9.25	13.13	18.50	23.85	29.75	35.00
2	-	-	3.30	9.48	15.80	18.45	21.75	26.50
3	-	-	-	4.43	6.25	7.98	9.75	11.75
4	-	-	-	-	4.65	6.00	6.98	8.48
C. D. (P=0.05)	-	1.99	1.72	1.63	0.90	1.34	1.44	1.63
				Lucknow-49				
0	1.43	4.03	8.73	12.98	17.98	22.95	27.50	32.50
1	-	1.60	6.78	12.03	16.85	22.00	25.50	31.75
2	-	-	2.10	6.00	13.30	17.23	21.73	26.00
3	-	-	-	3.90	5.88	6.38	8.50	9.40
4	-	-	-	-	3.40	4.85	5.70	6.80
C. D. (P=0.05)	-	0.67	0.95	1.02	1.50	1.39	1.14	1.33

*Storage temperature under MA ~8^{0}C and after opening of bags ~28^{0}C; - Treatment did not exist.

because of MA effect.

The flesh firmness of fruits decreased progressively with increase in storage period (Table 2). The decrease in flesh firmness was slower and of lesser magnitude for fruits exposed for longer duration of MA. Fruits exposed to MA for longer than three days remained firm and hard (firmness more than 36 kg/cm^2) even by total eight days of storage, however, fruits exposed to lesser durations of MA resulted in firmness lesser than 9 kg/cm^2. The maintenance of flesh firmness throughout the storage period was higher in cv. Lucknow-49 than cv. Hisar Safeda. Maintenance of excessive hardening of fruits stored for more than three days in MA could possibly be due to gelling behaviour of water soluble pectins, which got reconstituted to form protopectin under MA conditions and led to flesh hardening on prolonged storage (8, 10).

There was no ripening observed in all the treatments

Table 2. Effect of modified atmosphere (MA) on flesh firmness (kg/cm^2) of different cultivars of guava fruits during storage

MA (days)	Total period of storage (days)*									
	0	1	2	3	4	5	6	7	8	Mean
						Hisar Safeda				
	48.50	33.25	24.25	13.25	8.75	9.00	7.55	7.25	7.00	17.64
1	(48.50)	*49.25*	37.00	28.25	13.50	10.25	8.50	7.00	6.25	23.17
2	(48.50)	(49.25)	*50.75*	41.00	34.50	27.00	17.00	10.00	8.50	31.83
3	(48.50)	(49.25)	(50.75)	*54.00*	53.00	49.75	44.75	39.25	35.75	47.22
4	(48.50)	(49.25)	(50.75)	(54.00)	54.00	53.50	54.25	50.25	50.50	51.67
Mean	48.50	46.05	42.70	38.10	32.75	29.90	26.41	22.75	21.60	
C. D. (P=0.05)				MA = 1.05; Storage = 1.41 MA x Storage = 3.15						
						Lucknow-49				
0	*54.25*	37.25	29.00	14.75	11.00	8.50	6.75	6.50	7.25	19.47
1	(54.25)	*54.50*	37.00	30.50	17.50	9.75	7.50	7.25	6.25	24.94
2	(54.25)	(54.50)	*54.75*	42.50	33.25	21.00	17.00	10.00	8.00	32.81
3	(54.25)	(54.50)	(54.75)	*57.25*	55.25	48.75	49.00	42.25	41.25	50.81
4	(54.25)	(54.50)	(54.75)	(57.25)	59.25	58.75	57.00	56.00	53.00	56.08
Mean	54.25	51.05	46.05	40.45	35.25	29.35	27.45	24.40	23.15	
C. D. (P=0.05)				MA = 0.97; Storage = 1.30; MA x Storage = 2.90						

*Storage temperature under MA ~8^{0}C and after opening of bags ~28^{0}C. Figures in parentheses are assumed values (equivalent to previously analysed italicized value in the column), taken into considerations for the purpose of statistical analysis only.

Table 3. Effect of modified atmosphere (MA) on ripening (%) of different cultivars of guava fruits during storage

MA (days)	Total period of storage (days)*								
	0	1	2	3	4	5	6	7	8
					Hisar Safeda				
0	-	-	-	18.40	38.78	79.83	100.00	100.00	100.00
					(38.49)	(63.48)	(90.00)	(90.00)	(90.00)
1	-	-	-	-	17.30	37.30	78.53	100.00	100.00
					(24.51)	(37.62)	(62.38)	(90.00)	(90.00)
2	-	-	-	-	0.00	15.33	36.10	74.48	100.00
					(4.05)	(23.04)	(36.91)	(59.00)	(90.00)
3	-	-	-	-	0.00	0.00	0.00	7.75	11.75
					(4.05)	(4.05)	(4.05)	(16.00)	(19.91)
4	-	-	-	-	0.00	0.00	0.00	0.00	0.00
					(4.05)	(4.05)	(4.05)	(4.05)	(4.05)
C. D. (P=0.05)					2.40	1.40	2.15	1.40	1.67
					Lucknow-49				
0	-	-	-	19.25	44.08	88.58	100.00	100.00	100.00
					(41.57)	(70.28)	(90.00)	(90.00)	(90.00)
1	-	-	-	-	23.75	51.25	83.50	100.00	100.00
					(29.89)	(45.71)	(66.22)	(90.00)	(90.00)
2	-	-	-	-	0.00	19.43	45.75	71.75	100.00
					(4.05)	(26.11)	(42.54)	(57.90)	(90.00)
3	-	-	-	-	0.00	0.00	0.00	8.75	15.00
					(4.05)	(4.05)	(4.05)	(17.00)	(22.04)
4	-	-	-	-	0.00	0.00	0.00	0.00	0.00
					(4.05)	(4.05)	(4.05)	(4.05)	(4.05)
C. D. (P=0.05)					2.82	3.02	3.37	2.52	2.26

*Storage temperature under MA ~8^{0}C and after opening of bags ~28^{0}C. Figures in parentheses denote the angular transformed values. - indicates no decay loss.

up to 2nd day of storage (Table 3). Control fruits (0-day MA) started ripening from 3rd day and were 100% ripened by 6th day of storage. The ripening was little faster in cv. Lucknow-49 than cv. Hisar Safeda. The ripening in both the cultivars was delayed by exposing the fruits to MA. However, there was little or no ripening observed throughout the storage period in fruits stored under MA for ≥ 3 days. This delayed ripening observed in the present investigation could be due to decreased metabolic processes under elevated CO_2 level and reduced O_2 level in the MA storage condition (4, 5). At longer durations of exposure of fruits under MA, the toxic effect of CO_2 probably had reached to the level where repair was not possible and hence the fruits could not ripen (6, 10).

There was no decay loss observed in any of the treatment up to 4th day of storage and later, it increased with increasing storage periods (Table 4). Control fruits for both the cultivars showed total decay by 8th day of storage, as the fruits over-ripened, turned excessively soft and were thus highly susceptible to infestation by microbes. The decay loss was either not observed or observed to be lesser extent when the fruits were stored under MA for ≥ 3 days, due to delayed ripening, maintenance of higher firmness and presence of unfavourable conditions like reduced oxygen availability and high CO_2 inside the package. The elevated levels of CO_2 have been reported to delay growth of aerobic and anaerobic micro-organisms present on the fruit surface (3). The decreased decay loss in guava fruits wrapped by polyethylene bags was also reported by Jitender Kumar *et al.* (6).

From the results obtained from the present investigation it can be concluded that exposure of fruits for ≤ 2 days to MA resulted in enhanced shelf life of fruits when further stored under ambient conditions. Exposure to MA for three days resulted in development of “cricket ball” syndrome in guava, where the fruits remained green, hard and did not ripe.

Table 4. Effect of modified atmosphere (MA) on decay loss (%) of different cultivars of guava fruits during storage

MA (days)	Total period of storage (days)*								
	0	1	2	3	4	5	6	7	8
						Hisar Safeda			
0	-	-	-	-	-	29.93 (33.11)	49.25 (44.52)	78.50 (62.41)	100.00 (90.00)
1	-	-	-	-	-	5.57 (13.76)	13.00 (21.05)	30.00 (33.17)	59.50 (50.47)
2	-	-	-	-	-	0.00 (4.05)	0.00 (4.05)	16.50 (23.93)	33.25 (35.19)
3	-	-	-	-	-	0.00 (4.05)	0.00 (4.05)	5.50 (13.41)	17.00 (24.14)
4	-	-	-	-	-	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	7.50 (20.79)
C. D. (P=0.05)						1.60	2.34	2.16	2.94
						Lucknow-49			
0	-	-	-	-	-	20.75 (27.06)	51.03 (45.51)	76.25 (60.85)	100.00 (90.00)
1	-	-	-	-	-	10.48 (18.84)	28.85 (32.46)	65.75 (54.12)	91.25 (75.09)
2	-	-	-	-	-	0.00 (4.05)	8.50 (16.36)	26.25 (30.73)	49.75 (44.84)
3	-	-	-	-	-	0.00 (4.05)	0.00 (4.05)	8.00 (16.30)	12.50 (20.65)
4	-	-	-	-	-	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	6.00 (16.36)
C. D. (P=0.05)						1.40	2.34	2.77	7.35

*Storage temperature under MA ~8^{0}C and after opening of bags ~28^{0}C. Figures in parentheses denote the angular transformed values. - indicates no decay loss.

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Haryana J. hortic. Sci., **41** (3 & 4) : 121-125 (2012)

Standardization of Sweet Orange Squash and its Storage

C. N. BYANNA AND I. N. DOREYAPPA GOWDA[1]
Department of Horticulture, University of Agricultural Sciences, G. K. V. K., Bengaluru-560 065 (Karnataka), India

ABSTRACT : The experiment comprised three treatments of squash recipes containing varying juice percentages of 25, 30 and 35 with fixed TSS of 40° Brix and 1.0% acidity in factorial completely randomised design replicated five times. The squash with 35% juice, 40°Brix and 1.0% acidity exhibited significantly highest score for colour, consistency, flavour and overall acceptability up to six months of storage. The TSS, acidity, reducing sugars, non-enzymatic browning increased, while pH, total sugars, non-reducing sugars, ascorbic acid and antioxidant activity decreased in all the treatments at different storage intervals.

Key words : Sweet orange, sathgudi, squash, antioxidant activity, storage, sensory analysis

Citrus fruits are very popular for their refreshing taste and flavour and they occupy 10% of the total area under fruits. Sweet oranges are present in 20% of total citrus area. Sweet oranges are the second largest group of citrus fruits cultivated in the country. Maximum area under sweet oranges is in Andhra Pradesh followed by Maharashtra and Karnataka states (9). Most of the commercially produced fruits are used for fresh consumption and a small quantity is utilized for fresh juice extraction. Their utilization as processed products is very meagre, even though the juice is rich in vitamin C, sugars, acids and minerals. It also contains neutraceuticals such as carotenoids, limonoids, flavonones and vitamin B complex (6) which are known for their health promoting properties. During peak season of production, farmers are forced to sell the fresh produce at a very low price due to limited demand. Processing of these fruits into squash or any other type of processed products would benefit both the producers and the consumers. Hence, an investigation was undertaken to develop recipe for squash and to study storage stability.

MATERIALS AND METHODS

The experiment on standardization of recipe for preparation of sweet orange squash was carried out in the Processing Laboratory of the Division of Post Harvest Technology, Indian Institute of Horticultural Research, Bengaluru from November 2008 to June 2009. Sweet orange fruits (var. Sathgudi) of optimum maturity and colour were procured from the farmers gardens in Anantapur district, Andhra Pradesh and these were washed in potable running water and 20 fruits were selected at random and their physico-chemical parameters were studied. The fruits were peeled using stainless steel knives. Albedo portion was removed, the juice sacs were separated from segments and blended in a mixer. The juice obtained was filtered through muslin cloth. The TSS and titratable acidity were estimated in the juice and then squash with different treatments containing 25% juice, TSS of 40° Brix and 1.0% acidity, 30% juice, TSS of 40°Brix and 1.0% acidity and 35% juice, TSS of 40° Brix and 1.0% acidity were prepared. The required quantities of juice, cane sugar, water and citric acid were calculated. Strained fruit juice and freshly prepared sugar syrup were mixed together in the proportion as per the recipes on weight basis. Finally, potassium metabisulphite (350 ppm) was added to the product to prevent spoilage. The prepared squash was filled into PET bottles of 1 litre capacity. The bottles were sealed with food grade paraffin film and closed tightly with caps to avoid spoilage, bottles were labelled and stored at ambient conditions. Chemical analysis and sensory evaluation of the squash were carried out at 0, 3 and 6 months after storage. The sensory evaluation was performed by a panel of 10 judges having maximum score 30 for colour, 30 for consistency and 40 for taste and flavour with over all acceptability score of 100. Total soluble solids (TSS) of the juice were measured using hand Refractometer (Erma), pH was determined using Elico digital pH meter. Titratable acidity, ascorbic acid, reducing sugars and total sugars were estimated using the method suggested by Ranganna (10, 11). Non-reducing sugars were obtained by deducting the value for reducing sugars from total sugars. Antioxidant activity was estimated using the methodology given by Leong and Shui (7). The data collected from the three treatments with five replications were analysed using factorial completely randomised design by a method given by Sundar Raj *et al*. (14).

[1]Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bengaluru-560 089 (Karnataka), India.

RESULTS AND DISCUSSION

The average fruit weight was 200 g, horizontal and vertical diameter of fruit was 63.61 and 66.06 mm, respectively. Number of segments per fruit was 10.58 and average segment weight was 10.58 g. Peel thickness and peel weight were 3.55 mm and 32.08 g, respectively. The juice recovery was 46.00% (Table 1). Fruit juice had total soluble solids of 10.1^{0}Brix with a pH of 3.66 titratable acidity of 0.81% and ascorbic acid of 69.30 mg per 100 g (Table 2).

Table 1. Physical parameters of sweet orange (var. Sathgudi) fruits

S. No.	Parameters	Observation
1.	Weight (g)	200
2.	Horizontal diameter (mm)	63.61
3.	Vertical diameter (mm)	66.06
4.	No. of segments/fruit	10.58
5.	Segment weight (g)	10.58
6.	Peel thickness (mm)	3.55
7.	Peel weight/fruit (g)	32.08
8.	Juice recovery (%)	46.00

Table 2. Chemical composition of sweet orange var. Sathgudi

S. No.	Parameters	Observation
1.	Total soluble solids (^{0} Brix)	10.10
2.	pH	3.66
3.	Titratable acidity (% citric acid)	0.81
4.	Ascorbic acid (mg/100 g)	69.30

Significantly higher TSS was found in squash with 35% juice compared to least in 25% juice (Table 3). Significant increase in TSS in all the treatments during storage was due to solubility of juice constituents during storage and degradation of starch and pectin substances into simple sugars by hydrolysis of polysaccharides and also increased titratable acidity. Jadhav *et al.* (2) reported similar results in kokum squash.

Squash with 35% juice showed higher pH compared to least in 25% juice (Table 3). The pH decreased in all the recipes during storage due to simultaneous increase in titratable acidity which is in agreement with the results reported by Sogi and Singh (13) in sweet orange squash.

Squash with 35% juice showed higher acidity than other recipes due to release of more acid from higher juice content. Significant increase of acidity in all the treatments during storage (Table 3) was due to release of acid from sweet orange juice. Similar results were reported by Sogi and Singh (13) in sweet orange squash.

Reducing sugars were maximum in squash with 30% juice, while least were in 35% juice (Table 4). Significant increase in reducing sugars in all the recipes during storage was due to conversion of non-reducing sugars to reducing sugars by hydrolysis. Similar findings were reported by Jain *et al.* (3) in aonla squash and Sogi and Singh (13) in sweet orange squash.

Squash with 35% juice recorded higher non-reducing sugars than other recipes. Decrease in non-reducing sugars was in all the treatments during storage due to inversion of non-reducing sugars to reducing sugars by acids (Table 4). The results are in line with the observations made by Jain *et al.* (3). Squash with 35% juice showed highest non-reducing sugars at 0 day compared to other recipes due to higher juice content. Squash with 35 and 30% juice showed higher total sugars compared to 25% juice due to higher juice concentration (Table 4). Total sugars decreased in all the recipes during storage due to reaction of sugars with amino acids for their involvement in non-enzymatic browning. Similar results were reported by Kumar and Manimegalai (4) in strawberry squash.

Squash with 35% juice showed higher ascorbic acid, while least in 25% juice due to more ascorbic acid coming from the higher juice content. Loss of ascorbic acid during storage might be due to oxidation by entrapped oxygen in PET bottles by formation of dehydro-ascorbic acid and storage temperature (Table 5). This result is in agreement with the results of Sogi and Singh (13), and Kumari Karuna *et al.* (5). Squash with 35% juice recorded highest ascorbic acid at 0 day and least was found in 25% juice at all storage intervals due to higher juice content.

Squash with 35% juice showed higher antioxidant activity, compared to least in 25% juice (Table 5). Higher juice in squash had contributed to higher antioxidant activity. During storage of squash, an increase in antioxidant activity was recoded up to 90th day of storage and declined later. Similar results were reported by Piga *et al.* (8) in mandarin and Satsuma fruits and Guizhi Zhang *et al.* (1) in apple and apple juice. Squash with 35% juice on 90th day of storage showed maximum antioxidant activity, compared to least in 25% juice at 180th day of storage. It might be attributed to higher amount of antioxidants coming from the higher quantity of juice used (35% juice).

Minimum NEB was recorded in squash with 25% juice. NEB might be due to reaction of ascorbic acid

Table 3. TSS, pH and titratable acidity of sweet orange squash during storage

Treatment	TSS °B				pH				Titratable acidity (%)			
	Storage (days)											
	0	90	180	Mean	0	90	180	Mean	0	90	180	Mean
Squash with 25% juice, 40 ^{0}brix TSS, acidity 1%	40.00	40.37	40.93	40.43	2.83	2.73	2.54	2.70	1.01	1.16	1.31	1.16
Squash with 30% juice, 40 ^{0}brix TSS, acidity 1%	40.50	40.83	41.20	40.84	2.93	2.87	2.66	2.82	1.00	1.14	1.29	1.14
Squash with 35% juice, 40 ^{0}brix TSS, acidity 1%	41.00	41.50	41.60	41.37	2.92	2.86	2.71	2.83	1.02	1.16	1.32	1.17
Mean	40.50	40.90	41.24	-	2.89	2.82	2.64	-	1.01	1.15	1.31	-
	F test	S. Em±	C. D. at 5%	-	F test	S. Em±	C. D. at 5%	-	F test	S. Em±	C. D. at 5%	-
Treatments (A)	*	0.125	0.371	-	*	0.002	0.007	-	*	0.003	0.007	-
Storage (B)	*	0.125	0.371	-	*	0.002	0.007	-	*	0.003	0.007	-
A x B	NS	0.216	-	-	*	0.004	0.011	-	NS	0.004	-	-

*Significant at P=0.05 level. NS–Not Significant.

Table 4. Reducing sugars, non-reducing sugars and total sugars of sweet orange squash during storage

Treatment	Reducing sugars (%)				Non-reducing sugars (%)				Total sugars (%)			
	Storage (days)											
	0	90	180	Mean	0	90	180	Mean	0	90	180	Mean
Squash with 25% juice, 40 ^{0}brix TSS, acidity 1%	29.89	31.50	32.00	31.13	4.61	2.10	0.90	2.54	34.50	33.60	32.90	33.67
Squash with 30% juice, 40 ^{0}brix TSS, acidity 1%	30.00	32.45	32.83	31.76	4.70	1.35	0.62	2.22	34.70	33.80	33.40	33.97
Squash with 35% juice, 40 ^{0} brix TSS, acidity 1%	29.50	30.55	31.22	30.42	5.30	3.35	1.75	3.47	34.80	33.90	33.30	34.00
Mean	29.80	31.50	32.02	-	4.87	2.27	1.09	-	34.67	33.77	33.20	-
	F test	S. Em±	C. D. at 5%	-	F test	S. Em±	C. D. at 5%	-	F test	S. Em±	C. D. at 5%	-
Treatments (A)	*	0.100	0.297	-	*	0.113	0.336	-	*	0.058	0.173	-
Storage (B)	*	0.100	0.297	-	*	0.113	0.336	-	*	0.058	0.173	-
A x B	*	0.173	0.514	-	*	0.196	0.582	-	NS	0.101	-	-

*Significant at P=0.05 level. NS–Not Significant.

Table 5. Ascorbic acid, antioxidant activity and non-enzymatic browning of sweet orange squash during storage

Treatment	Ascorbic acid (mg/100 g)				Antioxidant acitvity (mg/100 ml)				Non-enzymatic browning (OD at 440 nm)			
	Storage (days)											
	0	90	180	Mean	0	90	180	Mean	0	90	180	Mean
Squash with 25% juice, 40 ^{0}brix TSS, acidity 1%	13.30	11.00	9.50	11.27	37.46	39.55	21.07	32.69	0.042	0.057	0.089	0.063
Squash with 30% juice, 40 ^{0}brix TSS, acidity 1%	14.25	12.20	10.25	12.23	37.57	41.72	22.50	33.93	0.050	0.070	0.132	0.084
Squash with 35% juice, 40 ^{0}brix TSS, acidity 1%	15.30	13.95	12.92	14.06	38.68	42.85	23.09	34.87	0.060	0.077	0.142	0.093
Mean	14.28	12.38	10.89	-	37.90	41.37	22.22	-	0.051	0.068	0.121	-
	F test	S. Em±	C. D. at 5%	-	F test	S. Em±	C. D. at 5%	-	F test	S. Em±	C. D. at 5%	-
Treatments (A)	*	0.024	0.071	-	*	0.051	0.150	-	*	0.002	0.006	-
Storage (B)	*	0.024	0.071	-	*	0.051	0.150	-	*	0.002	0.006	-
A x B	*	0.041	0.123	-	*	0.088	0.261	-	*	0.004	0.011	-

*Significant at P=0.05 level.

Table 6. Organoleptic qualities of sweet orange squash during storage

Treatment	Colour				Consistency				Flavour				Overall acceptability			
	Storage period (days)															
	0	90	180	Mean	0	90	180	Mean	0	90	180	Mean	0	90	180	Mean
Squash with 25% juice, 40 ^{0}brix TSS, acidity 1%	23.10	20.40	15.30	19.60	23.50	22.10	18.10	21.23	26.80	24.80	23.00	24.87	73.40	67.30	56.50	65.73
Squash with 30% juice, 40 ^{0}brix TSS, acidity 1%	23.40	20.20	15.10	19.57	25.30	24.00	21.00	23.43	28.50	26.10	24.10	26.23	77.20	70.30	60.20	69.23
Squash with 35% juice, 40 ^{0}brix TSS, acidity 1%	23.00	20.10	17.30	20.13	27.00	25.50	23.60	25.37	30.00	26.90	24.80	27.23	80.00	72.50	65.50	72.67
Mean	23.17	20.23	15.90	-	25.27	23.87	20.90	-	28.43	25.93	23.97	-	76.87	70.03	60.73	-
	F test	S. Em±	C. D. at 5%	-	F test	S. Em±	C. D. at 5%	-	F test	S. Em±	C. D. at 5%	-	F test	S. Em±	C. D. at 5%	-
Treatments (A)	NS	0.620	-	-	*	0.239	0.673	-	*	0.446	1.255	-	*	0.880	2.476	-
Storage (B)	*	0.620	1.745	-	*	0.239	0.673	-	*	0.446	1.255	-	*	0.880	2.476	-
A x B	NS	1.075	-	-	NS	0.415	-	-	NS	0.773	-	-	NS	1.525	-	-

*Significant at P=0.05 level. NS–Not Significant.

and sugars giving rise to furfural which may polymerize and combine with amino compounds. NEB was increased up to six months of storage (Table 5). Similar result of browning in citrus juice during storage was reported by Sandhu and Singh (12). The squash with 35% juice showed higher NEB values at all storage intervals due to higher juice concentration.

The results of organoleptic qualities of sweet orange squash are presented in Table 6. During storage, colour scores of squash declined due to oxidative loss of pigments and non-enzymatic browning. Similar results of decreased colour scores were reported by Jadhav *et al.* (2) and Sogi and Singh (13).

Squash with 35% juice showed higher consistency scores compared to least in 25% juice. Higher consistency scores were attributed to higher juice content and cloudiness. Consistency scores decreased in all the recipes during storage due to change in juice composition and reduction of viscosity during storage. Similar results were reported by Jadhav *et al.* (2).

Squash with 35% juice recorded higher flavour score and least was noted in 25% juice. Higher flavour score was associated with higher juice content due to presence of more volatile aromatic compounds. Decrease in flavour scores during storage was due to loss of volatile aromatic constituents. Similar results were reported by Sogi and Singh (13) and Jadav *et al.* (2).

Squash with 35% juice recorded better overall acceptability score than other recipes due to higher colour, consistency and flavour scores. Overall acceptability scores decreased in all the treatments during storage due to decline in colour, consistency and flavour scores. Similar results were reported by Sogi and Singh (13) and Jadhav *et al.* (2).

Good quality sweet orange squash can be prepared using 35% juice, TSS of 40^0 Brix and acidity 1.0% with good sensory scores and overall acceptability along with better chemical properties.

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Haryana J. hortic. Sci., **41** (3 & 4) : 126-128 (2012)

Studies on Utilization of Date Palm Fruits for Preparation of Delicious Drink

R. S. SINGH*, GARIMA PAL AND R. BHARGAVA
Central Institute for Arid Horticulture, Bikaner-334 006 (Rajasthan), India
**(e-mail : rssingh1@yahoo.com)*

ABSTRACT : Date palm (*Phoenix dactylifera* L.) is a nutritious fruit having high calorific value in the form of sugar, minerals and vitamins with high market potential. The ripe fruits (*doka* or *khalal*) are used for fresh consumption and value addition. Date fruit pulp is used for flavouring the bakery products. In India, date palm fruits are harvested during mid-June to July at *doka* or *khalal* stage (hard ripe yellow, red or dark red colour) of maturity because of early rains. Besides, it is spoiled due to poor shelf life. In India, limited work has been carried out on post-harvest management for proper utilization of fruits. Keeping in view, an attempt was made to utilize *doka* stage date palm fruits for preparation of delicious drink. The small size fruits, which are astringent in taste, unfit for dry date and *pind khajoor* preparation could be successfully utilized for the preparation of delicious drink. Organoleptic score revealed that squash could be prepared from doka stage fruits and utilized up to 30 days of storage under refrigerator. However, it fermented after 4-5 days of storage under room temperature condition.

Key words : Date palm, *Phoenix dactylifera*, value addition, fruit quality, squash, storage

Date palm (*Phoenix dactylifera* L.) is a potential fruit tree for semi-arid and hot arid regions of the country. Date fruit is a highly nutritious and favourite fruit throughout the country. Besides fresh consumption, several value added products viz., dry dates (*chhuhara*), soft date (*pind khajoor*), jam, beverages, biscuit, chutney, pickle, etc. are prepared from fruits (8). This fruit can supplement the dietary needs of the desert people, where very less nutritious food is available. Dates are cured as dry dates and soft dates, which have great demand and market in the country. Date fruits provide abundant quantities of sugar, iron, potassium, calcium and nicotinic acid. Small amounts of protein, copper, magnesium, chlorine, sulphur, vitamins A, B_1 and B_2 are also present in date pulp. Fresh 100 g date fruit contains 59.2 g moisture, 1.2 g protein, 0.4 g fat, 1.7 g minerals, 3.7 g fiber, 33.8 g carbohydrates, 22.0 mg calcium, 38.0 mg phosphorus and other elements (2). Date fruit pulp is used for flavouring the bakery products. In India, date palm fruits are harvested during mid-June to July at *doka* or *khalal* stage (hard ripe yellow, red or dark red colour) of maturity because of early rains. If fruits are left on the trees beyond July to attain full ripening (pind stage), these may get spoiled due to monsoon rains and high humidity. The storage life of fruit is less and fresh fruit has to be utilized immediately. In our country, maximum area of date palm 16,688 ha is under cultivation in the coastal belts of Kachchh, Gujarat with annual fruit production of 1,23490 t, where maximum fruits are harvested at doka stage (4). The fruits of small size, astringent in taste, unfit for dry date and *pind khajoor* preparation can be successfully utilized by the preparation of ready to serve delicious drink. In recent times, to make better use of fruits there has been a renewed interest in the date palm as a component for food preparation like sweet confectionery, health food, alcoholic beverages, delicious drink, etc. Seed kernel is also used in the preparation of cattle feed. In date growing countries, a number of value added products, drinks, wine, etc. are prepared from doka fruits, however, in India, limited work has been carried out on post harvest management for proper utilization of fruits.

Keeping this in view, an attempt was made to utilize *doka* stage fruits for preparation of delicious drink.

MATERIALS AND METHODS

The experiment was carried out in Post Harvest Laboratory, CIAH, Bikaner during the year 2010-11. The freshly harvested fruits of cultivar Sedami, yellow in colour and astringent in taste at doka stage (*khalal*) were taken for preparation of delicious drink. Morphological and physico-chemical parameters of fruits were also recorded before extraction of juice.

Fruits were washed in water after sorting green, over ripe and infected berries and then they were cut into halves for removal of seed and extraction of juice. Seeds were removed manually. The fruit pieces were boiled with water in pressure cooker for 6-8 min and filtered the cooked material by muslin cloth. Sugar 300 g per litre of extracted juice was added to maintain TSS (38 °Brix). The squash was prepared during last week of July and filled in clean sterilized bottle and kept in lab for organoleptic testing. A total of three treatments viz., T_1–Date squash, T_2–Squash added with 5 g of ginger extract per litre of juice and T_3–Added with preservative KMS (500 ppm) were made for further sensory evaluation. All the bottles of three

treatments were kept under refrigerator conditions. One set of 100 ml was kept under room temperature to see the storage life. TSS and acidity were estimated as per standard procedure described by Rangana (6). The artificial colour was not mixed because the drink retained the natural yellowish colour.

Organoleptic testing was carried out at weekly interval with a panel of 10 judges on score basis (maximum 10 marks). The squash was diluted by mixing water in ratio of 30 : 70 for sensory evaluation. Hedonic scale method was used for the organoleptic evaluation of drink for colour, flavour, acceptability, taste and appearance at 0, 7, 15 and 30 days storage period. The mean data of score were assessed for sensory evaluation of ready-to-serve drink of date palm fruits.

RESULTS AND DISCUSSION

The morphological character of fruits was observed in terms of average weight (8.41 g), berry size (2.3 x 0.8 cm), stone size (2.3 x 0.8 cm), stone weight (1.2 g) and pulp : stone ratio (5 : 8). The TSS (18°Brix) and acidity (0.4%) of fresh fruit were observed. It was clear from the data that quality of fruit was good except taste character of fruits, which was astringent at hard, yellow ripen doka stage.

The data on organoleptic testing of squash are given in Table 1. The sensory evaluation revealed that ready-to-serve drink mixed with 30 : 70 ratio water was acceptable by the panel of judges. The score of acceptability and taste characters indicated that the squash was a better product of doka stage fruits for proper utilization.

The colour of product is an important character of any value added product. The initial colour of product was yellowish and attractive. The maximum score (8.00) for colour was observed when it was fresh in all the treatments. The colour of product was very good up to 30 days of storage under T_2 (5.50) then it declined to 4.90 under T_1 followed by 4.80 under T_3. Storage had an effect on colour perception of drink. As the storage period increased, fermentation started in squash. The gradual loss in colour over the entire period was due to action of different kinds of acids present in the drink. The minimum score was obtained at 30 days of storage i. e. 4.80 which showed the decrease in quality of squash. However, flavour and colour of squash were good having 5.50 score for colour under T_2. The TSS was observed higher in ginger blended squash at 30 days of storage than that of T_1 and T_3. The change in colour during storage of beverage was reported by Jain *et al.* (3).

The maximum score of squash was obtained for acceptability followed by flavour character. In sensory evaluation, taste is very important factor after colour and flavour. The highest score (7.50) was ranked for taste character at seven days followed by 15 days of storage and thereafter it was slightly decreased after 30 days of storage of squash. The minimum score (3.10) was given by tasters at 30 days of storage, which may possibly be due to poor taste sensation and beginning of fermentation of product under T_1 and T_3 treatments. The finding is similar with the earlier results on sensory evaluation of ready-to-serve drink prepared from date juice (1).

The appearance of product was attractive in packed glass bottle at fresh and then it declined gradually during storage period. The appearance of squash was yellowish getting maximum score (7.66). A decreasing trend in score was recorded with increasing the period of storage. The minimum score (3.70) was recorded at 30 days of storage and discarded. Acceptability character of drink also noted the similar trend of score of appearance. The appearance, taste and flavour of ginger blended date squash were good even after 30 days of storage in comparison to other treatments. Similar trend was also observed in ginger-kinnow blended beverage by Nath and Yadav (5).

The acceptability of drink gradually declined with the increasing period of storage because of taste sensation.

Table 1. Sensory evaluation of squash prepared from date fruits on score basis

Character	0 day (initial stage)			7 days of storage			15 days of storage			30 days of storage		
	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
Appearance	7.66	7.50	8.16	7.62	7.56	7.50	6.91	7.16	6.66	3.70	4.50	3.60
Taste	7.00	6.83	8.32	7.50	7.25	7.12	6.91	7.16	5.50	3.10	4.20	3.40
Flavour	7.50	7.00	8.50	7.62	7.00	6.37	6.08	6.66	5.83	2.40	4.60	3.50
Acceptability	7.16	7.50	8.50	7.37	6.50	7.12	6.75	6.66	4.50	3.00	4.50	3.70
Colour	8.00	8.00	8.30	7.25	7.00	6.87	6.75	6.66	6.66	4.90	5.50	4.80
T. S. S. (°Brix)	38.00	39.02	38.2	28.60	28.20	26.60	27.20	30.6	27.6	24.4	29.20	26.80

This may possibly be due to the chemical reactions between carbohydrates and different types of acids. During storage, physico-chemical changes are common in any value added products. The finding is similar with the results reported by Jain *et al.* (3) and Singh *et al.* (7).

TSS of squash was monitored periodically but there was a marginal decrease in TSS of squash during storage period, which may possibly be due to fermentation of squash. Moreover, flavour and colour of squash were better having 5.50 score under T_2. The TSS was acceptable in ginger blended squash at 30 days of storage than that of T_1 and T_3 treatments.

The sensory evaluation was indicative of high acceptance of product. By this way, date palm fruits of doka (*Khalal)* stage particularly small size and of astringent taste can be utilized for making delicious drink. Further, it can be stored up to 30 days without major changes in quality of product under refrigerator. However, fast fermentation in squash was observed under storage at room temperature. This technique provides the date growers an ample scope to utilize their produce profitability in arid region.

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In vitro Protocol for Clonal Propagation of *Jatropha curcas* : An Important Bio-diesel Plant

KAMLA MALIK*, ASHOK DHAWAN[1] AND JAYANTI TOKKAS[2]
Department of Microbiology, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India
**(e-mail : kamlamalik@rediffmail.com)*

ABSTRACT : An efficient and reproducible method for *in vitro* multiplication of *Jatropha curcas* was developed. Shoots were regenerated from nodal segments on Murashige and Skoog's (MS) medium supplemented with BAP (2.0 mg/l), Kinetin (0.25 mg/l) and IAA (0.1 mg/l) produced multiple shoots (9.80±1.52) with maximum length (5.13±0.61 cm) after four weeks. The micro-shoots rooted well on MS medium supplemented with IBA (3.0 mg/l). The regenerated plants were successfully acclimatized and about 70-80% of plantlets survived under *ex vitro* conditions.

Key words : *Jatropha curcas*, nodal segment, *in vitro* multiplication, regeneration

Jatropha curcas L. is a perennial, deciduous large shrub or small tree about 3-5 m in height which belongs to family Euphorbiaceae. It grows on a wide range of climates and soils. This is commonly known as Ratanjyot, Physic nut, Safed arand, Chanderjyot, Jamalghota or Purgative nut. It grows well in tropical and sub-tropical climate in India. *J. curcas* is one of the most valuable crude drugs of primitive times and is still widely used in modern medicine. In recent years, this plant has received extensive attention of many scientists in view of its great economic importance, medicinal significance and for its seed oil as commercial source of fuel. It is conveniently used to making soaps, candles, paints, lubricants and medicinally as a purgative. However, despite their economic importance, drought resistance characteristics and medicinal value, in order to meet the demand of fuel in the near future, the development of appropriate technology for the rapid regeneration of this species is essential. The conventional method of propagation through seeds will not solve the problem. The seeds are heterozygous in nature and cuttings are seasonal. Moreover, it is reported that vegetative cuttings are not deep rooted and easily uprooted as they do not form a taproot system. Seed set has been reported to be low in vegetative propagated plants (8). Various aspects of *in vitro* multiplication of *J. curcas* have been investigated using different explants like shoot tip (4), nodal segment (1) hypocotyls and leaf explants. Plants regenerated from somatic embryos were induced directly from green cotyledon explants (2). Under this situation *in vitro* regeneration of this species through tissue culture techniques offers a powerful method to overcome the problem. Despite its multifarious potentiality, there are some limitations in propagation of this potent plant species, as it is latex containing shrub that makes it recalcitrant for tissue culture. Keeping in view these facts, an attempt was made to develop efficient method for *in vitro* clonal propagation of *J. curcas* using nodal explants.

MATERIALS AND METHODS

The explants used for *in vitro* propagation of *J. curcas* were nodal segment (1.5- 2.0 cm) collected from Centre for Plant Biotechnology, CCSHAU, New Campus, Hisar. The explants were first washed with tap water followed by 4-5 drops of liquid soap for 10 min. After washing with tap water properly the explants were surface sterilized with 0.1% $HgCl_2$ for 4 min and 4% sodium hypochlorite for 3 min and thoroughly washed with sterile distilled water for 4-5 times to remove the traces of sterilant.

Culture media consisted of MS medium (3) supplemented with 3% sucrose and 0.8% agar supplemented with different concentrations of BAP (0.25-2.0 mg/l), Kn (0.25-0.5 mg/l), IAA (0.1-0.5 mg/l), NAA (0.1-0.5 mg/l), TDZ (0.1-0.25 mg/l) and GA_3 (1.0-2.0 mg/l) either individually or in combination. Along with growth hormones, additives like adenine sulphate (25 mg/l), citric acid (50 mg/l), ascorbic acid (50 mg/l) and charcoal (2.0 g/l) were also used for induction and multiplication of shoots. The pH of medium was adjusted to 5.8 before adding agar and was autoclaved at 15 psi at 121°C for 20 min. Cultures were maintained at 24±2°C and 50-60% relative humidity (RH) under 14 h photoperiod in a growth chamber. Sub-culturing was made periodically at 10-15 days interval to obtain adequate number of shoots.

[1]Centre for Plant Biotechnology.
[2]Department of Biochemistry.

For root initiation, the shoots were transferred to the rooting medium containing different levels of NAA (1.0-3.0 mg/l) and IBA (1.0-3.0 mg/l).

Rooted micro-shoots were placed on filter paper and washed thoroughly with running tap water. The plantlets were then transferred to pots containing soil+sand+vermicompost (1 : 1 : 1) under controlled growth chamber conditions. The cultures were observed after one week. Each treatment had three replicates with five cultures per replicate. The experiments were repeated thrice and observations given in tables are mean+SE of the three repeated experiments. The data obtained from three replicates were statistically analyzed using one-way analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Explants were cultured on MS medium containing different growth regulators (BAP, Kn, IAA, NAA, TDZ, 2,4-D and GA_3) singly as well combination showed varied response with respect to shoot length and number of shoot buds obtained per explant (Table 1). Explants remain green and fresh but fail to develop shoot buds in growth regulators free medium (control). Of these, the most effective combination for shoots proliferation was found in MS medium supplemented with BAP (2.0 mg/l), Kn (0.25 mg/l) and IAA (0.1 mg/l). In this combination, the maximum numbers of shoots (9.80±1.52) with average length of (5.13± 0.61cm) shoots per explant were observed after four weeks of cultures (Fig. 1). When the explants were cultured on Kin based media, only 50% were proliferated to shoots and only 6.13±1.23 micro-shoots per explant were produced. Similarly, no specific increase in multiple shoot formation was observed on different media. In the present study showed negligible effect of TDZ and GA_3 on induction of shoot multiplication as also reported in *J. curcas* earlier (8). However, there were only few reports on morphogenesis and plant regeneration from tissue culture of *J. curcas* (5, 7). This clearly indicates that BAP in combination with low concentration of auxin produced more number of shoots. However, it showed that in *J. curcas* that required higher concentration of only one type of cytokinin (BAP) for induction phase and lower concentration of another type of cytokinine (Kn) proliferation of shoots.

Table 1. Effect of growth regulators on shoot proliferation and number of shoots per culture from nodal explants of *Jatropha curcas*. Data (Mean±S. D.) were recorded after four weeks.

Growth regulators (mg/l)	No. of shoots/ explant	Shoot length (cm)
Control	1.00±0.01	1.63±0.20
MS+BA 1.0	1.73±0.37	0.36±0.31
MS+BA 2.0	2.03±0.40	0.86±0.32
MS+BA 2.0+ Kn 0.5	3.70±0.17	1.26±0.52
MS+BA 0.5+Kn 0.25+IAA 0.25	3.86±0.31	1.76±0.18
MS+BA 1.5+Kn 0.5+IAA 0.5	6.13±1.23	3.40±0.32
MS+BA 2.0+Kn 0.25+IAA 0.1	9.80±1.52	5.13±0.61
MS+BA 2.0+ NAA 0.1	3.00±0.99	4.73±0.64
MS+BA 1.0+Kn 0.3+NAA 0.5	3.66±0.88	4.40±0.36
MS+BA 1.0+ TDZ 0.1	3.01±0.41	1.93±0.17
MS+BA 1.0+ TDZ 0.25+ GA_3 1.0	2.33±0.23	1.10±0.25
MS+BA 0.25+ GA_3 2.0	3.16±0.33	1.93±0.23

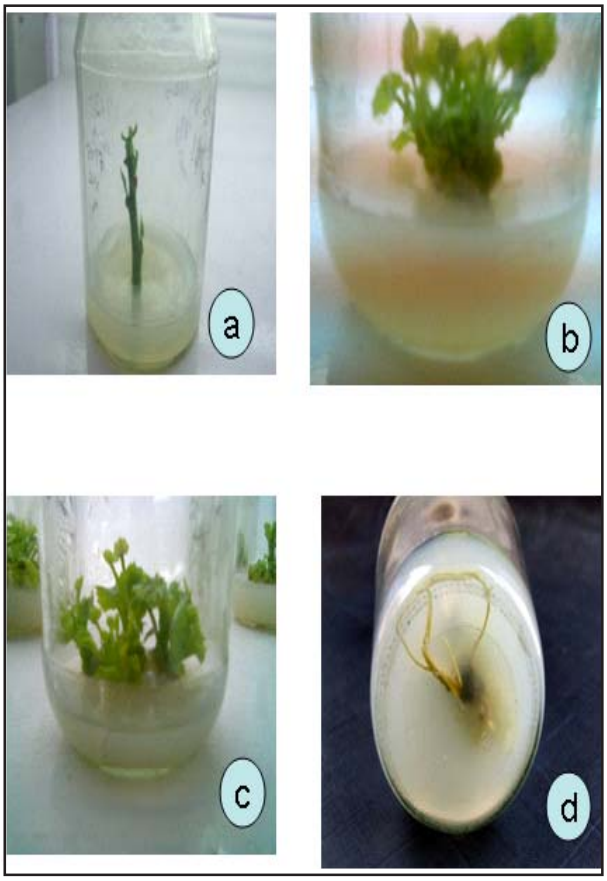

Fig. 1. *In vitro* propagation of *Jatropha curvas* L. from nodal explants : a : Initiation of shoot bud after 7 days , b and c : Multiple shoots proliferation on MS+BAP 2.0 mg/1+Kn 0.25 mg/l+IAA 0.1 mg/l and d : Rooting of *in vitro* shoots in MS medium with MS+IBA 3.0 mg/l.

Influence of additives was studied after determining the optimum cytokinin and auxin levels for shoot bud induction to improve the quality of shoots (Table 2). Maximum number of shoots per explant was recorded at BAP (2.0 mg/l)+IAA (0.1 mg/l)+adenine sulphate (30 mg/l)+active charcoal (2.0 g/l) showing 2.76±0.92 number of shoots with 1.73±0.54 cm fold increase in

Table 2. Influence of adenine sulphate, ascorbic acid, citric acid and charcoal along with BA (2.0 mg/l)+IAA (0.1 mg/l) on shoot multiplication

Additives (mg/l)				No. of shoots/ explant	Shoot length (cm)
Adenine sulphate	Ascorbic acid	Citric acid	Charcoal (g/l)		
25	50			0.01±0.00	2.66±0.33
25		50		1.46±0.74	1.33±0.88
25			2.0	2.76±0.92	1.73±0.54

shoot length as compared to control. An efficient *in vitro* clonal propagation of physic nut (*Jatropha curcas*) has been developed on MS medium supplemented with BA, IBA and IAA along with additives like adenine sulphate, glutamine, arginine, citric acid (6) and activated charcoal (4).

In vitro shoots were transferred to MS medium with IBA (1.0-3.0 mg/l) and NAA (1.0-3.0 mg/l) (Table 3). Rooting initiation started after two weeks of culture on rooting media and completed four weeks. The best rooting on MS with IBA 3.0 mg/l with maximum number of roots 3.01±0.57, with 1.93±0.84 fold increase in root length as compared to control (Fig. 1d). While no root was noted in the presence of NAA (1.0-4.0 mg/l), but profuse callusing at the base of the shoot took place. IBA is considered as the most effective auxin for root induction (1). The plantlets with well developed roots were transferred to small polythene bags containing a mixture of soil, vermicompost and sand (1 : 1 : 1) and then acclimatized gradually to the normal environment. The present study describes efficient and reliable *in vitro* multiplication protocol for *J. curcas* from nodal segment with much higher rate multiplication.

In vitro multiplication of *J. curcas* was regenerated from nodal segments on Murashige and Skoog's (MS) medium supplemented with BAP (2.0 mg/l), Kinetin (0.25 mg/l) and IAA (0.1 mg/l) and produced multiple shoots (9.80±1.52) with maximum length (5.13±0.61 cm) after four weeks. The root was developed on MS medium supplemented with IBA (3.0 mg/l). The regenerated plants were successfully acclimatized.

Table 3. Effect of IAA and IBA on root induction of *Jatropha curcas*

Growth regulators (mg/l)	No. of roots/ explant	Root length (cm)	Base callus frequency
Control	0	0	-
MS+NAA 1.0	0	0	+
MS+NAA 2.0	0	0	+++
MS+NAA 3.0	0	0	+++
MS+IBA 1.0	2.16±0.44	0.80±0.11	+
MS+IBA 2.0	2.66±0.33	0.76±0.38	-
MS+IBA 3.0	3.01±0.57	1.93±0.84	-

+–Poor, +++–High.

ACKNOWLEDGEMENT

The authors wish to thank Department of Science & Technology, New Delhi for financial support to this research project.

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Management of Okra Shoot and Fruit Borer (*Earias vittella* Fab.) by Changing Pattern of Irrigation Intervals

H. K. GAUTAM[1], N. N. SINGH AND A. B. RAI[2]
Department of Entomology & Agricultural Zoology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221 005 (U. P.), India

ABSTRACT : The field trial was carried out at Indian Institute of Vegetable Research , Varanasi (India) Research field during Zaid season of 2008 and 2009 to find out infestation of shoot and fruit borer, *Earias vittella* (Fab.) on okra cv. Kashi Pragati (VRO-6). The minimum shoot borer infestation (9.1%) was found with irrigation at 20 days interval and maximum was (19.2%) at two days of irrigation interval, while the minimum fruit borer infestation (14.1%) was found with irrigation at 20 days interval and maximum was (24.6%) at two days of irrigation interval. The yield was maximum in eight days irrigation interval and net gain also by this treatment.

Key words : Irrigation interval, infestation, okra, *Earias vittella*

The shoot and fruit borer, *Earias vittella* Fab. (Lepidoptera : Noctuidae) is an important insect-pest of okra [*Abelmoschus esculentus* (L.) Moench]. The immature stage of *Earias vittella* bores the growing shoot of okra plant prior to fruit formation shoot dried. But availability of okra fruits larva moves to feeding okra fruit and causes direct yield losses. The proper use management of irrigation practices can reduce insect-pest damage and increase yield also.

MATERIALS AND METHODS

The seeds of okra variety Kashi Pragati (VRO-6) were sown on 8 March during the year 2008 and 2009. The crop was irrigated with six irrigation schedules i. e. 2, 4, 8, 12, 16 and 20 days intervals to study the impact on okra shoot and fruit borer infestation. No pesticides were used during the period of experimentation. The experimental crop was monitored on regular basis to record the incidence of shoot and fruit borer. The observations were recorded at weekly interval by counting total number of healthy and damaged shoot and fruit of five randomly selected plants. On the basis of cost of irrigation and profit made the economics of each schedule was calculated separately. The irrigation treatment started from 1 April and before it all plots were irrigated at weekly interval.

RESULTS AND DISCUSSION

The different irrigation intervals revealed marked difference in shoot borer infestation. The minimum shoot borer infestation (8.8%) was noticed in irrigation at 20 days interval and this treatment was found most outstanding being significantly superior to the remaining interval of irrigation. The maximum shoot borer infestation (18.8%) was recorded at two days of interval followed by four days interval (18.0) during 2008 (Table 1).

The trend was noticed during the year 2009 that the minimum shoot borer infestation (10.3%) was noticed in irrigation at 20 days interval and this treatment was found most outstanding being significantly superior to the remaining interval of irrigation. The maximum shoot borer infestation (19.6%) was recorded at two days of interval followed by four days interval (18.4%) during 2009 (Table 2).

The pooled data for the two years 2008 and 2009 followed trend in which the minimum shoot borer infestation (9.1%) was found with irrigation at 20 days interval and maximum was (19.2%) at two days of irrigation interval (Table 3).

The different irrigation intervals revealed marked difference in fruit borer infestation. The minimum fruit borer infestation (13.6%) was noticed in irrigation at 20 days interval and this treatment was found most outstanding being significantly superior to the remaining interval of irrigation. The maximum fruit borer infestation (23.8%) was recorded at two days of interval followed by four days interval (18.9%) during 2008 (Table 4).

The trend was noticed during the year 2009 that the minimum fruit borer infestation (15.5%) was noticed in irrigation at 20 days interval and this treatment was found most outstanding being significantly superior to the remaining interval of irrigation. The maximum fruit borer infestation (25.5%) was recorded at two days of

[1]Dy. P. D. (ATMA) Farmer Welfare and Agricultural Development, Shivpuri (M. P.), India (*e-mail : harshgautamg@gmail.com*).
[2]Division of Plant Protection, Indian Institute of Vegetable Research, Varanasi (U. P.), India.

Table 1. Effect of irrigation interval on shoot damage by *Earias vittella* on okra during *zaid* season of 2008

Treatment	Average shoot damage at different dates of observation							Mean
	8 April	15 April	22 April	29 April	6 May	13 May	20 May	
Irrigation at 2 days interval	0.0	20.0	33.3	24.4	23.3	19.2	11.1	18.8
		(21.9)	(35.0)	(29.4)	(28.9)	(26.0)	(19.4)	(23.0)
Irrigation at 4 days interval	6.7	26.7	26.7	21.4	20.3	16.1	8.1	18.0
	(8.9)	(26.2)	(30.8)	(27.5)	(26.8)	(23.7)	(16.4)	(22.9)
Irrigation at 8 days interval	0.0	26.7	26.7	20.2	18.4	15.8	11.9	17.1
		(30.8)	(30.8)	(26.7)	(25.4)	(23.4)	(20.2)	(22.5)
Irrigation at 12 days interval	0.0	13.3	20.0	18.4	15.7	13.1	9.6	12.9
		(17.7)	(26.6)	(25.4)	(23.4)	(21.2)	(18.1)	(18.9)
Irrigation at 16 days interval	0.0	20.0	20.0	19.9	17.6	15.1	11.6	14.9
		(26.6)	(26.6)	(26.5)	(24.8)	(22.9)	(19.9)	(21.0)
Irrigation at 20 days interval	0.0	6.7	13.3	14.5	11.7	9.1	6.0	8.8
		(8.9)	(17.7)	(22.3)	(20.0)	(17.6)	(14.1)	(14.4)
Mean	1.1	18.9	23.3	19.8	17.9	14.8	9.7	15.1
	(1.5)	(22.0)	(27.9)	(26.4)	(24.9)	(22.5)	(18.0)	(20.4)
Difference between the treatments				C. D. (P=0.05)=4.33				
Difference between the period of observations				C. D. (P=0.05)=3.31				
Difference between the treatments x Period of observations				C. D. (P=0.05)=11.46				

Figures in parentheses are arc sine transformed values.
Data presented in the table are average of three replications, five plants in each replication.

Table 2. Effect of irrigation interval on shoot damage by *Earias vittella* on okra during *zaid* season of 2009

Treatment	Average shoot damage at different dates of observation							Mean
	8 April	15 April	22 April	29 April	6 May	13 May	20 May	
Irrigation at 2 days interval	0.0	26.7	33.3	24.6	23.8	20.1	8.9	19.6
		(30.8)	(35.0)	(29.7)	(29.2)	(26.6)	(17.1)	(24.1)
Irrigation at 4 days interval	6.7	26.7	20.0	22.1	20.8	18.2	14.5	18.4
	(8.9)	(30.8)	(26.6)	(28.0)	(27.1)	(25.2)	(16.7)	(23.3)
Irrigation at 8 days interval	0.0	26.7	26.7	20.6	22.4	16.7	21.3	19.2
		(30.8)	(30.8)	(27.0)	(28.2)	(24.1)	(21.9)	(23.2)
Irrigation at 12 days interval	0.0	13.3	20.0	18.8	14.3	13.6	18.2	14.0
		(17.7)	(26.6)	(25.7)	(22.2)	(21.6)	(19.1)	(19.00
Irrigation at 16 days interval	0.0	20.0	20.0	20.1	16.9	15.6	19.6	16.0
		(21.9)	(26.6)	(26.6)	(24.2)	(23.2)	(20.6)	(20.4)
Irrigation at 20 days interval	0.0	6.7	13.3	14.5	12.3	11.0	14.5	10.3
		(8.9)	(17.7)	(22.4)	(20.5)	(19.4)	(16.2)	(15.0)
Mean	1.1	20.0	22.2	20.1	18.4	15.9	16.2	16.3
	(1.5)	(23.5)	(27.2)	(26.6)	(25.2)	(23.4)	(18.6)	(20.8)
Difference between the treatments				C. D. (P=0.05)=3.71				
Difference between the period of observations				C. D. (P=0.05)=2.84				
Difference between the treatments x Period of observations				C. D. (P=0.05)=9.84				

Figures in parentheses are arc sine transformed values.
Data presented in the table are average of three replications, five plants in each replication.

interval followed by 16 days interval (20.4%) during 2009 (Table 5).

The pooled data for the two years 2008 and 2009 followed trend in which the minimum fruit borer infestation (14.1%) was found with irrigation at 20 days interval and maximum was (24.6%) at two days of irrigation interval (Table 6).

The pooled data of yield were maximum in eight days irrigation interval and net gain also by this treatment (Table 7).

Table 3. Effect of irrigation interval on shoot damage by *Earias vittella* on okra during *zaid* season (Pooled data of 2008 and 2009)

Treatment	Average shoot damage at different dates of observation							Mean
	8 April	15 April	22 April	29 April	6 May	13 May	20 May	
Irrigation at 2 days interval	0.0	23.3	33.3	24.5	23.6	19.6	10.0	19.2
		(26.4)	(35.0)	(29.7)	(29.0)	(26.3)	(18.3)	(23.5)
Irrigation at 4 days interval	6.7	26.7	23.3	21.7	20.6	17.2	8.2	17.8
	(8.9)	(28.5)	(28.7)	(27.8)	(27.0)	(24.4)	(16.5)	(23.1)
Irrigation at 8 days interval	0.0	26.7	26.7	20.4	20.4	16.3	12.9	17.6
		(30.8)	(30.8)	(26.9)	(26.8)	(23.8)	(21.0)	(22.9)
Irrigation at 12 days interval	0.0	13.3	20.0	18.6	15.0	13.4	10.2	12.9
		(17.7)	(26.6)	(25.6)	(22.8)	(21.4)	(18.6)	(18.9)
Irrigation at 16 days interval	0.0	20.0	20.0	20.0	17.2	15.4	12.0	14.9
		(24.2)	(26.6)	(26.6)	(24.5)	(23.0)	(20.2)	(20.7)
Irrigation at 20 days interval	0.0	6.7	13.3	14.5	12.0	10.1	6.9	9.1
		(8.9)	(17.7)	(22.4)	(20.3)	(18.5)	(15.1)	(14.7)
Mean	1.1	19.4	22.8	20.0	18.1	15.3	10.0	15.3
	(1.5)	(22.7)	(27.6)	(26.5)	(25.0)	(22.9)	(18.3)	(20.6)
Difference between the treatments				C. D. (P=0.05)=1.08				
Difference between the period of observations				C. D. (P=0.05)=0.84				
Difference between the treatments x Period of observations				C. D. (P=0.05)=3.05				

Figures in parentheses are arc sine transformed values.
Data presented in table are average of three replications, five plants in each replication.

Table 4. Effect of irrigation intervals on fruit damage by *Earias vittella* on okra during *zaid* season of 2008

Treatment	Average fruit damage at different dates of observation							Mean
	8 April	15 April	22 April	29 April	6 May	13 May	20 May	
Irrigation at 2 days interval	13.7	22.4	28.4	32.8	34.3	21.9	13.2	23.8
	(21.7)	(28.2)	(32.2)	(34.9)	(35.8)	(27.9)	(21.3)	(28.9)
Irrigation at 4 days interval	11.5	19.7	28.0	37.9	13.0	12.3	10.1	18.9
	(19.8)	(26.3)	(31.9)	(38.0)	(21.1)	(20.6)	(18.5)	(25.2)
Irrigation at 8 days interval	12.5	20.7	29.1	39.9	14.0	14.2	11.4	20.3
	(20.7)	(27.0)	(32.7)	(39.2)	(21.9)	(22.1)	(19.7)	(26.2)
Irrigation at 12 days interval	6.1	16.1	24.6	33.7	10.0	7.1	6.6	14.9
	(14.3)	(23.6)	(29.7)	(35.5)	(18.4)	(15.4)	(14.8)	(21.7)
Irrigation at 16 days interval	9.4	19.3	27.4	36.7	13.4	10.3	10.0	18.1
	(17.8)	(26.0)	(31.5)	(37.3)	(21.4)	(18.7)	(18.4)	(24.5)
Irrigation at 20 days interval	5.6	15.0	23.2	31.9	8.0	5.9	5.5	13.6
	(13.7)	(22.8)	(28.8)	(34.4)	(16.4)	(14.0)	(13.5)	(20.5)
Mean	9.8	18.8	26.8	35.5	15.4	12.0	9.5	18.3
	(18.0)	(25.7)	(31.1)	(36.6)	(22.5)	(19.8)	(17.7)	(24.5)
Difference between the treatments				C. D. (P=0.05)=0.58				
Difference between the period of observations				C. D. (P=0.05)=0.44				
Difference between the treatments x Period of observations				C. D. (P=0.05)=1.53				

Figures in parentheses are arc sine transformed values.
Data presented in table are average of three replications, five plants in each replication.

The minimum shoot & fruit borer infestation was noticed in irrigation at 20 days interval, and maximum shoot & borer infestation was recorded at two days of interval during both the years. The maximum yield in terms of net value was obtained from eight days irrigation interval.

Mrig *et al.* (2) was studied in the field in Haryana, India during 1987-88. The use of timing of irrigation for the control of *Chilo infuscatellus* and *Emmalocera depressella* [*Polyocha depressella*] was found on

Table 5. Effect of irrigation intervals on fruit damage by *Earias vittella* on okra during *zaid* season of 2009

Treatment	Average fruit damage at different dates of observation							Mean
	8 April	15 April	22 April	29 April	6 May	13 May	20 May	
Irrigation at 2 days interval	13.8	25.9	29.9	34.0	36.6	23.4	14.6	25.5
	(21.8)	(30.6)	(33.2)	(35.6)	(37.2)	(28.9)	(22.4)	(30.0)
Irrigation at 4 days interval	12.0	21.3	29.8	32.3	13.9	13.5	18.2	20.1
	(20.2)	(27.5)	(33.1)	(34.3)	(21.9)	(21.5)	(19.8)	(25.5)
Irrigation at 8 days interval	13.6	22.5	30.3	41.5	15.2	15.3	20.1	22.6
	(21.6)	(28.3)	(33.4)	(40.1)	(23.0)	(23.0)	(19.0)	(26.9)
Irrigation at 12 days interval	6.9	17.1	25.9	36.8	11.0	8.5	13.2	17.1
	(15.3)	(24.4)	(30.6)	(37.3)	(19.3)	(17.0)	(16.0)	(22.8)
Irrigation at 16 days interval	10.6	20.5	29.1	39.8	14.4	11.1	17.4	20.4
	(19.0)	(26.9)	(32.6)	(39.1)	(22.3)	(19.4)	(19.9)	(25.6)
Irrigation at 20 days interval	6.2	16.3	23.4	34.4	8.6	7.1	12.8	15.5
	(14.4)	(23.8)	(28.9)	(35.9)	(17.0)	(15.4)	(15.0)	(21.5)
Mean	10.5	20.6	28.1	36.5	16.6	13.1	16.0	20.2
	(18.7)	(26.9)	(32.0)	(37.1)	(23.4)	(20.9)	(18.7)	(25.4)
Difference between the treatments				C. D. (P=0.05)=1.02				
Difference between the period of observations				C. D. (P=0.05)=0.78				
Difference between the treatments x Period of observations				C. D. (P=0.05)=2.71				

Figures in parentheses are arc sine transformed values.
Data presented in table are average of three replications, five plants in each replication.

Table 6. Effect of irrigation intervals on fruit damage caused by *Earias vittella* on okra during *zaid* season of 2008 and 2009

Treatment	Average fruit damage at different dates of observation							Mean
	15 April	22 April	29 April	6 May	13 May	20 May	27 May	
Irrigation at 2 days interval	13.8	24.2	29.2	33.4	35.5	22.7	13.9	24.6
	(21.7)	(29.4)	(32.7)	(35.3)	(36.5)	(28.4)	(21.9)	(29.4)
Irrigation at 4 days interval	11.7	20.5	28.9	35.1	13.4	12.9	10.8	19.0
	(20.0)	(26.9)	(32.5)	(36.2)	(21.5)	(21.0)	(19.1)	(25.3)
Irrigation at 8 days interval	13.0	21.6	29.7	40.7	14.6	14.8	11.0	20.8
	(21.1)	(27.7)	(33.0)	(39.6)	(22.4)	(22.6)	(19.3)	(26.5)
Irrigation at 12 days interval	6.5	16.6	25.3	35.3	10.5	7.8	7.1	15.6
	(14.8)	(24.0)	(30.2)	(36.4)	(18.9)	(16.2)	(15.4)	(22.3)
Irrigation at 16 days interval	10.0	19.9	28.3	38.3	13.9	10.7	10.8	18.8
	(18.4)	(26.5)	(32.1)	(38.2)	(21.8)	(19.1)	(19.1)	(25.0)
Irrigation at 20 days interval	5.9	15.6	23.3	33.2	8.3	6.5	6.1	14.1
	(14.0)	(23.3)	(28.8)	(35.2)	(16.7)	(14.7)	(14.3)	(21.0)
Mean	10.1	19.7	27.4	36.0	16.0	12.5	9.9	18.8
	(18.3)	(26.3)	(31.5)	(36.8)	(23.0)	(20.3)	(18.2)	(24.9)
Difference between the treatments				C. D. (P=0.05)=0.61				
Difference between the period of observations				C. D. (P=0.05)=0.30				
Difference between the treatments x Period of observations				C. D. (P=0.05)=1.35				

Figures in parentheses are arc sine transformed values.
Data presented in table are average of three replications, five plants in each replication.

Table 7. Economics of different irrigation intervals

Treatment	Yield (q/ha) (Pooled for 2008 and 2009)	Profit (Rs./ha)	Irrigation cost (Rs./ha)	Net profit (Rs./ha)
Irrigation at 2 days interval	36.25	36250.0	35000	1250.0
Irrigation at 4 days interval	30.25	30250.0	17500	12750.0
Irrigation at 8 days interval	25.25	25250.0	8750	16500.0
Irrigation at 12 days interval	15.25	15250.0	5833.3	9416.7
Irrigation at 16 days interval	8.25	8250.0	4375	3875.0
Irrigation at 20 days interval	4.25	4250.0	3500	750.0
C. D. (P=0.05)	3.25			

Irrigation charges @ Rs. 40/h, 25 h/ha; labour charges @ Rs. 100 day, 4/ha, 25 days for 25 irrigations in two days interval.

ratoon sugarcane. An irrigation interval of 10 days was effective in reducing the incidence of both the pests, followed by intervals of 20 and 30 days. Higher numbers of millable canes and cane yield/ha were obtained with an irrigation interval of 10 days than with an interval of 30 days.

The present findings are similar with those of Bhatt *et al.* (1) who reported increased population of *Earias* due to moisture level. The maximum mean percentage incidence was found at two irrigation intervals.

Randhawa *et al.* (3) reported that the newly planted sugarcane crop, irrigation interval of eight days was very effective for decreasing the incidence of early shoot borer, followed by 16, 24 and 32 days irrigation intervals. Higher cane yield per acre was also obtained under eight days irrigation interval as compared to longer period of irrigation intervals.

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Effect of Naphthalene Acetic Acid on Periodical Changes in Bio-chemical Composition of Ber cv. Umran

RACHNA ARORA AND SUKHDEV SINGH
Department of Horticulture, Faculty of Agriculture and Forestry, Khalsa College, Amritsar-143 003 (Punjab), India

ABSTRACT : The present studies were aimed at evaluating the effects of varying doses of NAA on the bio-chemical changes of ber fruit during development. NAA @ 0, 10, 30 and 50 ppm was applied at fruit set stage and then superimposed one month thereafter. The periodical bio-chemical analyses of developing ber fruits revealed that total soluble solids concentration increased maximum during initial stages of fruit development i. e. between interval of 25 to 50 days of NAA application, while total sugars and ascorbic acid increased and acidity decreased as the fruit reached maturity i. e. between 75 to 100 days of NAA application. The NAA 30 ppm dose resulted in maximum expression of acidity, total sugars and ascorbic acid at final harvest of ber, while total soluble solids showed maximum improvement with NAA 50 ppm. Thus, it is implicated that NAA application is beneficial in improving flavour and taste of ber.

Key words : Ber, bio-chemical, periodical, interval, naphthalene acetic acid

Ber (*Zizyphus mauritiana* Lamk.) is distributed throughout the tropical and sub-tropical regions of the world. It is one of the most hardy fruit trees with wider adaptability to adverse soil and climatic conditions and thus is recommended for cultivation on marginal land. India ranks first among the ber growing countries of the world. The fruit is equally relished by people of all classes. A comparison of nutritive value of ber and apple reveals that the ber is richer in the amount of protein, mineral matter, calcium, phosphorus, carotene and vitamin than that of apple. That's why ber is referred to as 'the apple of arid zone'.

In Punjab, the flowering in ber starts from first week of September and continues till first week of November, whereas the fruit setting starts in second week of October. The most active phase of fruit growth is first six weeks of fruit set (2). During this time the developing fruits undergo numerous physical and bio-chemical changes which increase the fruit size and improve the taste. The application of growth regulators like naphthalene acetic acid (NAA) is reported to have profound effects on improving the fruit quality (3, 4, 5, 10, 15, 16). These effects are more pronounced if the application is done during active growth phase. In the present studies the periodical changes in bio-chemical composition of ber fruits as brought about by varying doses NAA were evaluated.

MATERIALS AND METHODS

The present investigations were carried out in the Faculty of Agriculture and Forestry, Khalsa College, GNDU, Amritsar during the year 2007-08. Eight years old trees of ber cv. Umran with uniform size and vigour were selected for the experiment. The trees were sprayed during active growth phase in the 3rd week of October and again superimposed spray was applied one month thereafter. The growth regulator naphthalene acetic acid (NAA) in different concentrations i. e. 10, 30 and 50 ppm each in addition to water sprayed control was applied. There were three replications each with one tree per replication. The trees were sprayed uniformly by using knapsack sprayer with flood jet nozzle. Five uniform branches per tree were selected and tagged. After second spray at 25 days interval (i. e. after 25, 50, 75 and 100 days and then at harvest), the developing fruits were periodically harvested and the observations on four bio-chemical traits viz., total soluble solids (%), acidity (%), total sugars (%) and ascorbic acid (mg/100 g) were recorded to evaluate changes in chemical composition of developing ber fruits. To record TSS percentage, the juice of 10 randomly selected fruits from each replication was extracted and strained through a muslin cloth and TSS content of juice was measured with the help of Bausch and Lomb hand refractometer. The values of total soluble solids were then corrected to 20ºC with the help of temperature correction chart (1). To determine citric acid percentage, 10 g of fruit pulp was extracted and titrated against N/10 NaOH solution using phenolphthalein as an indicator. The total sugars were estimated by Lane and Eynon method (1). The ascorbic acid was determined by titration method using 10 g of fruit pulp macerated in 3% meta phosphoric acid solution and titrated against 2,6-dichlorophenol indophenol dye.

RESULTS AND DISCUSSION

The data pertaining to effect of varying concentrations of NAA on TSS content of Umran ber are presented

in Table 1 and Fig. 1. At the final harvest, all the treatments had significantly improved the TSS over control, which revealed that application of NAA had direct effect on assimilation of metabolic compounds within the fruits which improved TSS control and ultimately the fruit flavour and taste. Improvement in TSS is very important from processing point of view, as products like ber candy, Jelly, dried ber, etc. have direct association with TSS percentage of the fruit. There was maximum increase in TSS with application of NAA 30 ppm followed by NAA 50 ppm. The interaction effects between treatments and intervals were found to be significant. The studies corroborated with the findings of Singh and Singh (16), Bal *et al.* (4), Kale *et al.* (10) and Singh and Randhawa (15) who reported beneficial effects of NAA in improving TSS of ber fruits.

The effects of NAA on acidity of ber fruit are presented

Table 1. Effect of NAA on TSS (%) of ber fruits during development

Treatment	TSS (%) days after second spray									
	2007-08					2008-09				
	25	50	75	100	At harvest	25	50	75	100	At harvest
NAA 10 ppm	9.49	10.40	12.50	13.67	14.27	9.26	10.67	13.02	13.44	14.40
NAA 30 ppm	9.65	12.04	13.05	14.67	15.51	9.28	11.85	13.17	13.57	15.56
NAA 50 ppm	9.45	11.26	12.70	14.51	15.71	9.59	10.83	12.81	13.34	15.23
Control	8.78	10.13	11.22	12.08	12.60	9.06	10.15	10.94	12.83	13.19
C. D. (P=0.05) :	Intervals (A)		0.36	Year (B)	NS					
	Treatments (C)		0.32	AB	NS					
	AC		0.73	BC	NS					
	ABC		NS							

NS–Not Significant.

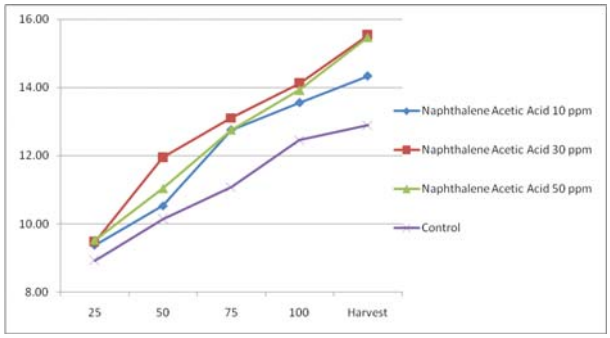

Fig. 1. Effect of NAA on TSS (%) of ber fruits during development (Pooled over both the seasons).

in Table 2 and Fig. 2. On periodic intervals, the acidity decreased significantly with application of NAA as compared to control and the treatments differed significantly among each other. The earlier workers Bankar and Prasad (6), Sandhu *et al.* (14) and Singh and Randhawa (15) also reported similar observations. The maximum periodic decrease in acidity of fruits was seen in interval of 75 to 100 days after application i. e. as the fruit reached towards maturity the acidity decreased. The decrease in acidity towards ripening may be attributed to faster movement of potassium into fruits with NAA application which in turn increased the membrane permeability of cells allowing respiration of stored acids within the cells, formation of complex compounds of malic acid (11) and reduced ability of fruits to synthesize organic acids towards maturity (9).

The application of NAA improved the percentage of total sugars in ber fruit at final harvest but the significant improvement was brought about by only 30 ppm dose of NAA (Table 3 and Fig. 3). Masalkar and Wavhal (12) and Bhati and Yadav (7) reported similar beneficial effects of NAA in improving fruit sugars of ber. There was significant periodic increase in sugars content at every interval with maximum increase recorded between 75 to 100 days interval i. e. towards fruit maturity. The interaction between treatments and intervals was found to be non-significant. This increase in sugars can be attributed to increase in concentration of volatile components concentration in fruits along with hydrolysis of starchy compounds towards maturity. These hydrolytic changes usually lead to formation of sugars. The extent of these hydrolytic changes might have increased with NAA application. Moreover, the organic acids present in fruits are translocated into sugars towards maturity and this translocation is made faster with NAA

Table 2. Effect of NAA on acidity (%) of ber fruits during development

Treatment	TSS (%) days after second spray									
	2007-08					2008-09				
	25	50	75	100	At harvest	25	50	75	100	At harvest
NAA 10 ppm	0.461	0.411	0.323	0.263	0.204	0.438	0.418	0.323	0.259	0.198
NAA 30 ppm	0.458	0.387	0.316	0.242	0.199	0.471	0.391	0.343	0.276	0.193
NAA 50 ppm	0.471	0.414	0.347	0.273	0.217	0.458	0.394	0.330	0.259	0.219
Control	0.488	0.438	0.387	0.279	0.242	0.498	0.461	0.387	0.279	0.242
C. D. (P=0.05) :	Intervals (A)		0.013	Year (B)	NS					
	Treatments (C)		0.012	AB	NS					
	AC		NS	BC	NS					
	ABC		NS							

NS–Not Significant.

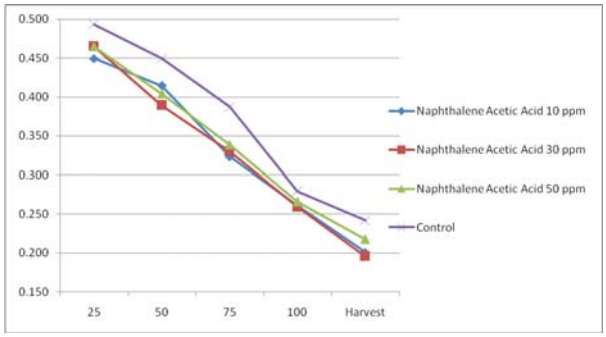

Fig. 2. Effect of NAA on acidity (%) of ber fruits during development (Pooled over both the seasons).

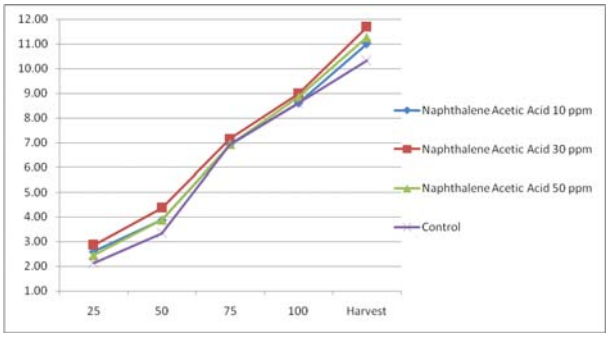

Fig. 3. Effect of NAA on total sugars (%) of ber fruits during development (Pooled over both the seasons).

Table 3. Effect of NAA on total sugars (%) of ber fruits during development

Treatment	Sugars (%) days after second spray									
	2007-08					2008-09				
	25	50	75	100	At harvest	25	50	75	100	At harvest
NAA 10 ppm	2.64	3.93	6.92	8.74	11.01	2.55	3.82	6.94	8.47	10.99
NAA 30 ppm	2.94	4.18	7.10	9.08	11.51	2.78	4.55	7.23	8.89	11.86
NAA 50 ppm	2.45	3.90	7.02	9.11	11.05	2.44	3.86	6.82	8.57	11.49
Control	2.07	3.37	7.03	8.63	10.14	2.20	3.30	6.85	8.55	10.49
C. D. (P=0.05) :	Intervals (A)		0.29	Year (B)	NS					
	Treatments (C)		0.26	AB	NS					
	AC		NS	BC	NS					
	ABC		NS							

NS–Not Significant.

application (8).

The ascorbic acid content is also directly influenced by application of PGRs as is expressed in Table 4 and Fig. 4. There was significant improvement in ascorbic acid content of ber fruits with NAA 30 ppm; however, the higher dose was detrimental for ascorbic acid percentage. In association with present evaluations, NAA when applied at slow growth phase exhibited

Table 4. Effect of NAA on ascorbic acid (mg/100 g) of ber fruits during development

Treatment	Ascorbic acid (mg/100 g) days after second spray									
	2007-08					2008-09				
	25	50	75	100	At harvest	25	50	75	100	At harvest
NAA 10 ppm	13.10	28.40	43.70	74.40	101.98	13.17	28.08	44.39	71.95	103.97
NAA 30 ppm	13.40	31.64	48.69	78.60	110.38	13.08	31.92	47.25	77.23	108.15
NAA 50 ppm	12.60	25.18	39.20	69.81	101.82	13.64	25.83	38.81	70.74	101.64
Control	14.44	30.99	41.81	72.05	92.81	13.22	30.70	41.49	71.92	95.74
C. D. (P=0.05) :	Intervals (A)		2.60	Year (B)	NS					
	Treatments (C)		2.33	AB	NS					
	AC		5.20	BC	NS					
	ABC		NS							

NS–Not Significant.

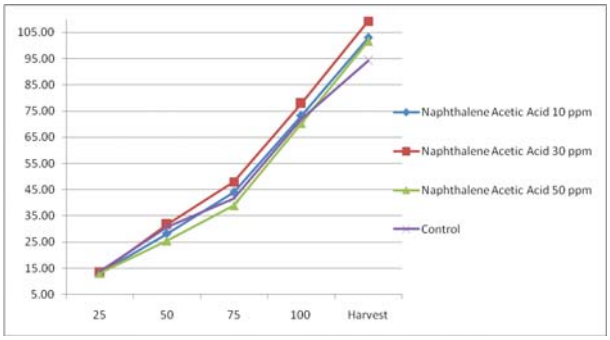

Fig. 4. Effect of NAA on ascorbic acid (mg/100 g) of ber fruits during development (Pooled over both the seasons).

the significant increase in ascorbic acid content of fruits (3, 13, 15). There was significant periodic improvement in ascorbic acid content with every interval of 25 days. The maximum increase was noticed towards maturity i. e. between 75 to 100 days interval. Similar periodic improvement in ascorbic acid of ber was reported by Sandhu *et al.* (14).

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Haryana J. hortic. Sci., **41** (3 & 4) : 141-142 (2012)

Evaluation of Economic Feasibility of Different Combinations of Nitrogen and Biofertilizers on Growth, Yield and Quality of Cabbage

LALU PRASAD YADAV* AND KAVITA ARAVINDAKSHAN
Department of Vegetable Science, Maharana Pratap University of Agriculture & Technology, Udaipur (Rajasthan), India
**(e-mail : yadavlaluprasad682@gmail.com)*

ABSTRACT : A field experiment was conducted to study the evaluation of economic feasibility of different combinations of nitrogen and biofertilizers on growth, yield and quality of cabbage during the **rabi** season of 2010-11 at Department of Vegetable Science, College of Horticulture & Forestry, Jhalawar. The experiment consisting of 17 treatments viz., four levels of nitrogen (control, 100, 125 and 150 kg) and three doses of biofertilizers (*Azotobacter, Azospirillium* and PSB) in combination with nitrogen levels and one is absolute control was laid out in simple RBD with three replications. The results revealed that the maximum net returns of Rs. 300022.2/ha with B : C ratio (6.48 : 1) were obtained when the crop was treated with treatment combination of 150 kg N+PSB and the minimum net profit of Rs. 129704.3/ha (absolute control) and 138662.3/ha (control).

Key words : Economics, nitrogen, biofertilizers, cabbage

Cabbage (*Brassica oleracea* var. *capitata* L.) is the most important member of genus *Brassica* grown in the world. It neutralizes acidity, improves digestion and appetite (3). Cabbage is suitable for both fresh and processed products. Nitrogen is a constituent of several macro and micro molecules including amino acid and is found to be associated with carbohydrates utilization and protein bio-synthesis. The deficiency of nitrogen leads to chlorosis, poor vegetative growth, reduced yield and quality of leafy vegetables (4). Its productivity depends on the use of balanced fertilizer and if not adequately fertilized, considerable yield losses are apparent. The indiscriminate use of chemical fertilizers increases soil acidity, impairs soil physical condition, reduces organic matter, creates micro nutrient deficiencies, increases plant susceptibility to pests and diseases, decreases soil lives, increases soil, water and air pollution via agricultural run-off and leaching. A spoonful of soil contains more organisms than there are people on the earth, 1 billion bacteria, 10-20 million actinomycetes, 1 million fungi, 10,020 million protozoa, 100,000 algae and some worms and insects (1). Biofertilizers include a range of nitrogen fixer's viz., *Rhizobium, Azotobacter, Azospirillium, Blue Green Algae* and *Azolla*. Out of these the importance of *Azotobacter* and *Azospirillium* has been well recognized for vegetable crops (2) and there are several reports to show the benefits of nitrogen fixing through *Azotobacter* and *Azospirillium*. The present day modern agriculture depends on heavy use of chemical fertilizers for boosting crop yield. However, these fertilizers are often in short supply and their indiscriminate use has an adverse effect on long term soil health and environment which has received global attention. Moreover, chemical fertilizers are costly and hence hardly affordable by small and marginal farmers, which constitute the majority of the farming community in developing countries. The most realistic solution is, therefore, to exploit the possibility of supplementing chemical fertilizers with biofertilizers of biological origin. These days biofertilizers have emerged as an important component to improve an overall crop performance, yield, nutrient supply, and reducing the quantity of chemical fertilizers (5). Biofertilizers are low cost, effective and renewable sources of plant nutrients to supplement chemical fertilizers and their role in cabbage as well as other vegetable production, therefore, assumes a special significance, particularly in the present context of very high cost of chemical fertilizers, so as to minimize the cost of production and to maintain biological productivity of soils, particularly because the farmers are reluctant to adopt recommended fertilizer doses due to the high cost and risk of crop failures on account of aberrant weather conditions. This research was undertaken to determine the most appropriate application affecting the economics of cabbage production.

MATERIALS AND METHODS

The experiment was conducted at Department of Vegetable Science, College of Horticulture and Forestry, Jhalrapatan city, Jhalawar. Jhalawar is situated between $23^0 45' 20''$ and $24^0 52' 17''$ North latitudes and $75^0 27' 35''$ and $76^0 56' 46''$ East longitudes covering an area of 6322.35 Km^2. Jhalawar district falls under sub-humid South Eastern Plains under agro-climatic zone V. The climate of Jhalawar is typically sub-humid and

Table 1. Economics of different treatments of cabbage cultivation with the application of different fertility levels and biofertilizers

Treatment	Yield of head/ha (q)	Cost of cultivation including the cost of treatment	Gross returns/ ha @ Rs. 800/q	Net returns (Rs./ha)	B : C ratio
T_0	213.99	41487.7	171192	129704.3	3.13
T_1	228.80	44377.7	183040	138662.3	3.13
T_2	302.88	45595.1	242304	196708.9	4.31
T_3	320.98	45899.4	256784	210884.6	4.59
T_4	376.95	46213.8	301560	255346.0	5.72
T_5	232.10	44477.7	185680	141202.3	3.18
T_6	332.51	45695.1	266088	220392.9	4.82
T_7	391.54	45999.4	313232	267232.6	5.81
T_8	416.46	46313.8	333168	286854.2	6.19
T_9	240.32	44477.7	192256	147778.3	3.32
T_{10}	334.15	45695.1	267320	221624.9	4.85
T_{11}	393.41	45999.4	314728	124877.0	5.84
T_{12}	418.10	46313.8	334480	288166.2	6.22
T_{13}	243.62	44477.7	194896	150418.3	3.38
T_{14}	337.45	45695.1	269960	224264.9	4.91
T_{15}	398.36	45999.4	318688	272688.6	5.82
T_{16}	432.92	46313.8	346336	300022.2	6.48

characterized by extremes of temperature both in summer and winter with high rainfall and moderate relative humidity. The soil of the experimental field was black cotton, pH 6.8, clay, and loam in texture, normal in reaction with medium in respect to nitrogen, phosphorus and potassium. The experiment consisting of 17 treatments viz., four levels of nitrogen (control, 100, 125 and 150 kg) and three doses of biofertilizers (*Azotobacter*, *Azospirillium* and PSB) in combination with nitrogen levels and one is absolute control was laid out in simple RBD with three replications.

The economics of the treatments is the most important consideration for making any recommendation to the farmers for its wide adoption. For calculating economics, the average treatment yield along with prevailing market rates for inputs and output were used. The net return was calculated by subtracting the cost of cultivation for each treatment from gross returns gained from the economic yield. B : C ratio was computed by dividing gross returns with cost of cultivation for each treatment.

RESULTS AND DISCUSSION

The economics of all treatments were calculated based on prevailing market prices of inputs and marketable yield. A perusal of data (Table 1) indicated that the cost of cultivation of cabbage crop was Rs. 41487.7/ha including labour charges, tractor charges, material inputs and fixed cost. The gross returns from sale of cabbage head were cultivated at the average prevailing market price of Rs. 800/q and are given in the same table. The net profit from cultivation under different treatments was worked out after subtracting cost of cultivation from gross returns. The economics of different treatments are presented in Table 1. An insight of data revealed that the maximum net profit of Rs. 300022.2/ha was obtained under the treatment T_{16} i. e. 150 kg N+PSB followed by T_{12} i. e. 150 kg N+*Azospirillium* and T_8 i. e. 150 kg N+*Azotobacter* which recorded net profit of Rs. 288166.2/ha with B : C ratio (6.48 : 1, 6.22 : 1 and 6.19 : 1), respectively. The minimum net profits of Rs. 129704.3 and 138662.3/ha were obtained in absolute control and control, respectively.

A perusal of data presented in Table 4.16 show that treatment T_{16} (150 kg N+PSB) resulted in maximum net profit of Rs. 3,00,022.20 followed by Rs. 2,88,166.20 under treatment T_{12} (150 kg N+*Azospirillum*) and Rs. 2,86,854.20 under T_8 (150+*Azotobacter*) with the benefit : cost ratio of 6.48 : 1, 6.22 : 1 and 6.19 : 1, respectively.

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Haryana J. hortic. Sci., **41** (3 & 4) : 143-149 (2012)

Studies on Physiological and Biochemical Parameters of Seed Quality in Coriander (*Coriandrum sativum* L.)

DESH RAJ AND SHER SINGH VERMA

Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India

ABSTRACT : In the present investigation, 10 coriander (*Coriandrum sativum* L.) varieties/genotypes were subjected to standard germination (%), seedling length (cm), seedling dry weight (mg), vigour index-I, vigour index-II, electrical conductivity (mS/cm/seed), tetrazolium test (%), accelerated ageing test (%), dehydrogenase activity test, respiration rate (µlO_2/seedling/h) and emergence rate index (%). The results revealed that all the genotypes/varieties showed the germination percentage above the Minimum Seed Certification Standard (60.0%). The germination percentage varied from 70.70 -93.00, whereas the genotype DH-269 had maximum germination and vigour index. Soaking period of 24 h for electrical conductivity, ageing period of 96 h for accelerated ageing test and five days old seedlings for respiration rate were found optimum for better results. The germination percentage after accelerated ageing ranged from 48.30 to 54.10%. The electrical conductivity ranged from 0.08-0.17 mS/cm/seed, whereas O_2 consumption for all the varieties/genotypes ranged from 22.80-32.20 µlO_2/seedling/h. The viability of all the varieties/ genotypes predicted by tetrazolium test and dehydrogenase activity test ranged from 80.0-90.0 and 0.04-0.11, respectively. The results revealed that the genotype DH-269 was found highly vigorous followed by Narnaul Selection. Hence, these genotypes were used for further breeding programme. The standard germination, vigour index-I, dehydrogenase activity test and respiration rate showed significant and positive correlation with emergence rate index, whereas electrical conductivity had significant and negative correlation with emergence rate index (-0.84**). The present study revealed that standard germination, vigour index-I, dehydrogenase activity test, electrical conductivity and respiration rate emerged as reliable predictors of field emergence.

Key words : Viability, vigour, electrical conductivity, tetrazolium test, accelerated ageing test, dehydrogenase activity, respiration rate

Seed has been an important entity since the crops were first domesticated. Quality seed is a basic input for releasing higher yield per unit area. It has been demonstrated and realized that the use of quality seed alone would increase productivity (24). The quality seed is the cheapest input in modern agriculture and it plays a pivotal role and determines quantity as well as quality of production. Therefore, the availability of genetically pure and vigorous seeds at planting time is important for achieving target of agricultural production. Among seed spices, the quality of seed is more important because of its high value. For increasing awareness among farmers about use of quality seeds of spices, there is a need to have some reliable parameters to evaluate seed quality before it is sown in the field. The quality of seed is generally estimated by its purity, germination and health.

Spices constitute an important group of agricultural commodities, which are virtually indispensable in the culinary art. They also play significant role in our national economy. There are so many spices grown for culinary purpose but among these, the coriander *(Coriandrum sativum* L.) is one of the most important spices used in two products (a) Coriander seed–the dried fruit of the plant and (b) Cilantro–the leaf of the plant. It has its own position in spices and is one of the earliest spices used by the mankind and extensively grown in India, Central Europe, Asia Minor and Morocco. The leaves are used for flavouring soups and some other food. The fruits are an important ingredient of curry powder, usually contributing the greatest quality of all the spices, followed by turmeric. It is used medically for a number of purposes, particularly as carminative. A limited amount is also used in pharmaceutical and perfumery. An infusion of coriander seed is useful in flatulence, indigestion, vomiting and other intestinal disorders. It is also used for curing bleeding piles, mucus diarrhea, rheumatism, neurologia & ciphalgia and locally in eye infection (2). Thus, biochemical and medical properties of this spice make it very important.

Now-a-days, the seed vigour as a quality attribute has gained significance as the germination does not reflect field performance potential of a seed lot/variety under varied environmental conditions. The advantages of high vigour seed are most apparent in early seedling growth and are often associated with rapid and high rate of emergence and stand establishment. Several vigour tests have gained wide acceptance, especially for certain species and in areas where production hazards are well known. It is also desirable to have inexpensive tests, which can be conducted in a reasonable short period. Hence, the coriander is one of the most important spice crops at national and international level. It is necessary to know the viability and vigour of coriander seed before it is exported or sold to the farmers. It has been observed that a little work has been conducted in this direction on this crop

and thus it is important to evaluate the various genotypes for seed viability and vigour. Keeping in view the importance of this crop, the present study was undertaken to determine the reliable parameters for seed viability and vigour in coriander (*Coriandrum sativum* L.).

MATERIALS AND METHODS

The seed materials for the present investigation comprising 10 genotypes of coriander viz., Hisar Anand, Pant Haritma, Narnaul Selection, DH-201, DH-208, DH-241, DH-242, DH-259, DH-266 and DH-269 were collected from the Department of Vegetable Crops, CCS Haryana Agricultural University, Hisar, India. Out of these 10 genotypes, the cultivars 'Hisar Anand' and 'Pant Haritma' are the released varieties at national level, whereas 'Narnaul Selection' is promising strain, which is recommended for the growing in coriander production area of Haryana, India. Seeds of all the varieties/genotypes were subjected to various viability and vigour tests in the Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar, India. The details of methods followed for recording the observations on various laboratory and field parameters are given below :

Standard Germination Test (%)

Hundred seeds of each variety/genotype in three replicates were placed in between sufficient moistened rolled towel papers and kept at 25^0C in the seed germinator. The final count was taken on 21st day and normal seedlings were expressed as germination per cent according to the Rules of International Seed Testing Association (11).

Seedling Length (cm)

At the time of final count, five seedlings from each replication were randomly removed and root and shoot lengths were measured and average of five seedlings was taken for final calculations.

Seedling Dry Weight (mg)

Ten normal seedlings were taken at the termination of germination test period and these were dried at 80^0C for 48 h and then seedling dry weight was recorded in mg. At last average weight of 10 seedlings was taken for calculation.

Seedling Vigour Index

The seedling vigour index-I was calculated as the product of seedling length (cm) and standard germination (%), whereas the seedling vigour index-II was measured as the product of seedling length and seedling dry weight (1).

Electrical Conductivity Test (mS/cm/seed)

The soaking period for coriander seed was standardized for above test. The 50 seeds were soaked in 100 ml beaker containing 75 ml distilled water for 12, 18, 24 and 30 h at 25^0C for three varieties, namely, Hisar Anand, Narnaul Selection and Pant Haritima. The maximum value of electrical conductivity was recorded at 24 h of the soaking period. Hence, 50 seeds of all the genotypes/varieties were soaked for 24 h at 25^0C temperature and electrical conductivity of seed leachates was measured with Systronics Conductivity Meter-306 and expressed as mS/cm/seed.

Tetrazoliun Test (%)

The seeds were soaked for 36 h in distilled water at room temperature. The pericarp of each seed was removed with the help of needle and forceps. Seeds were stained in 1.0% tetrazolium chloride solution at 30^0C for 4 h and the evaluation was done on the basis of staining of seeds (19).

Respiration Rate (μlO_2/seedling/h)

The O_2 uptake was measured with Gilson's Differential Respirometer. To find out the optimum stage of seedling for measuring the respiration rate of coriander, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 days old seedlings of three varieties viz., Hisar Anand, Narnaul Selection and Pant Haritima were used to determine age of seedling. Three randomly selected seedlings in each replication from each genotype were placed in the reaction flask containing 2 ml of distilled water and 0.2 ml of 10% KOH in the central well. A rolled filter paper strip of equal dimension was also placed in the central well to increase the surface area for absorption of CO_2. The temperature of water bath of Respirometer was set at 25^0C. The reaction flasks were attached and submerged in the water bath. The flasks were subjected to shaking of 78 oscillations/min for 30 min. Each set

was replicated thrice and rate of respiration was recorded as microlitres of oxygen absorbed per seedling per hour (μlO_2/seedling/h) at standard temperature and pressure. It was observed that the five days old seedlings absorbed maximum O_2 for respiration. After this, the optimum aged seedlings from all genotypes replicated thrice were used to measure O_2 uptake with the above mentioned procedure. The respiration rate was calculated by using the following formula :

$$\text{Respiration Rate} = \frac{O_2 \text{ Consumed}}{\text{Number of seedlings}} \times \text{Time}$$

Accelerated Ageing Test (%)

To observe the optimum time for accelerated ageing test (i. e. period of reduction of the germination up to 50%), sufficient number of seeds of three varieties (Hisar Anand, Narnaul Selection and Pant Haritima) were taken in a single layer on the wire mesh trays fitted in the plastic boxes. Each plastic box had 40 ml of distilled water. The boxes were placed in ageing chamber after closing of lids. The seeds were aged at 40°±1°C temperature and 100% relative humidity for 48, 72, 96 and 120 h followed by germination in three replications of 100 seeds each (11). The optimum time recorded for accelerated ageing was found 96 h. After standardization of this test, seeds from all the genotypes were subjected to accelerated ageing test in 100% RH at 40±1°C temperature for 96 h. Then seeds were evaluated in terms of standard germination only. The relation between germination of accelerated aged seeds and standard germination of normal seeds was also worked out.

Dehydrogenase Activity Test (DHA)

The DHA test was conducted as per method given by Kittock and Law (15). The reduction of 2, 3, 5 triphenyl tetrazolium chloride to red formazan by dehydrogenase enzyme in seed embryos is the basic principle of topographical tetrazolium test for seed viability. It is a quantitative method which may be used to determine varying dehydrogenase activity between seeds of similar viability and therefore, it is a measure of seed vigour. The representative seed samples of each lot, replicated thrice, were ground to pass through 20-mesh screen to obtain 200 mg flour. The flour was soaked in 5 ml of freshly prepared 1% 2, 3, 5 tetrazolium solution at 30°C. It was centrifuged after 4 h at 10,000 rpm for 3 min and supernatant was poured off. The formazan was extracted with acetone. Ten ml of acetone was added to the tube and kept for 16 h at room temperature. It was centrifuged for 3 min at 10,000 rpm and acetone solution containing formazan was transferred to the cuvette. The absorbance reading of solution was determined in spectrophotometer at 520 nm.

Emergence Rate Index

Four hundred seeds of all the 10 genotypes were sown in a randomized block design (RBD) replicated thrice at the research area of the Department of Seed Science & Technology, CCSHAU, Hisar. The number of seedlings emerged daily was counted up to 30 days after sowing. The emergence rate index (ERI) was estimated as follows (17) :

$$\text{ERI} = + \frac{\text{No. of seedlings emerged}}{\text{Days of first count}} + \cdots + \frac{\text{No. of seedlings emerged}}{\text{Days of final count R}}$$

RESULTS AND DISCUSSION

A number of viability and vigour tests have been recommended to evaluate the viability and vigour status of seeds of various cultivars based on physiological and biochemical parameters. In the present investigation, efforts were made to find out most practicable test, which could provide satisfactory and reproducible results with regards to field performance of the seeds. The analysis of variance of experimental design for laboratory and field parameters is presented in Table 1. The mean sum of squares due to varieties/genotypes was found highly significant for all the characters studied. The results of the present investigation revealed that the standard germination of all the genotypes was found more than the Minimum Seed Certification Standards (60.0%). The germination capacity of various cultivars ranged between 70.70 to 93.00%, whereas the genotype DH 269 showed the maximum germination (93.0%) and the cultivar DH-259 showed minimum germination (70.70%). The average value of all varieties/genotypes recorded 80.98% (Table 2).

Root and shoot lengths were measured after the germination test which has been presented in Table 2. The results indicated that the cultivar 'Narnaul Selection' showed longer roots, whereas the genotype DH-259 showed smallest roots among all the cultivars. Root length ranged from 12.80 to 19.20 cm and overall

Table 1. Analysis of variance for different seed quality parameters in coriander *(Coriandrum sativum* L.)

S. No.	Parameters	Mean sum of squares		C. V. (%)
		Genotype	Error	
1.	Standard germination (%)	72,86**	4.400	3.254
2.	Root length (cm)	11.12**	1.176	6.375
3.	Shoot length (cm)	4.81 **	2.335	7.913
4.	Dry weight/seedling (mg)	0.43**	0.002	1.304
5.	Vigour index-I	486399.24**	46884.0	7.340
6.	Vigour index-II	3575.03**	262.980	5.873
7.	Electrical conductivity (mS/cm/seed)	0.02**	0.002	0.615
8.	Tetrazolium test (%)	36.11*	9.950	4.503
9.	Accelerated ageing test (%)	3.43*	1.690	1.626
10.	Dehydrogenase activity test	0.02**	0.002	5.309
11.	Respiration rate (μlO_2/seedling/h)	25.25**	3.895	7.485
12.	Emergence rate index (%)	8.72*	2.320	14.461

*,**Significant at P=0.05 and P=0.01 levels, respectively.

Table 2. Mean values of different physiological parameters in coriander *(Coriandrum sativum* L)

Varieties/ Genotypes	Standard germination (%)	Root length (cm)	Shoot length (cm)	Seedling dry weight (mg)	Vigour index-I	Vigour index-II	Emergence rate index (%)
DH-201	73.00 (58.70)	15.10	18.20	3.74	2431.60	272.97	8.87
DH-208	83.00 (65.64)	17.80	20.70	3.76	3193.20	312.00	10.03
DH-241	80.70 (63.91)	18.40	20.30	3.46	3121.20	279.17	10.29
DH-242	75.70 (60.50)	19.10	19.50	3.86	2926.30	292.03	8.48
DH-259	70.70 (57.19)	12.80	16.80	3.00	2089.90	211.97	9.03
DH-266	83.00 (65.69)	17.60	20.50	2.86	3155.40	237.33	12.04
DH-269	93.00 (74.73)	16.50	19.80	3.40	3377.50	316.20	14.01
Hisar Anand	83.00 (65.63)	16.80	18.80	3.60	2952.70	298.80	9.80
Narnaul Selection	84.00 (66.46)	19.20	20.40	3.72	3319.30	296.27	11.74
Pant Haritma	83.70 (66.17)	16.80	18.30	2.92	2934.30	244.30	10.98
Overall mean	80.98 (64.46)	17.01	19.33	3.43	2950.14	276.10	10.56
Range	70.7-93.0	12.8-19.2	16.8-20.5	2.86-3.86	2089.9-3377.5	211.97-316.2	8.48-14.01
C. D. (P=0.05)	3.597	1.848	NS	0.085	371.382	27.814	2.632

Figures in parentheses are arcsine values. NS–Not Significant.

mean was recorded as 17.01 cm. The shoot length ranged from 16.80 to 20.70 cm, whereas genotypes DH-208 and DH-259 showed maximum and minimum shoot length, respectively. Dry weight of seedlings was also recorded which effected the vigour of the seedling as observed by Currah and Salter (6) in carrot. The dry matter per seedling ranged from 2.86 to 3.86 mg and it was found to be highest in genotype DH-242 (3.86 mg) followed by DH-208 (3.76 mg). The overall mean was recorded as 3.43 mg. The vigour index-I and vigour index-II ranged from 2089.50 to 3377.50 and 211.97 to 316.20, respectively. The maximum value for vigour index-I and II was found in genotype DH-269, whereas the genotype DH-259 recorded minimum value. It showed that genotype DH-269 was more vigorous than others and hence, the vigorous genotype can be used in further breeding programmes for better results. The average value recorded for seed vigour index-I and II was 2950.14 and 276.10, respectively.

The study on time course of electrical conductivity of seed leachates revealed that the electrical conductivity provided valuable information about storage. The electrical conductivity test of solution reflected the amount of leachates extruded from the seeds and the data are presented in Table 3. Before recording the electrical conductivity of all the genotypes, the soaking period was standardized and it was observed that the

soaking period of 24 h produced better results. Hence, the electrical conductivity of all the genotypes was recorded after soaking the seeds for 24 h. The data on electrical conductivity of leachates indicated that the highest membrane integrity was present in genotype DH-269 (0.08 mS/cm/seed) followed by cultivar Narnaul Selection (0.12 mS/cm/seed) and these genotypes may be termed as a good storers. The genotypes DH-259 and DH-201 showed higher value (0.17 mS/cm/seed) of electrical conductivity and thus both of these were rated as poor storers.

Tetrazolium test is generally used as a quick method for seed viability, where seed viability is determined on the basis of topographical staining of the live and storage tissue of the seed. The alive part of seed stained with red colour formazan, which indicated the viable part of the seed as reported by Jethani (12) and Sahoo and Swain (23) in coriander. The viability by tetrazolium test ranged from 80.0 to 90.0% and the overall mean was observed to be as 88.0%. The results showed that the standard germination and tetrazolium test expressed maximum viability percentage supporting the view that these tests are being conducted under optimum conditions to estimate the field emergence performance. The technique of accelerated ageing has provided valuable information on the storability and capacity of seeds to tolerate stress. In the present study, accelerated ageing period was standardized and a gradual declining in normal seedlings percentage during accelerated ageing was observed and the seeds lost their 50% germinability after 96 h of stress condition. Hence, the ageing period of 96 h was found to give desirable results. The genotype DH-269 showed maximum germination (54.1%) after accelerated ageing, hence, it had greater capacity to tolerate stress. The results revealed that there was a gradual decline in the percentage of normal seedlings after accelerated ageing. Similar results were reported by Verma *et al.* (27) in *Brassica* sp., Bailey *et al.* (4) in sunflower and Maity *et al.* (18) in mungbean. The average germination percentage in all the varieties/genotypes was recorded to be 52.12 (Table 3). Tao (25) in soybean and Karuna and Aswathaiah (13) in carrot observed that accelerated ageing was found good predictor of viability.

The dehydrogenase activity test with colorimetric estimation of formazan predicts the status of degree of aliveness of seed quickly. The range of optical density of formazon was estimated with the help of spectrophotometer. The results as periodic profile of absorbance of formazan have been presented in Table 3. The results revealed that highest intensity of formazan was observed in the seeds of genotype DH-269 (0.11) followed by the seeds of Narnaul Selection (0.10), whereas lowest in the genotype DH-259 (0.04). The average value recorded was 0.07 for all the genotypes. The seed respiration is a continuous process of degrading the stored seed reserves to provide metabolic energy for seed germination and seedling growth. It was observed that five days old seedlings were found to give the better results. Results revealed that the maximum oxygen uptake was recorded in the genotype DH-269 (32.20) followed by Narnaul Selection (28.70), whereas the minimum oxygen uptake was recorded for genotype DH-259 (22.80). The average oxygen uptake for all the genotypes/

Table 3. Mean values of different biochemical parameters in coriander (*Coriandrum sativum* L.)

Varieties/ Genotypes	Electrical conductivity (mS/cm/seed)	Tetrazolium test (%)	Accelerated ageing test (%)	Dehydrogenase activity test	Respiration rate ($\mu l.O_2$/seedling/h)
DH-201	0.17	80.00 (63.52)	49.3 (44.77)	0.05	23.30
DH-208	0.14	90.00 (71.67)	53.0 (46.70)	0.07	26.80
DH-241	0.15	90.00 (71.92)	52.3 (46.30)	0.06	26.20
DH-242	0.16	90.00 (71.69)	51.3 (45.73)	0.05	25.50
DH-259	0.17	80.00 (63.43)	48.3 (44.01)	0.04	22.80
DH-266	0.13	90.00 (71.73)	53.1 (46.76)	0.07	26.58
DH-269	0.08	90.00 (71.59)	54.1 (47.33)	0.11	32.20
Hisar Anand	0.14	90.00 (71.69)	52.9 (46.64)	0.05	28.30
Narnaul Selection	0.12	90.00 (71.59)	53.6 (47.05)	0.10	28.70
Pant Haritma	0.13	90.00 (71.71)	53.3 (46.86)	0.08	23.30
Overall mean	0.14	88.00 (70.05)	52.12 (46.22)	0.07	26.37
Range	0.08-0.17	80.0-90.0	48.30-54.10	0.04-0.11	22.80-32.20
C. D. (P=0.05)	0.01	5.41	NS	0.01	3.85

Figures in parentheses are arcsine values. NS–Not Significant.

Table 4. Simple correlation among different physiological and biochemical characters in coriander *(Coriandrum sativum* L.)

Characters	1	2	3	4	5	6	7	8	9	10	11	12
1. Standard germination (%)	1.00	0.44	0.60	0.06	0.87**	0.55	-0.92**	0.75**	0.93**	0.88**	0.84**	0.88**
2. Root length (cm)		1.00	0.84**	0.43	0.81**	0.56	-0.41	0.83**	0.69*	0.41	0.43	0.21
3. Shoot length (cm)			1.00	0.32	0.89**	0.60	-0.50	0.76**	0.73*	0.53	0.61	0.46
4. Seedling dry weight (mg)				1.00	0.20	0.79**	-0.04	0.09	0.01	0.01	0.27	0.33
5. Vigour index-I					1.00	0.66*	-0.79**	0.90**	0.95**	0.78**	0.78**	0.69*
6. Vigour index-II						1.00	-0.59	0.51	0.55	0.48	0.73*	0.24
7. Electrical conductivity (mS/cm/seed)							1.00	-0.67*	-0.83**	-0.89**	-0.86**	-0.84**
8. Tetrazolium test (%)								1.00	0.91**	0.55	0.60	0.49
9. Accelerated ageing test (%)									1.00	0.25	0.22	0.19
10. Dehydrogenase activity test										1.00	0.77**	0.91**
11. Respiration rate (μlO_2/seedling/h)											1.00	0.74*
12. Emergence rate index (%)												1.00

*,**Significant at P=0.05 and P=0.01 levels, respectively.

varieties was recorded as 26.37 μlO_2/seedling/h.

Under field conditions, the speed of seedling emergence was calculated as seedling emergence rate index and the results have been presented in Table 2. Results depicted that the highest value for emergence rate index was found in the genotype DH-269 (14.01) which was followed by genotype DH-266 (12.04) and Narnaul Selection (11.74). The average value of emergence rate index for all the genotypes was found 10.56%.

The correlation between laboratory and field parameters of different genotypes is presented in Table 4. The standard germination showed positive and significant correlation with vigour index-I (0.87**), tetrazolium test (0.75**), accelerated ageing (0.93**), dehydrogenase activity test (0.88**), respiration rate (0.84**) and emergence rate index (0.88**) but it showed negative and significant correlation with electrical conductivity (-0.92**). The correlation study revealed that there was a highly significant and positive correlation between standard germination and field emergence, suggesting that the germination test can be used successfully as prediction criteria of field performance of coriander seed. Similar results were also reported in chickpea (21), okra (20), rapeseed and mustard (27). The root and shoot lengths were found to be significantly correlated with vigour index-I, whereas seedling dry weight was found to be significantly correlated with vigour index-II (Table 4). The positive and significant association of vigour index-I with vigour index-II (0.66*) and emergence rate index showed that these parameters might be given due consideration for the prediction of seed quality and field establishment. Similar results were carried out by Ram *et al.* (22) in pigeonpea, Tekrony *et al.* (26) in soybean and Yadav and Dhankhar (28) in okra.

Negative and significant correlations were found between electrical conductivity and emergence rate index (-0.84**). The similar findings were reported by Kumari (16) in onion, Kharb *et al.* (14) in pigeonpea and Narwal (20) in okra. There was a significant and positive correlation between tetrazolium test and standard germination (0.75**) which indicated that the tetrazolium test helped in predicting the germination of seed as per the findings of Deswal and Chand (8) in rice bean and Dahiya *et al* (7) in sunflower. The respiration rate showed positive and significant correlation with emergence rate index (0.74*). The similar findings were also documented in the literature by Carver and Matthews (7) in pea, Gatica Vasouez *et al.* (9) in sunflower and Verma *et al.* (27) in barley. Emergence rate index showed a significant and positive correlation with standard germination (0.88**), vigour index-I (0.69*), dehydrogenase activity (0.91*) and respiration rate (0.74**) but it had negatively and significantly correlated with electrical conductivity (-0.84**). The similar observations to present findings have also been reported by Tao (25) in soybean, Alizaga *et al.* (3) in moong and Yadav and Dhankhar (28) in okra. It was predicted that genotype DH-269 had high values for accelerated ageing, respiration rate and dehydrogense activity test and hence, it can be used in further breeding programmes. The present study revealed that standard germination, vigour index-I, dehydrogenase activity test, electrical conductivity and respiration rate emerged as reliable predictors of field emergence but prediction of emergence rate index may be achieved by using electrical conductivity and respiration rate.

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Haryana J. hortic. Sci., **41** (3 & 4) : 150-152 (2012)

Effect of Plant Density and Irrigation Levels on Phenological and Physiological Characteristics of Chilli cv. HC-44

JAGAT SINGH AND J. N. BHATIA
CCSHAU Krishi Vigyan Kendra, Ambala City-134 003 (Haryana), India

ABSTRACT : The results on two most important agronomic aspects in chilli cv. HC-44 revealed that there was no significant difference in number of days taken to first flowering and fruit set in 50% plants during both the years of study. Number of days taken to ripening of first five fruits was affected significantly only due to irrigation levels. While root length, root biomass and biomass per plant along with fruits were significantly affected due to both plant density and irrigation levels during both the years. Lodging incidence (%) increased with the increase in frequency of irrigation during 1st year but it was not significantly affected during second year of study. Studies on dry matter content (%) of red ripe fruits decreased with the increase in frequency of irrigation and increased in plant density during both the years. There was no significant difference between the level of irrigation and plant density with respect to disease susceptibility during both the years.

Key words : Chilli, plant density, irrigation, physiological

Chilli (*Capsicum annuum* L.) is an important cash crop and remunerative vegetable crop of India and is grown both for home market and export. In Haryana, it occupies an area of about five thousand hectares which yields six thousand tonnes of dry chilli annually. Hisar Shakti (HC-44) is a high yielding chilli variety developed by CCSHAU, Hisar. Very little work has been done on this particular variety of chilli for improving the quality as well as yield. Hence, the present investigation was therefore undertaken to study the effect of plant density and irrigation levels on phenological and physiological characteristics of chilli cv. HC-44 under Hisar conditions.

MATERIALS AND METHODS

The present investigation was conducted at the Research Farm of the Department of Vegetable Crops, Chaudhary Charan Singh, Haryana Agricultural University, Hisar consecutively for two years in chilli cv. HC-44 . The experiment was laid out in split plot design with four replications having four irrigation levels in main plot viz., ID/CPE ratio of 0.5 (I_1), 0.75 (I_2), 1.0 (I_3) ID/CPE ratio of 0.5 (I_1), 0.75 (I_2), 1.0 (I_3) and 1.25 (I_4) and six plant densities in sub-plots viz., 36 plants/plot (D_1), 72 plants/plot (D_2), 30 plants/plot (D_3) and 60 plants/plot (D_4) thus comprising 24 treatment combinations. The field was divided into different plots measuring 3.6 x 2.7 m^2 having 2 m irrigation channels and 1 m buffer in between. The seeds of chilli cv. HC-44 were sown in the nursery and transplanting was done when the seeding attained at the age of 40 days. Plant to plant spacing was kept 45 cm in all the treatments. All the recommended packages of practices were followed during the course of investigation. Life irrigation was given equal in all the treatments during both the years and thereafter variable irrigation levels were scheduled as per treatments. The quality of water to be applied in each treatment was measured with the help of bucket. Observations on number of days taken to first flowering in 50% plants, number of days taken to first fruit set in 50% plants, number of days taken to ripening of first five fruits in 50% plants, root length, root biomass, biomass per plant, lodging incidence, dry matter content of fresh red ripe fruits and disease susceptibility were recorded. Two years data of various growth and yield contributing characters were pooled and analysed as suggested by Fisher (2).

RESULTS AND DISCUSSION

A perusal of data in Table 1 indicates that plant density and irrigation levels had no significant effect on number of days taken to first flowering and number of days taken to first fruit set in 50% plants during both the years. The results further revealed that the difference in number of days taken to ripening of first five fruits was significant only due to irrigation levels during both the years. Maximum (126.3 and 133.5) number of days taken to ripening of first five fruits was recorded when the crop was irrigated at I_3 level of irrigation during both the years, respectively. This might be due to vigorous plant growth under optimum soil moisture status. On the other hand less number of days taken to repening of first five fruits in 50% plants under lower (I_1) and higher (I_4) frequency of irrigation might be due to adverse effects of lower and higher soil moisture status on different growth processes of the plant.

Root length and root biomass per plant differed

Table 1. Effect of plant density and irrigation levels on number of days taken to first flowering and fruit set in 50% plants and number of days taken to repining of first five fruits in 50% plants in chilli cv. HC-44

Treatment	No. of days taken to first flowering in 50% plants		No. of days taken to first fruit set in 50% plants		No. of days taken to ripening of first five fruits in 50% plants	
	1st year	2nd year	1st year	2nd year	1st year	2nd year
Plant density						
D_1	47.1	60.8	54.8	66.5	124.0	130.8
D_2	45.4	61.6	52.7	67.9	124.1	130.7
D_3	47.7	60.0	56.0	66.3	124.6	131.8
D_4	45.7	61.9	54.0	68.4	122.7	132.2
D_5	48.6	59.4	55.8	66.0	124.3	130.9
D_6	46.7	60.8	54.1	67.2	127.7	130.7
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS
Irrigation levels						
I_1	46.2	61.0	54.1	66.9	120.0	127.1
I_2	48.1	60.9	55.0	67.5	124.4	132.8
I_3	47.3	60.6	55.4	67.1	126.3	133.5
I_4	46.1	59.4	53.8	66.7	125.2	131.4
C. D. (P=0.05)	NS	NS	NS	NS	3.1	2.5

NS–Not Significant.

significantly due to plant density and irrigation during both the years (Table 2). Maximum (26.3 and 19.9 cm) root and root length biomass (34.9 and 24.4 g) were recorded with the lowest plant density i. e. D_5 during both the years, respectively. These growth and yield contributing characters increased with the decrease in plant density and vice versa might be due to poor competition for moisture, nutrients, light and space under lower plant densities which led to vigourer vegetative growth of the plants. Similar results were reported by Aliyu and Yusuf (1) and Sairc and Ilic (4) in chilli. Root length, root biomass per plant and biomass per plant along with fruits increased with the increase in frequency of irrigation up to I_3 during first year and up to I_2 during second year of study. Increase in above characteristics might have been due to the beneficial effects of the optimum soil moisture status on various physiological and metabolic processes of the plant such as cell elongation, photosynthesis respiration, water absorption and nutrient uptake, etc.

Table 2. Effect of plant density and irrigation levels on root length, root biomass per plant and biomass per plant along with fruits in chilli cv. HC-44

Treatment	Root length (cm)		Root biomass (g)		Biomass/plant (g)	
	1st year	2nd year	1st year	2nd year	1st year	2nd year
Plant density						
D_1	24.5	18.3	32.5	23.2	525.3	342.3
D_2	21.1	16.1	27.8	21.2	438.7	293.2
D_3	26.3	19.1	33.6	24.4	559.2	341.4
D_4	23.2	17.3	29.8	22.6	458.4	308.6
D_5	26.3	19.9	34.9	24.1	569.9	342.3
D_6	24.0	18.5	31.2	23.2	468.4	318.9
C. D. (P=0.05)	2.3	1.3	2.4	2.5	6.2	10.0
Irrigation levels						
I_1	22.3	16.5	28.7	20.6	376.0	287.7
I_2	25.3	22.3	32.1	26.5	540.9	374.7
I_3	27.2	19.1	33.4	24.2	550.5	360.6
I_4	22.0	14.9	32.3	21.3	545.9	274.9
C. D. (P=0.05)	2.2	2.9	2.1	2.8	8.7	11.2

Similar findings were reported by Wankhade and Morey (6) and Wiertz and Lenz (7) in chilli. The decrease in root length, root biomass per plant and biomass per plant under I_3 and I_4 levels of irrigation in second year of study might be due to the adverse effects of excess moisture existing in root zone for longer period. Poor aeration and decaying of roots retarded the physiological activities of the plants which led to poor vegetative growth of the plants. Results are in line with those of Palevitch *et al*. (3) in chilli.

Results given in Table 3 revealed that lodging incidence and dry matter content of fresh red ripe fruits were significantly affected by plant density and irrigation levels. The higher lodging incidence under lower plant density was due to the increased vegetative growth, number of fruits and their size. The applications of higher number of irrigation resulted in more lodging incidence which might be due to higher vegetative and reproductive growth of the plants and higher soil moisture status due to which soil was loosely held by the roots which led to the increased lodging incidence. A direct relationship was found between plant density and per cent dry matter content of fresh red ripe fruits. Higher percentage of dry matter content under higher plant density may be due to lower moisture content of fresh red ripe fruits under higher plant density. Maximum dry matter content was recorded under the lowest (I_1) frequency of irrigation during both the years which might be due to low moisture content of fresh red ripe fruits under lower irrigation. These results are in consonance with the findings of Suh *et al.* (5).

Table 3. Effect of plant density and irrigation levels on lodging incidence, dry matter content of fresh red ripe fruits and disease susceptibility in chilli fruits in cv. HC-44

Treatment	Lodging incidence (%)		Dry matter content of fresh red ripe fruits (%)		Disease susceptibility (%)	
	1st year	2nd year	1st year	2nd year	1st year	2nd year
Plant density						
D_1	8.0	6.6	24.9	24.7	5.7	8.8
D_2	7.7	5.7	27.6	27.3	5.7	6.8
D_3	10.3	6.0	23.6	23.4	5.7	7.0
D_4	7.7	5.7	24.6	24.5	6.2	6.5
D_5	8.4	5.7	20.9	20.7	5.7	7.4
D_6	8.1	5.7	22.9	22.7	5.7	7.4
C. D. (P=0.05)	1.8	NS	1.0	1.2	NS	NS
Irrigation levels						
I_1	6.1	5.7	27.2	27.0	5.7	7.7
I_2	6.9	6.3	24.7	24.5	5.9	7.0
I_3	10.1	5.9	22.8	22.5	5.7	7.9
I_4	10.5	5.7	21.7	21.5	5.8	6.7
C. D. (P=0.05)	1.6	NS	1.0	0.7	NS	NS

NS–Not Significant.

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Haryana J. hortic. Sci., **41** (3 & 4) : 153-155 (2012)

Effect of Size of Seed Tubers on Production of Small Potato Seed Tubers

S. P. SINGH*
Central Potato Research Station, Gwalior-474 006 (M. P.), India
**(e-mail : drshivpratapsingh@yahoo.co.in*)

ABSTRACT : A field experiment was conducted during 2005-06 to 2006-07 at Central Potato Research Station, Gwalior to study the effect of size of seed tubers on production of 10-20 g seed tubers of potato (*Solanum tuberosum* L.). Results showed that highest number of small (10-20 g) tubers (7.1 lacs/ha) and tuber yield (124 q/ha) were recorded with 50-60 g planted tubers which were significantly higher over 10-20, 20-30 and 30-40 g planted tubers. Total number of tubers (15.37 lacs/ha) was highest with 40-50 g planted seed tubers, however, total tuber yield in different treatments was on par. Highest net returns of Rs. 58,477/ ha were recorded with 10-20 g planted seed tubers. Benefit : cost ratio (1.9) and return/rupee spent (0.9) were also highest with the same treatment. It was concluded that planting of 10-20 g tubers reduced cost of cultivation, increased net returns (Rs. 58.48 thousand/ha), benefit : cost ratio (1.9) and net return/rupee spent (0.9).

Key words : Seed size, small seed tubers, net returns

Formal system meets about 20% seed requirement of the country. The remaining seed requirement is met by the seed produced by informal system (1). The cost of production has continuously risen without commensurate increase in returns (7). In general, seed size plays significant role in increasing potato yield, and there is direct correlation between seed size and tuber yield. Among various inputs for potato, seed alone costs 40-50% of the total cost of cultivation (2, 3, 8).

Whole seed generally produces a heavier crop, the per cent emergence is greater and there is a less likelihood of spreading disease and further contamination of crop from which seed is usually harvested to produce subsequent ware crops. There is demand of healthy small size seed tubers weighing 10-20 g for planting which have almost equal yield potential if planted at a closure spacing and harvested at full maturity, but availability of such tubers is a problem. Keeping above points in view, a field experiment was conducted to find out suitable size of seed tuber for production of small seed tubers.

MATERIALS AND METHODS

A field experiment was conducted at the Central Potato Research Station, Gwalior, India during 2005-06 and 2006-07. The silty clay loam soil of experimental field had organic carbon 0.44%, available N 180, P 6.9 and K 280 kg/ha with pH of 6.7. Treatments consisted of five seed sizes viz., 10-20, 20-30, 30-40, 40-50 and 50-60 g. Haulm cutting in all the treatments was done at 65 days after planting (DAP).The experiment was planted in randomized block design with four replications. Well sprouted seed tubers of cv. Kufri Ashoka were planted on 7 November, 2005 and 4 November 2006 at a row to row spacing of 40 cm and tuber to tuber spacing of 10 cm. Nitrogen, phosphorus and potassium were applied @ 150, 26 and 84 kg/ha, respectively. Full doses of P through single super phosphate, K through muriate of potash and half dose of N (75 kg/ha) through ammonium sulphate were applied at the time of planting. Remaining half dose of N (75 kg/ha) was applied through urea at the time of earthing up. Hoeing and earthing up were done on 27 November, 2005 and 20 November 2006 during first and second years, respectively. Overall, five irrigations were applied during both the years. First irrigation was given just after planting. Haulm cutting was done on 12 January 2006 and 9 January 2007 at 65 DAP in all the treatments. Crop was harvested on 1 February 2006 and 19 February 2007.

RESULTS AND DISCUSSION

Growth and Yield Attributes

Plant height : There was no significant effect of different seed size tubers on plant height of potato.

Number of stems/running metre : Increasing seed size increased number of stems per running metre from 39 with 10-20 g planted tubers to 102 with 50-60 g planted tubers (Table 1). Seed tubers of 50-60 g recorded highest number of stems and were significantly higher over all other treatments. It may be due to higher number of sprouts per unit area as number of sprouts are influenced by the size of the seed. Similar results were reported by Mettej *et al.* (4).

Table 1. Effect of size of seed tubers on growth, yield attributes and yield of potato (Pooled data for two years)

Size of planted seed tubers	Plant height (cm)	Stems/ running metre	No. of tubers/ plant	No. of tubers (thousand/ha)				Proportion of different size of tubers by number (%)			Tuber yield/ plant (g)	Tuber yield (t/ha)			
				<10 g	10-20 g	>20 g	Total	<10 g	10-20 g	>20 g		<10 g	10-20 g	>20 g	Total
10-20 g	37.9	39	5.0	429	509	323	1261	34.0	40.4	25.6	99	2.0	8.5	14.2	24.7
20-30 g	39.2	59	5.1	415	510	353	1278	32.5	39.9	27.6	102	1.9	8.9	14.8	25.6
30-40 g	37.7	65	5.6	502	580	321	1403	35.7	41.3	23.0	108	2.5	10.0	14.5	27.0
40-50 g	40.5	78	6.1	569	649	319	1537	37.0	42.2	20.8	108	2.7	10.8	13.4	26.9
50-60 g	40.3	102	6.1	561	707	266	1534	36.6	46.1	17.3	110	2.8	12.4	12.4	27.6
C. D. (P=0.05)	NS	19	0.9	152	72	47	213	35.2*	41.9*	22.9*	NS	NS	2.2	2.0	NS

*Mean value. NS–Not Significant.

Number of tubers/plant : Increase in size of seed tubers increased number of tubers per plant (Table 1). Highest number of tubers per plant was recorded with 50-60 g planted tubers and was significantly higher over 10-20 and 20-30 g planted seed tubers. Number of tubers/plant is governed by number of stems per plant. Since, higher number of stems/plant was recorded with 50-60 g planted seed tubers, hence, this treatment also gave higher number of tubers per plant.

Number of tubers/ha : Highest number of <10 g tubers was recorded with the planting of 40-50 g seed tubers which was significantly higher over 20-30 g planted seed tubers (Table 1). Production of <10 g tubers with the planting of 10-20, 30-40 and 50-60 g seed tubers was statistically on par.

Increase in size of planted seed tubers increased production of 10-20 g tubers. Highest number of 10-20 g tubers was recorded with 50-60 g planted seed tubers which was significantly higher over 10-20, 20-30 and 30-40 g planted seed tubers. Production of 10-20 g tubers in 40-50 g planted seed tubers and 50-60 g planted seed tubers was statistically on par. Similar results were reported by Singh and Kushwah (8) and Singh *et al.* (5).

Planting of 50-60 g size seed tubers produced 266 thousand tubers per ha having >20 g weight and was significantly lower over all other treatments. This may be due to production of large number of tubers in limited space leaving little space for its development/ bulking.

Highest total number of tubers was recorded with the planting of 40-50 g seed tubers which was significantly higher over 10-20 and 20-30 g planted seed tubers. Production of total number of tubers with 30-40, 40-50 and 50-60 g planted tubers was statistically on par.

Highest proportion of 10-20 g tubers (46.1%) was recorded with the planting of 10-20 g tubers and lowest proportion (17.3%) of >20 g tubers was recorded with the planting of 50-60 g tubers.

Tuber yield : Tuber yield per plant increased with the increase in size of planted tubers (Table 1). It may be due to more competition among the plants. Production of <10 g tubers was not affected by different sizes of planted tubers. Highest tuber yield (12.4 t/ha) of 10-20 g tubers was recorded with the planting of 50-60 g seed tubers which was significantly superior over all other treatments except 40-50 g planted seed tubers. Planting of 40-50 and 50-60 g seed tubers produced almost equal tuber yield of 10-20 g.

Lowest tuber yield of >20 g tubers was recorded with the planting of 50-60 g seed tubers which was significantly lower than 20-30 and 30-40 g planted seed tubers.

Total tuber yield was not affected by planting of different sizes of seed tubers and was found to be non-significant. It may be due to more competition among the plants due to closer spacing. Similar results were reported by Singh *et al.* (6).

Increasing size of planted seed tubers produced almost equal proportion of <10 g tubers. Increase in size of planted seed tubers increased proportion of 10-20 g tubers which was highest with 50-60 g planted seed tubers, however, increasing seed sizes reduced the proportion of >20 g tubers.

Highest proportion of >20 g tubers (57.8%) was recorded with 20-30 g planted seed tubers and lowest with the 50-60 g planted seed tubers.

Economics

Increase in size of planted seed tubers increased cost of cultivation (Table 2) from Rs. 65.02 thousand/ha with 10-20 g seed tubers to Rs. 145.02 thousand/ha with 50-60 g planted seed tubers due to increase in

seed rate/ha. Similarly, gross returns increased from Rs. 123.5 thousand/ha to Rs. 138 thousand/ha from 10-20 to 50-60 g planted tubers. Increase in gross returns was not proportionate to the cost of cultivation as yield could not increase proportionately. Increase in cost of planted seed tubers reduced net returns. Highest net returns of Rs. 58.48 thousand/ha were recorded with the planting of 10-20 g seed tubers and were lowest (Rs. 9.48 thousand/ha) with 40-50 g tubers and were negative (-Rs. 7.02 thousand/ha) with 50-60 g planted seed tubers due to use of higher seed rate which added to cost of cultivation without adding much to the tuber yield. Highest benefit : cost ratio (1.9) was recorded with 10-20 g planted seed tubers and lowest (0.9) with 50-60 g planted seed tubers.

CONCLUSION AND RECOMMENDATION

It was concluded that planting of 10-20 g tubers was economical proposition. Planting 10-20 g tubers reduced cost of cultivation, increased net returns (Rs. 58.48 thousand/ha), benefit : cost ratio (1.9) and net returns per rupee spent (0.9).

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Haryana J. hortic. Sci., **41** (3 & 4) : 156-158 (2012)

Seed Production Potential of Okra under Changing Climatic Scenario in Northern Plain of India

VIKAS SHARMA, VIJAYPAL SINGH AND A. C. YADAV
Department of Vegetable Science, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India

ABSTRACT : An experiment was conducted at Vegetable Research Farm and Seed Technology Centre of CCS Haryana Agricultural University, Hisar during rainy season to evaluate the effect of different sowing time and plant spacing on quality seed production of okra cv. Hisar Unnat. The experiment was laid out in split plot design with three replications having four sowing dates viz. second week of June, last week of June, second week of July and last week of July as main plot treatments and four spacing viz. 45 x 20 cm, 45 x 30 cm, 60 x 20 cm and 60 x 30 cm as sub-plot treatments. Different dates of sowing and plant density significantly influenced the growth, yield and quality parameters. Maximum plant emergence (64.92%), number of branches per plant (4.95), number of flowers per plant (20.78), number of seeds per fruit (57.56), total seed yield (18.61 q/ha), seedling length, seedling dry weight and vigour index II were recorded in second week of June sown crops. Plant spacing of 60 x 30 cm was found better for plant emergence (63.09%), number of branches per plant (4.91), number of seeds per fruit (57.03) and seed yield per hectare (15.57 q/ha) as compared to other spacings. Maximum seedling length, seedling dry weight and vigour index II were also recorded under 60 x 30 cm plant spacing.

Key words : Okra, seed production, sowing date, plant spacing

Okra is an important annual vegetable crop propagated through seed in tropical and sub-tropical regions of the world. It belongs to family 'Malvaceae' and is grown mainly for its tender green fruits used as vegetable in India. In Haryana state, it is grown twice a year during spring-summer (March-June) and rainy (July-October) seasons. Besides the environmental factors, seed production in okra is influenced by different sowing time and plant spacing. Therefore, there is an urgent need to find out the suitable sowing time and plant population for developing good quality seed production of okra.

MATERIALS AND METHODS

The experiment was conducted at Vegetable Research Farm and Seed Technology Centre of CCS Haryana Agricultural University, Hisar during the rainy season to evaluate the effect of different sowing time and plant spacing on quality seed production of okra cv. Hisar Unnat. The experiment was laid out in split plot design with three replications having four sowing dates viz., second week of June, last week of June, second week of July and last week of July which were taken as main plot treatments and four spacings viz., 45 x 20 cm, 45 x 30 cm, 60 x 20 cm and 60 x 30 cm which were taken as sub-plot treatments. Thus, made a total of 16 treatment combinations.

RESULTS AND DISCUSSION

The highest plant emergence (64.92%) was recorded in second week of June sown crop which was significantly higher than all other sowing times. Lowest plant emergence (61.15%) was recorded in last week of July sown crop. Plant density had no influence on germination in the field.

Maximum number of branches (4.95) was observed in second week of June sown crop which was significantly higher from all other sowing times. High density produced more branches per plant in comparison to low density. The wider spacing (60 x 30 cm) produced maximum (4.91) number of branches per plant. This might be due to the fact that at wider spacing plants got more space for lateral growth and there might be a tendency towards more branching which was significantly higher than other. Similar observation was given by Singh *et al.* (3, 4).

The data showed almost an increasing trend in number of days to flower initiation from second week of June onwards. Highest number of days (44.50) to flower initiation was recorded when the crop was sown on last week of July, while lowest number of days (36.50) for flower initiation was recorded on second week of June which was followed by last week of June. Plant density also had significant effect on days to flower initiation. Maximum number of days (44.25) for flower initiation was taken when the plants were spaced at 45 x 20 cm, while the widest spacing i. e. 60 x 30 cm took minimum (36.75) days for flower initiation.

Maximum number of flowers per plant (20.78) was observed in early sown crop (second week of June). These decreased gradually with delayed sowing. Minimum number of flowers (14.46) per plant was observed when crop was sown on last week of July. Similarly, plant density also had influence on number

Table 1. Effect of sowing time and plant spacing on growth and quality characters of okra seed crop

	Characters								
	Plant emergence (%)	No. of branches/ plant	Days to flower initiation	No. of flowers/ plant	No. of seeds/ fruit	Seed yield (q/ha)	Seedling length (cm)	Seedling dry weight (g)	Seed vigour index-II
Sowing time									
Second week of June	64.92	4.95	36.50	20.78	57.56	18.61	17.74	1.13	86.15
Last week of June	63.41	4.20	39.00	17.43	55.75	15.57	17.11	1.07	79.65
Second week of July	61.87	3.53	41.75	15.44	52.13	11.59	16.39	1.02	71.86
Last week of July	61.15	2.43	44.50	14.46	50.33	8.52	15.80	0.94	67.51
C. D. (P=0.05)	0.90	0.21	2.97	0.60	0.58	0.49	0.67	0.11	8.30
Plant spacing (cm)									
45 x 20	62.63	2.69	44.25	15.27	49.19	12.06	15.20	0.86	58.39
45 x 30	62.91	4.75	39.25	17.91	56.50	13.94	17.23	1.04	77.13
60 x 20	62.71	3.25	41.50	16.23	53.06	12.74	16.41	0.98	72.27
60 x 30	63.09	4.91	36.75	18.69	57.03	15.57	18.19	1.28	97.43
C. D. (P=0.05)	NS	0.22	1.58	0.77	0.75	1.29	0.40	0.07	5.60

NS–Not Significant.

of flowers per plant significantly. The maximum number of flowers per plant (18.69) was recorded at a spacing of 60 x 30 cm. The minimum number of flowers (15.27) was recorded at a spacing 45 x 20 cm. Maximum number of seeds per fruit (57.56) was recorded in second week of June sown crop which was significantly higher than other dates of sowing. The lowest number of seeds per fruit (50.33) was recorded in last week of July sowing. Various spacing also influenced seeds per fruit significantly. The number of seeds per fruit was recorded maximum (57.03) at 60 x 30 cm spacing, while minimum (49.19) number of seeds per fruit was found when plants were spaced at 45 x 20 cm.

The highest seed yield (18.61 q/ha) was observed in second week of June sown crop, which proved to be statistically superior over all other sowing dates. Because all the growth and yield attributing characters directly or indirectly favoured the total seed yield in second week of June sown crop followed by last week of June sown crop. The lowest seed yield (8.52 q/ha) was observed in last week of July sowing. Higher seed yield of okra in June sown crop was reported by Yadav *et al.* (5). Plant density also had a significant effect on seed yield per hectare. The highest seed yield (15.57 q) was recorded at 60 x 30 cm spacing as compared to other spacings. These findings are similar to the findings of Birbal *et al.* (1) and Sharma and Gupta (2) who observed higher seed yield under 60 x 30 cm spacing in comparison to closer and wider spacing.

Longest length of seedling (17.74 cm) was recorded in second week of June sown crop, which was found to be statistically at par with last week of June (17.11 cm), while significantly superior to all other sowing times. Plant density also had significant influence on seedling length. Seedling dry weight was found to be highest in second week of June sown crop planted at a spacing of 60 x 30 cm which was superior to other dates of sowing and spacings.

The vigour index-II is a function of germination and seedling dry weight. Higher value of vigour index-II was observed in second week of June sown crop (86.15), which was significantly higher than all other sowing dates. The lowest value of vigour index-II was recorded in last week of July sown crop (67.51). Plant density also had significant effect on vigour index-II. The highest vigour index-II value (97.43) was observed at 60 x 30 cm spacing and it was significantly higher than all other plant spacings. The lowest value (58.39) was observed under plant spacing of 45 x 20 cm. Yadav *et al.* (5) reported that significant higher values were observed for seedling length and vigour index in 13 June sown crops as compared to other sowing dates.

It may be concluded from findings of the present investigation that seed harvested from second week of June sown crop planted at 60 x 30 cm spacing was bold and more vigorous and gave higher seed yield.

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Haryana J. hortic. Sci., **41** (3 & 4) : 159-163 (2012)

Effect of Irrigation, Fertility and Spacing on Carrot Seed Crop (*Daucus carota* L.) cv. Hisar Gairic

VIKASH HOODA, VIJAYPAL SINGH AND A. C. YADAV
Department of Vegetable Science, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India

ABSTRACT : The experiment was conducted at Vegetable Research Farm of CCS Haryana Agricultural University, Hisar, over a period of two years. There were 27 treatment combinations comprising three irrigation levels (60, 90 and 120 mm CPE), three fertility levels (60 : 30 : 30, 80 : 40 : 40 and 100 : 50 : 50 N : P : K kg/ha) and three plant spacings (30 x 30, 30 x 45 and 30 x 60 cm) with three replications. Maximum plant height (145.83 and 137.72 cm), number of branches per plant (7.25 and 6.76), first order umbels and second order umbels per plant were produced when the crop was irrigated at 60 mm CPE during both the years, respectively. Highest seed yield of main umbel (6.18 and 5.95 g), first and second order umbels per plant and per hectare seed yield (11.22 and 10.06 q/ha) were recorded by irrigating the crop at 60 mm CPE in comparison to irrigation at 90 and 120 mm CPE during both the years of investigation. Crop supplied with fertility dose of 100 : 50 : 50 NPK kg/ha produced maximum plant height, number of branches, first order umbels and second order umbels per plant, seed yield per plant and per hectare (10.49 and 9.54 q/ha) in comparison to other two fertility levels i. e. 80 : 40 : 40 and 60 : 30 : 30 N : P : K kg/ha during both the years of experimentation. 30 x 30 cm spacing gave maximum plant height (139.34 cm) and minimum under widest spacing i. e.30 x 60 cm. Number of branches (6.80 and 6.36) and umbels per plant were significantly higher under wider spacing i. e. 30 x 60 cm. Highest seed yield per hectare (12.02 and 11.36 q/ha) was obtained under closest spacing of 30 x 30 cm during both the years of investigation.

Key words : Carrot, irrigation, fertility, spacing

Carrot (*Daucus carota* L.) is a popular cool season root vegetable of Umbelliferae family. It is cultivated in temperate countries during spring and summer season, while in tropical region during winter season. It is used in several forms namely salad, cooked vegetable and pickles, etc.

The area under carrot crop is increasing every year and the demand for quality seed is also increasing fast. The seed is the basic, most important and cheapest input and has profound influence on the ultimate yield of the crop. In carrot, the demand for quality seed especially of Asiatic type is not only within the country but there are possibilities of export to other countries in tropical and sub-tropical regions where seed production has not yet been commercially exploited.

A number of factors are responsible for quality seed production of carrot. Among these factors the optimum irrigation, fertility and plant spacing are the principal factors, which affect both qualitative and quantitative yielding capacity of carrot seed crop.

MATERIALS AND METHODS

The present investigation was conducted at Vegetable Research Farm of the Department of Vegetable Science of CCS Haryana Agricultural University, Hisar, over a period of two years (2004-05 and 2005-06). There were 27 treatment combinations comprising three irrigation levels (60, 90 and 120 mm CPE), three fertility levels (60 : 30 : 30, 80 : 40 : 40 and 100 : 50 : 50 N : P : K kg/ha) and three plant spacings (30 x 30, 30 x 45 and 30 x 60 cm) which were laid out in a split-split plot design with three replications.

RESULTS AND DISCUSSION

Plant Height

Maximum plant height (145.83 cm during 2004-05 and 137.72 cm during 2005-06) was recorded when the crop was irrigated at 60 mm CPE (I_1). Minimum plant height of 128.58 cm in 2004-05 and 118.95 cm during 2005-06 was observed when crop was irrigated at 120 mm CPE in I_3 treatment. The pronounced effects of irrigation levels on plant height might be due to beneficial effect of water on cell turgidity and cell elongation. These observations are also supported by the results of Batra (2).

Fertility levels also significantly influenced the plant height during both the years. The height of plants was appreciably favoured by high fertility (F_3) treatments followed by F_2. Highest plant height (140.55 cm in 2004-05) was observed with 100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha (F_3 treatment) fertility treatment which was followed by application of 80 kg N, 40 kg P_2O_5 and 40 kg K_2O/ha (F_2) and the minimum (126.12 cm in 2005-06) height was recorded with 60 kg N, 30 kg P_2O_5 and 30 kg K_2O/ha (F_1). Plant height was reported to increase with the application of nitrogen reported by Malik and Kanwar (5) and Ahmed and Tanki (1) in carrot.

No significant difference was observed under different

levels of spacing on plant height during both the years of experimentation.

Branches/Plant

Maximum branches (7.25 during 2004-05 and 6.76 during 2005-06) were recorded in the crop when irrigated at 60 mm CPE (I_1) during both the years. The minimum branches (6.32 during 2004-05 and 5.81 during 2005-06) were recorded when crop was irrigated at 120 mm CPE (I_3) in each year. The pronounced effects of irrigation levels on number of branches per plant might be attributed to beneficial effect of water on cell turgidity, cell elongation, photosynthesis, respiration, uptake of nutrients and translocation of photosynthates to the active growing plant parts. These observations are also supported by the results of Batra (2), Yadav (15) and Nain (9). Fertility levels also influenced branches per plant significantly during both the seasons. Branches per plant increased with each increase in fertility level. Maximum branches (6.85 in 2004-05 and 6.39 in 2005-06) were observed at higher fertility level (F_3). The minimum (6.13 in 2005-06) branches per plant were recorded in F_1 fertility treatment. The branches per plant in F_1 and F_2 treatment of fertility were found statistically at par.

Different spacing levels also significantly affected the number of branches per plant. Wider spacing (60 x 30 cm) produced greater number of branches (6.80 in 2004-05 and 6.36 in 2005-06) per plant as compared to closer spacing (30 x 30 cm) which produced 6.62 branches during first year and 6.12 during second year. Higher number of branches per plant under wider spacing can be attributed to plenty of space, air, light and nutrients available to the plants in comparison to closer spacing. The results are in concurrence with those obtained by Singh *et al.* (14) and Muhammad and Anjum (8) in carrot.

Number of First Order Umbels

Each irrigation level significantly affected the number of first order umbels per plant (Table 1). Highest number of first order umbels per plant (8.46 during 2004-05 and 7.84 during 2005-06) was recorded in I_1 irrigation treatment. While lowest (6.11 in first and 5.91 in second year) number of first order umbels was recorded in I_3 irrigation treatment. The favourable effect of irrigation may be explained on the basis of more plant height which ultimately led to more number of branches and hence more number of umbels per plant. F_3 (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) fertility level produced highest (7.29 in 2004-05 and

Table 1. Effect of irrigation, fertility and spacing on plant height, branches per plant, number of first order umbels and number of second order umbels per plant at harvest in carrot

Treatment	Plant height (cm)		No. of branches/ plant		No. of first order umbles/plant		No. of second order umbles/plant	
	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
Irrigation levels (CPE)								
I_1 (60 mm)	145.83	137.72	7.25	6.76	8.46	7.84	15.68	14.63
I_2 (90 mm)	140.73	129.03	6.61	6.17	6.88	6.68	14.34	13.30
I_3 (120 mm)	128.58	118.95	6.32	5.81	6.11	5.91	11.95	10.99
C. D. (P=0.05)	3.98	4.72	0.26	0.25	0.09	0.23	0.35	0.47
Fertility levels (N : P : K kg/ha)								
F_1 (60 : 30 : 30)	136.10	126.12	6.61	6.13	7.00	6.72	13.71	12.69
F_2 (80 : 40 : 40)	138.49	127.50	6.72	6.22	7.16	6.41	14.04	12.94
F_3 (100 : 50 : 50)	140.55	132.08	6.85	6.39	7.29	6.96	14.23	13.29
C. D. (P=0.05)	1.53	2.26	0.15	0.13	0.17	0.18	0.27	0.27
Spacing (cm)								
S_1 (30 x 30)	139.34	127.71	6.62	6.12	7.04	6.73	13.88	12.83
S_2 (45 x 30)	138.43	128.43	6.77	6.26	7.15	6.81	13.93	12.96
S_3 (60 x 30)	137.37	129.55	6.80	6.36	7.26	6.89	14.17	13.13
C. D. (P=0.05)	NS	NS	0.15	0.13	NS	NS	0.27	0.27

NS–Not Significant.

6.96 in 2005-06) number of first order umbels per plant during both the years of investigation. These were found statistically at par in F_1 and F_2 and F_2 and F_3 fertility levels during 2004-05.

Number of Second Order Umbels

The lowest number of second order umbels per plant (11.95 during 2004-05 and 10.99 during 2005-06) was observed with I_3 irrigation treatment, while maximum umbels (15.68 in 2004-05 and 14.63 in 2005-06) were recorded in I_1 irrigation treatment during the two years (Table 1). Each fertility level also affected umbels per plant of second order. Second order umbels increased with each increase in fertility level and highest were recorded with F_3 fertility level during both the seasons (14.23 in 2004-05 and 13.29 in 2005-06), while lowest (13.71 in first and 12.69 in second year) were recorded when plants were supplied with F_1 fertility level. Similar results were also obtained by Kumar and Nandpuri (3) and Sharma and Singh (13). Spacing also directly affected the second order umbels per plant and its numbers increased with wider spacing i. e. in S_3 (14.17 in 2004-05 and 13.13 in 2005-06), while closer spacing (S_1) produced 13.88 second order umbels in first and 12.83 in second year, respectively. No significant differences were observed for production of second order umbels in S_1 (30 x 30 cm) and S_2 (45 x 30 cm) and between S_2 and S_3 treatments in the two years of experimentation.

Seed Yield of Main Umbel

Maximum (6.18 g in 2004-05 and 5.95 g in 2005-06) seed yield per plant in main umbel was observed when the crop was irrigated at 60 mm CPE (I_1), while lowest seed yield of main umbel per plant was recorded by irrigating the crop at 120 mm CPE (I_3) (Table 2). Per plant seed yield in main umbel increased with each increase in fertility level during both the years. Minimum (5.45 g during 2004-05 and 5.25 g during 2005-06) seed yield of main umbel per plant was found when crop was given lowest fertility level i. e. 60 kg N, 30 kg P_2O_5 and 30 kg K_2O/ha (F_1), while maximum (5.86 g in first and 5.62 g in second year) seed yield of main umbel per plant was recorded under highest fertility level (F_3) during the two seasons. Higher seed yield of main umbel with F_3 treatment may be due to its beneficial effect on plant growth. Similar observation was also observed by Singh *et al*. (14). Various plant spacings could not significantly affect the seed yield of main umbel per plant.

Table 2. Effect of irrigation, fertility and spacing on seed yield of first and second order umbels and total seed yield at harvest in carrot

Treatment	Seed yield of main umbles (g)		Seed yield of first order umbels/plant (g)		Seed yield of second order umbles/plant (g)		Total seed yield (q/ha)	
	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
Irrigation levels (CPE)								
I_1 (60 mm)	6.18	5.95	18.19	17.15	2.43	1.95	11.22	10.06
I_2 (90 mm)	5.59	5.39	16.40	15.31	2.20	1.70	10.38	9.58
I_3 (120 mm)	5.15	4.95	14.75	13.67	1.14	0.61	8.19	7.93
C. D. (P=0.05)	0.03	0.12	0.11	0.13	0.08	0.15	0.88	0.83
Fertility levels (N : P : K kg/ha)								
F_1 (60 : 30 : 30)	5.45	5.25	16.14	15.07	1.86	1.35	9.14	8.95
F_2 (80 : 40 : 40)	5.61	5.41	16.48	15.43	1.93	1.39	9.90	9.35
F_3 (100 : 50 : 50)	5.86	5.62	16.72	15.63	1.99	1.52	10.49	9.54
C. D. (P=0.05)	0.16	0.18	0.18	0.14	0.06	0.07	0.77	0.82
Spacing (cm)								
S_1 (30 x 30)	5.54	5.31	16.22	15.18	1.89	1.37	12.02	11.36
S_2 (45 x 30)	5.64	5.44	16.47	15.40	1.92	1.42	10.01	8.82
S_3 (60 x 30)	5.74	5.54	16.65	15.55	1.96	1.46	7.77	7.06
C. D. (P=0.05)	NS	NS	0.18	0.14	0.06	0.07	0.77	0.82

NS–Not Significant.

Seed Yield of First Order Umbels

The effect on seed yield of first order umbels per plant as affected by different irrigation, fertility and spacing levels is presented in Table 2. Highest seed yield of first order umbels per plant (18.19 g in 2004-05 and 17.15 g in 2005-06) was recorded in the crop when irrigation was applied at 60 mm CPE (I_1) during both the seasons. While lowest seed yield (14.75 g during 2004-05 and 13.67 g during 2005-06) of first order umbel per plant was obtained by irrigating the crop at 120 mm CPE (I_3). Regarding fertility levels, F_3 (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) dose of fertilizer produced maximum (16.72 g in 2004-05 and 15.63 g in 2005-06) seed yield of first order umbels per plant, while lowest seed yield (16.14 g in first and 15.07 g in second year) per plant was obtained in F_1 (60 kg N, 30 kg P_2O_5 and 30 kg K_2O/ha) level of fertilizer. Various spacings also affected per plant seed yield in first order umbels significantly. S_3 (60 x 30 cm) spacing produced maximum (16.65 g in 2004-05 and 15.55 g in 2005-06) seed yield in first order umbel, while minimum (16.22 g in 2004-05) seed yield per plant was produced in S_1 (30 x 30 cm) spacing. The S_2 and S_3 spacings were statistically at par during 2004-05.

Seed Yield of Second Order Umbels/Plant

Seed yield of second order umbels per plant is presented in Table 2. The perusal of data showed that per plant seed yield of second order umbels increased significantly with the increase in irrigation frequency. Maximum (2.43 g in first and 1.95 g in second year) seed yield per plant in second order umbels was recorded in I_1 (60 mm CPE) irrigation regime during both the years of investigation which was followed by I_2 and, the minimum (1.14 g in 2004-05 and 0.61 g in 2005-06) seed yield in second order umbels per plant was recorded in I_3 moisture regime. Among the different fertility levels, F_3 produced maximum (1.99 g in first and 1.52 g in second year) seed yield per plant in second order umbels closely followed by F_2 during 2004-05. The lowest (F_1) fertility gave minimum seed yield of second order umbels per plant. Higher seed yield of first order and second order umbels with F_3 treatment may be due to its beneficial effect on plant growth. Singh *et al*. (14) also reported that higher dose of fertility increased the plant height, umbels/plant and seed yield per plant.

Total Seed Yield

Maximum seed yield (11.22 q/ha during first and 10.06 q/ha during second year of studies) was harvested in I_1 irrigation at 60 mm CPE treatment, which was closely followed by I_2 and was statistically at par. Minimum seed yield (8.19 q/ha in first and 7.93 q/ha in second year) was harvested in I_3 (120 mm CPE) irrigation regime. Significant increase in seed yield under increased irrigation levels corroborates the findings of Patel *et al.* (11) and Sharma and Prasad (12) in fennel; Marouelli *et al.* (7) and Batra (2) in carrot and Pareek and Sethi (10) and Nain (9) in coriander.

Various fertility levels also significantly influenced the total seed yield. The F_3 (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) level of fertility produced significantly higher seed yield (10.49 and 9.54 q/ha during 2004-05 and 2005-06, respectively) over F_1 (60 kg N, 30 kg P_2O_5 and 30 kg K_2O/ha) fertility treatment. No significant differences were observed between F_1, F_2 and F_3, F_2 levels of fertility. The significant increase in seed yield with the doses of fertility may be increased explained on the basis of better plant growth, increase in first and second order umbels. The maximum seed yield (12.02 q/ha) was observed under the closest i. e. S_1 spacing (30 x 30 cm), while the minimum (7.06 q/ha) was found in widest spacing (60 x 30 cm). Kumar and Nandpuri (3), Sharma and Singh (13), Malik *et al.* (6) and Lal and Pandey (4) also reported consistent findings and the results of their studies are in agreement with their results.

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Haryana J. hortic. Sci., **41** (3 & 4) : 164-167 (2012)

Effect of Organic and Inorganic Nutrition on Growth, Yield, Nutrients Uptake and Fruit Quality of Tomato (*Lycopersicon esculentum* Mill.)

RAJESH KUMAR, V. K. BATRA AND R. K. SINGH[1]

Department of Vegetable Science, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India

ABSTRACT : A field experiment with 13 treatments including control was conducted at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during spring-summer to find out the most appropriate integrated nutrient management system for sustainable tomato production. It was found that application of 43.5 t farm yard manure (FYM) and 50% of recommended dose of fertilizers (RDF) gave maximum fruit yield (284.81 q/ha) over control (198.6 q/ha) which was significantly higher over all the treatments except green manuring and 100% recommended dose of fertilizer (T_{13}). The organic sources of nutrition along with inorganic sources showed incremental effect for almost all parameters including yield over inorganic sources alone. Maximum net return (Rs. 40203/ha) and B : C ratio (1.29) were also recorded with application of 43.5 t FYM and 50% RDF over control (Rs. 25650/ha) and 1.06, respectively.

Key words : Tomato, manure and fertilizers, fruit quality and yield

Tomato (*Lycopersicon esculentum* Mill.) is one of the most popular vegetable crops grown all over the world due to its wider adaptability to various agro-climatic conditions. Being a nutrient exhaustive, this crop requires ample supply of plant nutrients for satisfactory growth, yield and quality. The productivity of a crop is controlled by many factors of which mineral nutrition is by and large the most important one but the application of all the needed nutrients through chemical fertilizers had deleterious effect on soil fertility leading to unsustainable yield. It has been realized worldwide that chemical fertilizers while increasing crop yield may have adverse effect on soil health and its fertility in case of imbalance use. Further, indiscriminate use of chemicals, on account of environmental concern and high cost, could not sustain vegetable production (7). Hence, an alternate technology is the use of organic manure in conjunction with inorganic fertilizers, which still sustain high yield over years and ensure environmental safety. Therefore, the present study was undertaken to study the effect of application of organic and inorganic sources of nutrition on growth, yield, nutrients uptake and fruit quality of tomato.

MATERIALS AND METHODS

A field experiment was conducted at Vegetable Research Farm, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during spring-summer season on tomato cv. Hisar Arun. The soil of experimental field was sandy loam with pH 8.3, organic carbon 0.39%, available nitrogen 100 kg/ha, available phosphorus 22.0 kg/ha and available potassium 370 kg/ha.

The experiment comprised 13 treatments viz., T_1 : Control (no organic manure and inorganic fertilizer), T_2 : 100% recommended dose of fertilizers (RDF) i. e. 100 kg N, 62.5 kg P_2O_5 and 50 kg K_2O/ha, T_3 : 25 t farm yard manure (FYM)/ha, T_4 : 37.5 t FYM/ha, T_5 : 43.5 t FYM/ha, T_6 : 25 t FYM/ha and 100% RDF, T_7 : 37.5 t FYM/ha and 75% RDF, T_8 : 43.75 t FYM/ha and 50% RDF, T_9 : Green manuring (GM), T_{10} : GM and 12.5 t FYM/ha, T_{11} : GM and 25 t FYM/ha, T_{12} : GM and 50% RDF and T_{13} : GM and 100% RDF. The experiment was laid out in randomized block design with three replications. FYM (0.68% N, 0.36% P and 1.2% K) was applied 15 days before transplanting tomato seedlings. *Dhaincha* was used as green manure crop in **kharif** season and incorporated into soil at flowering stage i. e. preceding to tomato. Half dose of nitrogen and full dose of phosphorus and potassium were applied as basal dose, whereas rest amount of nitrogen was applied in two split doses after transplanting. The first split dose of N was applied at 35 days after transplanting and the second split dose was given 50 days after transplanting. The seedlings of tomato were raised in the nursery bed containing mixture of well rotten farm yard manure (FYM) and soil. The proportion of FYM and soil was 1:1 and the texture of soil used in the nursery bed was sandy loam. One month old seedlings of tomato were transplanted at row spacing of 60 cm and within row 45 cm. Proper package of practices were followed throughout the crop period. Data on growth parameters like plant height and branches per plant were recorded after 90

[1]Present Address : Scientist (SS), Central Potato Research Station, Sahaynagar, Patna-801 506 (Bihar), India.

days of transplanting of tomato seedlings. The data on yield were recorded at every picking and were calculated to get total yield. The pericarp (epicarp+mesocarp) thickness was measured in mm with Vernier caliper by dissecting equatorial plane of the fruits. The content of lycopene was estimated. Total soluble solids were determined with the help of Erma Hand Refract meter and expressed as per cent TSS. Ascorbic acid content in tomato fruits was determined by 2, 6- dichlorophenol indophenols titration method (1) and expressed in mg per 100 g of fruit weight. Acid content of extracted juice was determined by titrating the fruit juice against N/10 NaOH using phenolphthalein as in indicator (1).

RESULTS AND DISCUSSION

The experimental results revealed that the growth characteristics like plant height and branches per plant were significantly influenced by various treatments (Table 1). Application of 43.5 t of FYM and 50% RDF (T_8) gave taller plants (60.0 cm) than other treatments, which was at par with treatment T_2, T_6, T_7, T_{11}, T_{12} and T_{13}. The shortest plants were recorded with control. Similarly, maximum number of branches was also noticed with T_8 and least in control. Though all the treatments proved statistically non-significant for days to 50% flowering but they showed earliness than the control. All treatments showed significant earliness over control for days to first harvesting. Renuka and Sankar (5) also reported earliness in flowering and fruiting in tomato when FYM was used along with biogas slurry. Earliness of flowering and fruiting is an important trait in tomato crop and in these cases, it could be attributed to the faster enhancement of vegetative growth and storing sufficient reserved food material for differentiation of buds into flower buds.

Yield attributes such as fruit number and average fruit weight were recorded maximum in T_8 (43.75 t FYM and 50% RDF) which resulted in the highest yield of 0.850 kg/plant and 284.81 q/ha. The lowest yield (198.6 q/ha) was recorded with control plots. Next to it application of GM and 100% RDF gave yield of 270.44 q/ha, which was significantly superior over control as well as 100% RDF. It is clear that integration of organic with inorganic sources of nutrition proved superior over recommended dose of fertilizer. The findings are in the close agreement with the findings of Kumaran *et al*. (2) and Nanthakumar and Veeraragavetatham (4) who observed similar increase in yield of tomato and brinjal, respectively, when organic and inorganic sources were applied together than inorganic sources alone. This might be due to the availability of more plant nutrients by improving soil physical conditions and solubilizing the nutrients in soil by applying organic sources of nutrition which ultimately reflected in terms of yield attributing characters and yield.

It is evident from Table 2 that various organic sources of nutrition significantly influenced different quality parameters of tomato. All treatments increased the pericarp thickness of tomato significantly over control

Table 1. Growth, yield attributing characters and yield as influenced by organic and inorganic sources of nutrition

Treatment	Plant height (cm)	No. of branches/ plant	Days to 50% flowering	Days to 1st harvesting	No. of fruits/ plant	Average fruit weight (g)	Yield/ plant (kg)	Yield (q/ha)
T_1–Control	54.40	5.20	43.06	92.00	22.96	24.76	0.700	198.60
T_2–100% RDF	58.40	6.56	41.00	82.10	32.56	40.54	0.760	260.00
T_3–25 t FYM/ha	54.50	5.73	42.06	86.50	30.46	28.92	0.740	218.50
T_4–37.5 t FYM/ha	55.66	5.66	42.40	85.96	31.20	36.62	0.750	227.00
T_5–43.75 t FYM/ha	57.06	5.90	42.06	84.20	32.26	39.16	0.790	233.10
T_6–25 t FYM and 100% RDF	57.80	6.00	41.30	83.53	33.66	38.28	0.830	244.50
T_7–37.5 t FYM and 75% RDF	57.46	6.80	41.00	82.63	35.00	40.83	0.800	262.53
T_8–43.75 t FYM and 50% RDF	60.00	7.23	41.93	81.50	36.46	73.76	0.850	284.81
T_9–GM	54.73	5.90	42.00	85.93	30.33	34.95	0.690	215.20
T_{10}–GM and 12.5 t FYM	56.86	6.00	41.86	84.93	31.70	38.37	0.780	229.03
T_{11}–GM and 25 t FYM	57.63	6.36	41.40	82.93	32.33	39.33	0.820	240.00
T_{12}–GM and 50% RDF	57.53	6.80	41.20	82.73	34.36	39.68	0.830	250.23
T_{13}–Gm and 100% RDF	58.60	7.00	40.76	82.10	33.56	41.69	0.840	270.44
C. D. (P=0.05)	2.60	0.44	NS	1.90	2.73	2.63	0.070	14.40

RDF–Recommended dose of fertilizer, FYM–Farm yard manure and GM–Green manuring. NS–Not Significant.

Table 2. Fruit quality and nutrient uptake as influenced by organic and inorganic sources of nutrition

Treatment	Pericarp thickness (mm)	Lycopene (mg/100 g of juice)	TSS (%)	Ascorbic acid (mg/g)	Titratable acidity (%)	N content (g/plant)	P content (g/plant)	K content (g/plant)
T_1–Control	3.33	1.93	3.96	19.57	0.42	0.70	0.05	0.03
T_2–100% RDF	3.60	2.18	4.13	23.18	0.50	0.72	0.16	0.33
T_3–25 t FYM/ha	4.10	2.19	4.46	20.19	0.46	0.71	0.12	0.32
T_4–37.5 t FYM/ha	3.83	2.10	4.50	20.76	0.47	0.70	0.11	0.32
T_5–43.75 t FYM/ha	4.40	2.12	5.00	21.14	0.48	0.70	0.11	0.32
T_6–25 t FYM and 100% RDF	4.06	2.13	4.60	23.76	0.56	0.82	0.12	0.33
T_7–37.5 t FYM and 75% RDF	4.63	2.13	4.70	23.59	0.57	1.10	0.17	0.33
T_8–43.75 t FYM and 50% RDF	4.83	2.22	4.80	25.38	0.61	1.20	0.19	0.35
T_9–GM	3.63	2.10	4.30	20.15	0.49	0.70	0.11	0.30
T_{10}–GM and 12.5 t FYM	4.00	2.19	4.10	20.14	0.52	0.78	0.10	0.31
T_{11}–GM and 25 t FYM	4.33	2.17	4.20	20.03	0.53	0.98	0.11	0.31
T_{12}–GM and 50% RDF	4.23	2.15	4.00	22.53	0.52	1.10	0.12	0.32
T_{13}–GM and 100% RDF	4.60	2.20	4.20	23.16	0.51	1.15	0.13	0.33
C. D. (P=0.05)	0.47	NS	0.29	1.76	0.05	0.05	0.02	0.03

except RDF (T_2) and green manuring (T_9). No treatment showed statistically significant influence over control for lycopene content, however, the treatment T_8 showed maximum lycopene content. Application of 43.75 t FYM/ha gave maximum total soluble solids which were at par with treatment T_8. It was also observed that the application of 43.75 t FYM and 50% RDF (T_8) gave maximum ascorbic acid content (25.38 mg/g) and titratable acidity (0.61%) over control (19.57 mg/g) and 0.40%, respectively. Yadav *et al*. (8) also reported that TSS increased when plants were supplied either with organic sources alone or in combination with inorganic components. The increase in titratable acidity might be due to the increased activity of the enzyme acetone.

It is clear from the data given in Table 2 that different treatments also significantly influenced the nutrients uptake in tomato. Application of 43.75 t FYM and 50% RDF (T_8) showed maximum nitrogen uptake (1.2 g/plant) followed by the application of green manuring and 100% RDF (T_{13}) which were at par with each other. All treatments increased the uptake of phosphorus significantly over control but maximum uptake (0.19 g/plant) was recorded with T_8, which was at par with T_7. Similarly, all the treatments increased potassium uptake significantly over control.

These findings are in close agreement with the findings of Nair and Peter (3). The combined effect of organic and inorganic fertilization enhanced P uptake which was also noticed by Sen *et al*. (6). Organic sources when added to the soil, with the action of micro-organisms, complex nitrogenous compounds slowly breakdown and its availability in the form of nitrate is steady throughout crop growth, whereas increase in phosphorus availability may be attributed to more solubility of native phosphorus from the soil due to the action of various organic acids liberated during the decomposition of organic matters.

The data presented in Table 3 clearly indicate that though the cost of cultivation was higher with application of 43.75 t FYM and 50% RDF (T_8) but it gave higher yield and net profit (Rs. 40203/ha) over control (Rs. 25650/ha). This treatment also gave highest B : C ratio (1.29) compared to control (1.06). Other two treatments gave almost equal B : C ratio, while least was from control.

Results of study thus clearly indicated that various treatments significantly influenced the growth, yield,

Table 3. Comparison of economics of yield for the best treatment with control in tomato cv. Hisar Arun

Treatment	Total yield (q/ha)	Gross income (Rs.)	Approx. cost of cultivation (Rs./ha)	Net profit (Rs./ha)	B : C ratio
100% RDF	260.00	65,000	29,200	35,800	1.23
43.75 t FYM and 50% RDF	284.81	71,203	31,000	40,203	1.29
GM and 100% RDF	270.44	67,610	30,500	37,110	1.22
No manure and fertilizer	198.60	49,650	24,000	25,650	1.06

fruit quality and nutrient uptake in tomato. Application of organic and inorganic sources of nutrition together showed superiority over inorganic alone. It was found that application of 43.75 t FYM and 50% RDF (T_8) gave maximum fruit yield (284.81 q/ha) and also showed superiority over other treatments for fruit quality. Application of green manure and 100% RDF (T_{13}) gave fruit yield (270.44 q/ha) which was at par with treatment T_8. Maximum net returns (Rs. 40203/ ha) and B : C ratio (1.29) were obtained from treatment T_8.

ACKNOWLEDGEMENT

The authors are thankful to the Head of Department, Vegetable Science, CCS Haryana Agricultural University, Hisar for his encouragement and providing necessary facilities to carry out this work.

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Haryana J. hortic. Sci., **41** (3 & 4) : 168-170 (2012)

PS/06-24 : A Red Skin Potato Hybrid with Higher Yield and Good Keeping Quality for Eastern Plains

SHAMBHU KUMAR
Central Potato Research Station, Sahay Nagar, Patna-801 506 (Bihar), India

ABSTRACT : A red-skin hybrid (PS/06-24) was identified giving highest total and marketable tuber yields among the four advanced generation red-skin hybrids in eastern plains along with red skin and white-skin control varieties. This red skin hybrid is having attractive flattened oval, tubers with medium dormancy, fleet eyes and yellow flesh with high dry matter (18.9%), resistance to late blight disease and better keeping quality under on-farm storage conditions. It has also potential to replace the existing late blight susceptible red-skin varieties e.g. Kufri Arun, Kufri Lalima and Kufri Sindhuri. Medium size tubers and better keeping quality of the hybrid will certainly help in maintaining the popularity of red skin varieties in the eastern plains.

Key words : Potato, advanced hybrids, yield, storability

Traditionally, red-skinned potatoes are highly preferred in Bangladesh, Bhutan, Nepal, Pakistan and Phillipins (7). Simultaneously, it has also been in demand by the farmers as well as consumers of north Indian plains due to its colour and waxy texture. Early released and popularly grown red-skinned potato varieties e. g. Kufri Sindhuri and Kufri Lalima have failed to continue their acceptance among the farmers due to their late maturity and susceptibility to late blight disease (8). Even a newly released potato variety Kufri Arun (5) is not being preferred by the farmers due to its poor keeping quality. Actually, better yield performance, storability and resistance to late blight disease ensure the wider adaptability, acceptability and greater utilization of potato hybrids (7). Still, there is a long-felt demand of farmers for a high yielding potato variety with red skin tubers, resistant to late blight and good keeping quality. Generally, potato harvesting in north Indian plains starts from February and extends up to April. During this period, rise in temperature forces farmers to go in for distress sales due to higher rottage of tubers. In fact, farmers want to store the produce at least up to the month of June so that they can supply the produce slowly and fetch a good remunerative price.

MATERIALS AND METHODS

Keeping in view the above facts, four medium maturing advanced hybrids (one white skin and 3 red skin advanced hybrids) selected under breeding programme for eastern region were evaluated in four crop seasons along with controls Kufri Pukhraj, Kufri Khyati, Kufri Lalima and Kufri Arun for during 2008-09 to 2011-12 at CPRS, Patna (Bihar) their yield, resistance to late blight disease and storability at room temperature. The experiment was laid out in randomized complete block design with three replications. The tubers were planted at 60 x 20 cm and crop was raised following all the recommended cultural and mannurial practices for the region. The crop was dehaulmed at 75 days, after planting and harvested 10-12 days later. The data on total tuber yield and dry matter per replication were recorded and analyzed following standard statistical procedures (1). The storage behaviour of hybrids/controls was studied from 1st April to 15th June during both the years keeping 5 kg clear and uniform size tubers of each hybrid/ variety from the harvest of 75 days crop in hessian cloth bags at room temperature in randomized complete block design with three replications under room temperature. The data on per cent sprouting, rottage by number and weight, physiological weight loss and total weight loss (%) were recorded after 75 days of storage.

RESULTS AND DISCUSSION

White skin hybrids PS/05-73, red skin hybrids PS/05-75, PS/06-24 and PS/06-88 were selections from crosses Kufri. Laukar x Kufri.Pukhraj, CP 2376 x Kufri Kanchan, CP 2376 x D-150 and Kufri Arun x CP 3192, respectively (Table 2). These hybrids performed significantly (0.05) better than the best control Kufri Pukhraj (for white skin tubers) and Kufri Arun (for red skin hybrids) for yield at 75 days in most of the four seasons (Table 1). The average total yield of the hybrids PS/05-73, PS/05-75, PS/06-24 and PS/07-07 was higher than the best control by 13.50, 6.72, 7.77 and 12.55%, respectively. All the hybrids produced tubers with acceptable shape (round to round oval), skin colour, shallow to medium deep eyes, yellow flesh colour, appreciable dry matter per cent and moderately field resistant to late blight disease under Patna

Table 1. Yield performance (t/ha), dry matter (%) and late blight disease reaction of advanced stage hybrids at 75 days during 2009-12

Genotype	Tuber colour	Total tuber yield (t/ha) at 75 days				Average	Per cent increase over best control	Dry matter (%)	Late blight reaction
		2008-09	2009-10	2010-11	2011-12				
PS/5-73	White	31.80	26.28	30.26	28.68	29.75	13.50	17.69	Mod. resistant
PS/5-75	Red	24.69	22.33	29.06	24.92	25.25	6.72	17.74	Mod. resistant
PS/6-88	Red	-	25.09	21.94	29.46	25.50	7.77	18.70	Mod. resistant
PS/06-24	Red	-	25.89	25.27	26.73	26.63	12.55	18.90	Mod. resistant
K. Arun	Red	21.32	19.25	26.36	23.15	22.52	-	18.54	Mod. resistant
K. Lalima	Red	-	-	25.20	22.12	23.66	-	18.02	Susceptible
K. Pukhraj	White	-	24.31	28.18	26.15	26.21	-	15.91	Mod. resistant
K. Khyati	White	23.76	21.71	29.75	26.58	25.45	-	15.47	Mod. resistant
C. D. (P=0.05)		2.90	1.38	2.00	1.48	-	-	0.88	
C. V. (%)		6.2	5.00	4.60	4.06	-	-	3.02	

Table 2. Tuber characteristics of selected hybrids

Parentage	Name of advanced hybrids			
	PS/05-73 K. Laukar x K. Pukhraj	PS/05-75 CP 2376 x K. Kanchan	PS/06-24 CP 2376 x D-150	PS/06-88 K. Arun x CP 3192
Skin colour	White	Red	Red	Deep red
Shape	Oval	Flattened oval	Flattened oval	Round
Eyes depth	Fleet	Fleet	Fleet	Medium deep
Flesh colour	Creamy	Creamy	Yellow	Yellow
Dry matter (%)	17.69	17.74	18.90	17.80
Dormancy	Medium	Medium	Medium	Medium
L. B. reaction	Moderately resistant	Moderately resistant	Moderately resistant	Moderately resistant
Storability	Better than K. Pukhraj & K. Khyati	At par to K. Lalima	Better than K. Lalima	Better than K. Lalima

conditions. Tubers of these hybrids were easy to cook and had good flavour after cooking. Perusal of data on storage behaviour (Table 3), indicated that most of the varieties had comparatively longer dormancy (>8 weeks) except PS/05-73, PS/05-75 and Kufri Chip-1. However, longer dormancy or minimum sprouting is a desirable character under ambient storage, which reduces the total weight loss per cent. Minimum rottage (both by number and weight) was recorded in hybrid PS/06-24 (12.06 and 9.04), while Kufri Arun showed maximum rottage percentage (37.85 and 27.89). The data also revealed minimum physiological weight loss (9.72) in hybrid PS/06-24, among the hybrids studied and was comparable to potato varieties e.g. Kufri Lalima (9.74), Kufri. Surya (8.15) and Kufri Chipsona-1 (9.88), which are having good storability. Hybrid PS/06-24 had also minimum weight loss per cent (18.76%), while it was maximum in Kufri Arun (43.35%) indicating its better storage. Thus, this hybrid can be stored for a few months at ambient temperature without much loss even under Patna condition. The weather data indicate the fluctuations in minimum and maximum temperature, rainfall (%), sun shine hours and relative humidity during the storage period at Patna. Results obtained are in confirmity with the findings of Kang *et al.* (2, 3) and Pande and Luthra (6). Out of the four hybrids, PS/06-24 (red skin) had comparatively better storage behaviour than the other hybrids. White skinned hybrid PS / 05-73 had shown superior storage behaviour with comparison to Kufri Pukhraj but inferior to Kufri Pushkar and Kufri Surya which are considered as good keeper (4). Thus, produce of this hybrid can be kept for 3-4 months in ordinary stores without much deterioration and released at the appropriate time in the market. On the whole hybrid PS/06-24 possesses a potential to replace existing varieties Kufri Arun, Kufri Lalima and Kufri Sindhuri. These varieties are having lower yield, susceptibility to late blight disease and poor storability in eastern plains. This hybrid may ensure wider adaptability and greater utilization (As this hybrid has red skin, flattened oval tubers with fleet eyes and

Table 3. Mean performance for storage of advanced hybrids during 2010-12 at the end of 75 days storage

Hybrids	Sprouting % at the end (A)	% Loss due to spouting (B)	% Loss due to rottage		% Physiological wt. loss (E)	Total loss % (B+D+E)
			Number basis (C)	Wt. basis (D)		
PS/05-73 (White)	38.07	0.22	26.78	20.08	10.87	31.17
PS/05-75 (Red)	44.38	0.24	21.33	14.33	10.54	25.11
PS/06-24 (Red)	07.46	0.00	12.06	9.04	9.72	18.76
PS/06-88 (Red)	0.00	0.00	21.07	15.00	15.60	24.89
K. Khyati	15.61	0.03	28.64	18.20	14.96	33.19
K. Chip-1	22.60	0.02	26.94	22.48	9.88	32.38
K. Surya	0.00	0.00	17.05	13.35	8.15	21.50
K. Pushkar	9.07	0.00	18.63	12.33	10.55	22.89
K. Pukhraj	12.17	0.00	27.50	18.59	15.69	34.28
K. Arun	0.00	0.00	37.85	27.89	15.47	43.35
K. Lalima	0.00	0.00	17.78	17.17	9.74	26.90
C. D. (P=0.05)	NS	NS	4.30	6.80	5.16	8.02

yellow flesh colour with 17.8% dry matter) which shows a promise for export to the countries where red skinned tubers are traditionally preferred.

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