

Fruit production and quality improvement in aonla (*Emblica officinalis* Gaertn.) through canopy management

S. N. Ghosh*, B. Bera¹, A. Kundu¹, and S. Roy¹

Department of Fruits and Orchard Management, Bidhan Chandra Krishi Viswavidyalaya, Nadia-741252, West Bengal
¹MPS Farm, Jhargram, Paschim Midnapore – 721504, West Bengal

Abstract

In order to maintain the health and vigour and to sustain the productivity, a pruning experiment was conducted on four year old 'Balwant' cultivar of aonla grown in laterite soil, planted at a spacing of 5x5m. To find out the best pruning method, six levels of pruning was performed i.e., i) Light judicious pruning, ii) Detopping of primary branches at 8 feet from ground level + removal of all secondary branches, iii) Detopping of primary branches at 8 feet from the ground level + removal of all secondary branches at 2 feet from the base of primary branches, iv) Detopping of primary branches at 8 feet from the ground level + removal of all secondary branches at 1 feet from the base of primary branches, v) Light judicious pruning + Detopping of plant canopy of at 8 feet from the ground level, vi) No pruning (control). Results of three consecutive years of investigation revealed that light judicious pruning of thin, overlapping, criss-crossed, dead, unproductive and looping branches gave highest fruit yield in all the three years and resulted 64.4 per cent yield increment over control when average of three years was considered. Severe pruning of primary and secondary branches caused drastic reduction of yield for two consecutive years after pruning. Judicious pruning helped to produce better sizeable and quality fruits.

Key words : Aonla, close spacing, pruning, canopy management, yield, fruit quality.

Introduction

Aonla or Indian gooseberry (*Emblica Officinalis* Gaertn.), a versatile tree, is adaptable in diverse soil and climatic condition. Aonla is considered to be one the important fruits for its nutritive, medicinal and industrial value. Due to its multipurpose importance, cultivation of this crop is gradually spreading in different land situation including waste lands. It can be grown in the soil having pH 5.0 (acidic) to even in 8.5 (saline and alkaline). In West Bengal, an eastern state of India, the crop is being grown in red and laterite zone where the soil is red and lateritic type and pH ranges between 4.5 and 5.5. In this zone, the crop show luxuriant growth under proper nutritional care and the branches are need to be pruned within six years of planting for better aeration, sunlight penetration, improving yield and to minimize the pest population like mealy bug and shoot hole borer. The pruning is an art of removal of unwanted growth of plant parts in a scientific manner with the view to improve the productivity and efficacy of the orchard. In every fruit crop requires specialized pruning method in various agro-climatic situation. No work has been carried out on canopy management through judicious pruning in mature aonla plants grown under moderate planting

system in laterite soil. So, an intensive investigation was made for three consecutive years to optimize the best and effective pruning method for increasing the yield and quality of fruits of aonla grown in laterite soil at 5 m x 5 m spacing.

Material and methods

The trial was conducted in a farmer's field in the district of Paschim Midnapore, West Bengal, India during 2006 to 2008 on four year old plants of 'Balwant' cultivar of aonla of uniform vigour and productivity. The plants were planted at a spacing of 5 x 5m. The soil of the experimental orchard was lateritic having pH 5.7. The experiment was conducted in Randomized Block Design (RBD) having four replications with four plants in each replication. There were 6 pruning treatments viz.,

- T₁ : Light judicious pruning (removal of thin, overlapping, criss-cross and looping branches near the ground level).
- T₂ : Detopping of primary branches at 8 feet from ground level + removal of secondary branches.
- T₃ : Detopping of primary branches at 8 feet from ground level + removal of all secondary branches at 2 feet from the base of primary branches.
- T₄ : Detopping of primary branches at 8 feet from ground level + removal of secondary branches at 1 feet from the base of primary branches.

* Corresponding author's e-mail :
profsnghosh@yahoo.co.in

T₁: Light judicious pruning + detopping of the canopy at 8 feet from the ground level.

T₆: No pruning except removal of dead branches (control).

The pruning operation was conducted on 5th February, 2006. The plants were fertilized with yearly dose of 30 kg FYM; 200g N; 100g P₂O₅ and 100g K₂O per plant in two split doses viz., April and July. The plants were irrigated once in a month during February to May.

Observation on fruit yield was recorded on the basis of actual weight of mature fruits harvested per plant. Physico-chemical characteristics of mature fruits were observed in each year following standard method (A.O.A.C., 1990) and average was presented. All the collected data were statistically analyzed.

Results and discussion

Fruit yield

The fruit yield which is the main aim of the experiment was significantly influenced by different pruning treatments. The results clearly indicated that yearly light judicious pruning (T₁) in aonla was helpful for maintaining its health, vigour and productivity as it resulted highest yield in every year. It was calculated that light judicious pruning gave 192, 63 and 18 per cent more yield as compared to unpruned plants (control). Yield improvement due to light judicious pruning is explained from the fact that removal of overlapping, criss-crossed, dead, thin and dropping and unproductive branches resulted good light penetration and air circulation which may caused higher photosynthetic rate (Pratap *et al.*, 2003). Besides, this pruning method also helped for proper utilization and distribution of reserve food materials by the growing fruits, which were on re-

maining shoots. It was further observed that severe pruning like T₂, T₃ and T₄ had detrimental effect on yield in aonla which was due to loss of fruit bearing shoot. Unlike other fruit crops, aonla put forth flowers and fruits on mature shoots of more than one year age. So, removal of primary and/or secondary branches result loss of fruit bearing shoots which was reflected in subsequent years after pruning. Another interesting observation was noted that aonla has strong tendency to alternate bearing as yield pattern in judicious pruned and unpruned plants was like a tide. Beneficial effect of light pruning on yield improvement was also observed by Jadav and Khimani (2003) and Prabhu *et al.* (2003) in aonla.

Fruit weight

The fruit weight in pruned and unpruned plants was differed significantly. Maximum fruit weight of 25.2 g was measured from judicious pruned plants (T₁) and minimum weighted fruit (21.4 g) was recorded from the control plants (T₆). Higher fruit weight in pruned plants was due to more available photosynthates as compared to unpruned plants and this observation was also noted by Sharma *et al.* (1997) in kinnow mandarin; Pratap *et al.* (2003) in Mango; Khan and Syamal (2004) in Kagzi lime.

Pulp content

As aonla, is mainly utilized for preparation of various bye-products including ayurvedic medicine, pulp recovery is one of the important physical parameter for determining the treatments' effect. Investigation showed that pulp recovery percentage was more in fruits of pruned plants as compared to unpruned plants and it was highest from judicious pruned plants (94.2%). Similar observation was also noted by Jadav and Khimani (2003) in aonla.

Table 1. Effect of severity of pruning on yield and fruit quality of aonla cv. NA-10 grown in laterite soil.

Pruning Treatment	Fruit yield/plant (kg)					* Fruit weight (g)	*Pulp content (%)	*T.S.S (°B)	*Acidity (%)	*Vit. C. (mg/100g pulp)
	2006	2007	2008	Total yield in 3 years	Av.yield of 3 years					
T ₁	18.1	6.2	20.0	44.3	14.8	25.2	94.2	10.2	1.4	550
T ₂	0.0	0.5	30.5	31.0	10.3	24.4	93.0	9.4	1.1	538
T ₃	0.6	2.6	13.2	16.4	5.5	23.2	92.8	9.9	1.2	548
T ₄	0.0	2.6	3.9	6.5	2.2	24.1	93.9	9.8	1.2	542
T ₅	12.4	0.2	7.1	19.7	6.6	24.5	93.2	9.4	1.1	540
T ₆	6.2	3.8	17.0	27.0	9.0	21.4	91.6	8.7	1.2	530
C.D. at 5%	4.4	1.1	2.8	3.8	2.2	0.8	0.9	0.5	N.S.	2.8

* Average of 3 years

T₁ = Light judicious pruning

T₂ = Detopping of primary branches at 8 feet from ground level + removal of secondary branches.

T₃ = Detopping of primary branches at 8 feet from ground level + removal of all secondary branches at 2 feet from the base of primary branches.

T₄ = Detopping of primary branches at 8 feet from ground level + removal of secondary branches at 1 feet from the base of primary branches.

T₅ = Light judicious pruning + detopping of the canopy at 8 feet from the ground level.

Total soluble solids

The total soluble solids (T.S.S.) content of fruit is considered to be one of the important parameter for assessing its qualitative value. The T.S.S. content in fruits from the all the pruned plants was higher as compared to unpruned plants which showed the lowest value (8.7° Brix). High T.S.S. content in the fruits of pruned plants was due to accumulation of more carbohydrates and other metabolites. This observation was also corroborated the findings of Singh *et al.* (2004) in ber.

Fruit acidity

The fruit acidity in aonla was not significantly affected due to various pruning treatments.

Vit. C content

The vit. C or ascorbic acid is an important antioxidant for which aonla is considered to be one of the best nutritious fruit. It is the highest source of vit. C among the fruits after burbados cherry. Investigation showed that the pruning treatments has significant effect on vit. C content of the fruits. The fruits of all the pruned plants have higher vit. C content as compared to unpruned ones. The vit. C content was measured highest (550 mg/100 g) from the fruits of judicious pruned plants (T_1) and lowest (530 mg/100 g) in control plants (T_0). Improvement in vit. C content in fruits due to different pruning practices was also observed by Ghosh (2008) in ber.

References

- A. O. A. C. 1990. Official Methods of Analysis. Association of Official Agriculture Chemists (15th Edn.) Washington, D. C.
- Ghosh, S. N. 2008. Fruit production and quality improvement in Banarasi Karka cultivar of ber through canopy management. *Abstract of the First International Jujube Symposium*, 21-25 September, 2008. Baoding, China, pp. 55.
- Jadav, R. G. and Khimani, R. A. 2003. Pruning effect on yield and quality of aonla (*Emblica officinalis* Gaertn.) *Abstract of National Seminar on Production and Utilization of aonla* : 8-10 August, 2003, Salem, India.
- Khan, M. and Syamal, M. M. 2004. Effect of pruning on flowering and fruiting of Kagzi lime (*Citrus aurantifolia* Swingle). *Indian J. Hort.* 61 : 171-172.
- Prabhu, T., Kumar, S., Shantha-Kumar, P., Kalyanasundaram, B., Senthilraja, A. and Gnanasekarn, M. 2003. Training and pruning in Amla. *Abstract of National Seminar on Production and Utilization of aonla* : 8-10 August, 2003 Salem, India.
- Pratap, Bhanu, Sharma, H. C., Goswami, A. M., Singh, S. K. and Mishra, L. N. 2003. Effect of pruning on photosynthetic rate, canopy microclimate and yield in mango cv. Amrapali under high density planting. *Indian J. Hort.*, 60 : 339-342.
- Sharma, J. N., Josan, J. S. and Thind, S. K. 1997. Effect of pruning intensities on the productivity of kinnow mandarin. *Indian J. Hort.*, 54 : 304-307.
- Singh, H., Bal, J. S. and Singh, G. 2004. Standardization of pruning technique in ber. *Indian J. Hort.* 61 : 259-60.

Performance of nitrogen and zinc on yield and physico-chemical composition of ber (*Zizyphus mauritiana* Lamk) fruits cv. Gola

Hari Dayal*, G. Lal., D. Singh and P. Kumar

Central Arid Zone Research Institute, Krishi Vigyan Kendra, Pali - 306401, India.

Abstract

A field experiment was carried out to study the influence of different levels of nitrogen (250, 500 and 750g plant⁻¹ year⁻¹) and zinc sulphate (0.4, 0.6 and 0.8 per cent plant⁻¹ year⁻¹) on yield and physico-chemical composition of ber fruits. Applications of 500g nitrogen and 0.6% zinc sulphate plant⁻¹ exhibited highest fruit yield with maximum dry matter, pulp, pulp: seed ratio, TSS, ascorbic acid, reducing sugar, non reducing sugar, total sugars and minimum moisture and seed content.

Key words: Ber, nitrogen, zinc, yield, physico-chemical quality parameters.

Introduction

The ber (*Zizyphus mauritiana* Lamk) is hardy fruit plant, regular bearing habit and adaptability to adverse climatic condition. It can give better income on marginal lands where other fruit plant and crops can not survive. Since the ber crops is mainly grown in arid and semi-arid region where major and minor nutrients are lacking, the need for fertilizer application becomes essential. Among the major nutrients, nitrogen is considered to be the vital in case of ber and its requirement, depends on agro climatic situation where crop is grown.

In arid and semi-arid region, one of the factors which can ensure lucrative income from ber growing area continuously over number of years is proper feeding and judicious use of nutrients for plants. In case of ber nutrition, increase the fruit plant nutrient, nitrogen is major nutrient and zinc is minor nutrient, which are already deficient in Rajasthan soil (Akbari *et al.* 1995). Doses of these nutrients affect the quantity and quality of ber fruits. With this observation that present investigation was undertaken to carried out the application of nitrogen in soil in split and zinc as foliar spray on the performance of yield and quality of ber fruits.

Material and methods

The investigation was carried out on productive, healthy and vigorous ber trees cv. Gola at Central Arid Zone Research Institute, Krishi Vigyan Kendra Pali, during

2004-05 and 2005-06. The location was latitude 25° 47' 13" north altitudes and 73° 18' 42" east longitudes. The experimental soil was silty loam with available nitrogen (135.9kg ha⁻¹), available phosphorus (18.2kg ha⁻¹), potassium (256.1 kg ha⁻¹), Zinc (0.18 ppm) and pH 8.3. The area received annual rainfall of 325.9 and 645.6mm and average minimum 3.2°C and maximum 43.4°C temperature. Of the total precipitation 90 per cent was received during July to September. The relative humidity ranged from 25 to 95 per cent during the experimental span. The treatments composed of three levels of nitrogen viz 250, 500 and 750g plant⁻¹ year⁻¹ and three levels of zinc sulphate 0.4, 0.6 and 0.8 per cent plant⁻¹ year⁻¹. In all, there were ten treatment combinations including control. The experiment was laid out in RBD with factorial approach having three replications. Half dose was applied in month of July and remaining dose of nitrogen was applied in month of November. The zinc sulphate was sprayed thrice along with equal dose of lime for neutralization and teepol as a sticking agent in the 1st week of August, September and October.

All the common cultural practices were adopted and the ber trees were maintained under uniform conditions of orchard management. At the time ber fruit green colour turned light yellow colour (ripening stage), fruits were harvested and the yield was recorded accordingly. In all, there were 5 pickings. A sample of 500g fruits was collected randomly from 2nd picking from each treatment under all the replications to estimate the physico-chemical characteristics viz; moisture (%), dry matter (%), pulp

* Corresponding author's email:
drharidayal@gmail.com

content (%), seed content (%), pulp: seed ratio, TSS (%), ascorbic acid (mg 100g⁻¹ pulp), reducing sugar (%), non-reducing sugar (%) and total sugars (%). Pulp of the fruits was separated after removing the seeds and weight of pulp and seed was recorded and pulp: seed ratio was calculated accordingly. Fruit pulp was dehydrated at 60°C up to constant weight and total dry matter and moisture content was recorded. Total soluble solids (TSS) of the fruits were measured with the help of 'Erma' hand refractometer and corrected at 20°C temperature. Ascorbic acid, reducing sugar, non-reducing sugar and total sugar contents were determined with the help of methods suggested by A.O.A.C. (1990). The data for both the years were pooled and statistically analyzed with the help of method suggested by Gomez and Gomez (1984).

Result and discussion

The application of nitrogen significantly increased the dry matter, pulp, pulp: seed ratio, TSS, ascorbic acid, reducing sugar, total sugar and yield of fruit. However, non reducing sugar was not influenced significantly by the application of nitrogen. The maximum pulp content (91.27%), pulp: seed ratio (10.80), TSS (16.75%), ascorbic acid content (87.53mg 100g⁻¹), reducing sugar (5.30%), total sugar (10.71%) and yield of fruits (37.82kg tree⁻¹) were recorded at N₂ (500g N tree⁻¹) treatment as compared to minimum (85.40%, 5.86, 14.41%, 65.39mg 100g⁻¹, 3.75%, 8.56% and 26.81 kg tree⁻¹, respectively) under control, while the dry matter content (21.36%) was the highest with 750g N tree⁻¹ treatment and lowest (17.79%) under control. On other hand the moisture and seed content decreased significantly with the increasing rate of nitrogen from unfertilized control to 750g N tree⁻¹ treatment. The lowest moisture (78.56%) content was recorded at 750g N tree⁻¹, while the minimum seed content (8.73%) was recorded at 500g N tree⁻¹ treatment as compared to the maximum values of these parameters (82.21% and 14.60%, respectively) under control (Table 1 and 2).

The useful effect of nitrogen is attributed to increased efficiency of metabolic and physiological processes of plants, which encouraged the growth of trees and consequently increased size and weight of fruits. The size of fruit depends mainly upon the photosynthetic activity of plants and hence the healthy plants produced the fruits with maximum length, diameter, weight and volume (Singh *et al.*, 1996). The probable reason for the improvement in size may be due to the beneficial effect of N in cell division and cell enlargement, and increased activities of living tissues such as parenchyma. These changes altogether produced ultimately higher yield of ber in this investigation. Unsurprisingly, similar results had been reported by Lal *et al.* (2001 and 2003), Prasad and Bankar (2002), Prasad and Vashishtha (2004), and Prasad (2004) in ber.

The foliar application of zinc significantly influenced the, dry matter, pulp, pulp: seed ratio, ascorbic acid, reducing sugar, total sugar and yield of fruits, while moisture and seed content significantly decreased with the foliar application of zinc. The maximum dry matter content (21.25%), pulp (91.28%), pulp: seed ratio (10.77), ascorbic acid (87.30mg 100g⁻¹), reducing sugar (5.33%), total sugars (10.66%) and fruit yield (37.42 kg tree⁻¹) were recorded at Zn₂ (0.6% ZnSO₄) as compared to minimum (17.79%, 85.40%, 5.86, 65.39 mg 100g⁻¹, 3.75%, 8.56% and 26.81 kg tree⁻¹, respectively) under control, while TSS content in fruit (16.65%) was maximum at Zn₂ (0.8% ZnSO₄) treatment as compared to minimum (14.41%) under control. However, the lowest moisture (78.74%), and seed content (8.72%) were recorded at Zn₂ (0.6% ZnSO₄) treatment as compared to highest (82.21% and 14.60%, respectively) under control (Table 1 and 2).

The improvement in quality of fruits with the application of zinc might also be due to improved auxin content and at zinc acting as a catalyst in oxidation-reduction process. Besides, zinc helps the enzymatic reaction like hexokinase and formation of cellulose. Change

Table 1. Effect of N and Zn on moisture, dry matter, pulp and seed content of ber fruits.

Treatment	Moisture(%)	Dry matter(%)	Pulp(%)	Seed content(%)	Pulp seedratio
Unfertilized control	82.21	17.79	85.40	14.60	5.86
250g N tree ⁻¹ (N ₁)	79.68	20.31	90.34	9.64	9.58
500g N tree ⁻¹ (N ₂)	78.71	21.26	91.27	8.73	10.80
750g N tree ⁻¹ (N ₃)	78.56	21.36	91.20	8.77	10.56
SEm±	0.16	0.16	0.15	0.15	0.20
0.4% ZnSO ₄ (Z ₁)	79.46	20.48	90.46	9.50	9.73
0.6% ZnSO ₄ (Z ₂)	78.74	21.25	91.28	8.72	10.77
0.8% ZnSO ₄ (Z ₃)	78.76	21.19	91.08	8.92	10.43
SEm±	0.16	0.16	0.15	0.15	0.20
C D 5%	0.46	0.45	0.43	0.42	0.56

Table 2. Effect of N and Zn on yield, TSS, ascorbic acid sugars content of ber fruits.

Treatment	TSS (%)	Ascorbic acid (mg/100g ⁻¹ pulp)	Reducing (Sugar %) (Sugar %)	Non-reducing (Sugar %)	Total Sugar (%)	Yieldkg/tree ⁻¹
Unfertilized control	14.41	65.39	3.75	4.55	8.56	26.81
250g N tree ⁻¹ (N ₁)	15.82	80.50	4.85	5.23	10.23	34.48
500g N tree ⁻¹ (N ₂)	16.75	87.53	5.30	5.49	10.71	37.82
750g N tree ⁻¹ (N ₃)	16.67	86.38	5.17	5.21	10.15	37.62
SEM±	0.09	1.03	0.08	0.11	0.09	0.27
C D 5%	0.25	2.89	0.21	NS	0.26	0.76
0.4% ZnSO ₄ (Z ₁)	16.14	81.73	4.88	5.28	10.16	35.63
0.6% ZnSO ₄ (Z ₂)	16.45	87.30	5.33	5.39	10.66	37.42
0.8% ZnSO ₄ (Z ₃)	16.65	85.38	5.10	5.26	10.27	36.88
SEM±	0.09	1.03	0.08	0.11	0.09	0.27
C D 5%	0.25	2.89	0.21	NS	0.26	0.76

in sugar content of fruit may be attributed to the action of zinc on zymohexose, a metal protein in blocked by formation of complex cystein. The blocked enzyme is reactivated with zinc. Its presence however, is of great importance of sugar metabolism (Levitt, 1972). These findings are similar to the findings of Hoda *et al.* (1975) and Babu and Yadav (2005) who reported similar pattern in Khasi mandarin.

Hence, it is concluded that the application of 500g N per tree along with 0.6% ZnSO₄ as foliar application was found highest yield and good quality fruit of ber.

References

- A.O.A.C. 1990. *Official Methods of Analysis*. Association of Agricultural Chemists, Washington D.C.
- Akbari, K.N., Karan, F. and Pandya, H.R. 1995. Availability of zinc in red loam soil of zone IV A Rajasthan as related to certain soil characteristics. *Journal of Indian Society of soil science*. 43:131-133
- Babu, K.D. and Yadav, D.S. 2005. Foliar spray of micro nutrients for yield and quality improvement in khasi mandarin (*Citrus reticulata* Blanco). *Indian Journal of Horticulture*. 62 (3):280-281.
- Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedure for Agriculture Research*. 2nd edition. Pub. John Wiley & Sons Inc., New York.
- Hoda, M.N., Symal, N.B. and Chhonkar, V.S. 1975. Growth substances and zinc on the development and quality of Litchi of fruits. *Indian Journal of Horticulture*. 32 (3&4): 146-151.
- Lal, G., Dhaka, R.S., Pareek, C.S. and Agrawal, V.K. 2001. Effect of nitrogen and phosphorus application in ber (*Zizyphus mauritiana* Lamk). *Annals of Arid Zone*. 40 (2): 213-215.
- Lal, G., Pareek, C.S., Sen, N.L., and Soni, A.K. 2003. Effect of N, P and K on growth, yield and quality of ber (*Zizyphus mauritiana* Lamk) cv. Umran. *Indian Journal of Horticulture*. 60 (2):158-162.
- Levitt, J. 1972. *Effect of zinc on sugar response of plants to environmental stresses*, New York London. Academic Press.
- Prasad, R.N. and Bankar, G.J. 2002. Effect of N and P on growth and yield of ber (*Zizyphus mauritiana* Lamk) grown under rainfed condition of Indian arid zone. *Progressive Horticulture*. 34 (2):192-196.
- Prasad, R.N. and Vashishtha, B.B. 2004. Effect of N and P on growth, yield and quality of grown ber (*Zizyphus mauritiana* Lamk) grown under rainfed condition of western Rajasthan. *Proceeding of Indian Horticulture congress 2004*, organized by HSI during 6-9 Nov. at New Dehli, pp 229.
- Prasad, R.N. 2005. Effect of N and P on growth yield and quality of Ber grown under rainfed conditions of Indian arid zone. *Indian Journal of Horticulture*. 62 (4): 404-406.

Control of oxidative browning during *in vitro* culture initiation of guava genotypes

P. R. Meghwal* and H. C. Sharma

Division of Fruits and Horticultural Technology,
Indian Agricultural Research Institute, New Delhi-110012

Abstract

Micro propagation in guava is impaired by the problem of oxidative browning of explants and culture media during culture establishment phase. The study was conducted to see the efficiency of different techniques and antioxidant compounds on controlling phenolic browning and ultimate culture establishment for micropropagation. Significant differences were recorded between Allahabad Safeda and Aneuploid No. 82 in respect to quantum of exudated phenol and per cent sprouting. Agitation of explants in 0.5% PYPP and 2% sucrose for 40 minutes followed by a quick dip in a solution of citric acid and ascorbic acid @ 75 mg L⁻¹ and 50 mg L⁻¹ respectively before inoculation resulted in maximum sprouting and reduced exudation of phenol in both the genotypes. Mean phenol exudation in different seasons from nodal and shoot tip explant indicated lower phenol exudation and higher sprouting in Allahabad Safeda as compared to Aneuploid No. 82. Significantly higher sprouting was recorded when the explants were collected during spring or summer as compared to that of autumn season. The quantum of phenol leached into the medium and percent sprouting was found to be negatively correlated

Key words: *Oxidative browning, explant, polyphenol oxidase, antioxidants, in vitro culture initiation.*

Introduction

The poor response of explants from woody trees to *in vitro* manipulation is associated with leaching of phenolic compounds produced by the injured tissues of explants. The browning of explants and culture media is generally considered to be the results of oxidation of phenolic compounds by poly phenol oxidase (Mayer and Hasel, 1979), Peroxidases (Loomis and Battlaile, 1966) or by air (Robinson, 1983). The oxidized product quinones are known to be highly reactive and inhibit enzyme activity leading to the killing of explants due to necrosis (Hu and Wang, 1983).

In guava, tissue culture is essential for clonal propagation and genetic manipulation, since availability of planting material through conventional means is in short supply. Several previous studies have indicated the

problem of oxidative browning during micropropagation from mature trees (Amin and Jaiswal, 1987; Prakash, 1992). Many techniques have been used in an attempt to limit detrimental effect of oxidized phenolics on explant survival. Vietez and Vietez (1980) partially overcome the problem by soaking *Castanea sativa* explants in sterile distilled water for 2-3 hours prior to *in vitro* culture. Several antioxidants such as polyvinylpyrrolidone (Mc Comb, 1978), ascorbic acid and citric acid (Ziv and Havely, 1983) and glutathione (Rugini and Fontanazza, 1981) have also been tried to overcome the problem of oxidative browning in different woody species. Partial etiolation of stock plants (Sharma *et al.*, 1997) and collection of explants in the beginning of spring (Chevre *et al.*, 1983) have also been found to minimize the problem. Various techniques have been employed to reduce the inhibitory effect of exudated phenols and its correlation with explants survival and bud sprouting is lacking. Hence, the study was aimed at quantifying the exudation of phenolics as affected by

*Corresponding author's email:
prmeghwal@cazri.res.in

seasons of explanting, explants type and beneficial effect of media supplementation of different antioxidants and to establish correlation between exudated phenolics into the medium and successful culture establishment.

Material and methods

The study was conducted in the division of Fruits and Horticultural Technology and Central Tissue Culture Laboratory, NRC on Plant Biotechnology, IARI, New Delhi during 1997-99. Nodal and shoot tip explants were collected from coppiced growth of 12 -years old plants of variety Allahabad Safeda and Aneuploid No. 82 during three seasons i.e. Spring (March-April), Summer (May-June) and Autumn (September-October). Various techniques (Table 1) were adopted for controlling oxidative browning as pretreatment or medium supplement or both. The explants were surface sterilized using methods reported earlier (Meghwal et al., 2003). M S medium (Murashige and Skoog, 1962) supplemented with 1 mg L⁻¹ BAP (6-Benzylaminopurine), 3 % sucrose and 0.8% agar was used. The cultures were initiated on semi solid medium in test tube 20 mm x 150mm size containing 15 ml of medium. They were incubated at 25 ± 2°C under a 16/8 hour photo period at photon flux intensity of 50-70 µ Em⁻² S⁻¹ provided from cool white florescent tubes.

The alcoholic extraction of total phenol exudated into the medium was prepared as per method followed in grape explants (Sharma, 1993), while total phenol was

estimated by following improved procedure of Singleton and Rossi Jr. (1965). The total phenol leached into the medium was estimated 7 days after inoculation taking whole quantity 15 ml medium after removing the explants. The total phenol was expressed as µg gallic acid ml⁻¹ medium. Before analysis, the explants were transferred on fresh media to see per cent sprouting till one-month of inoculation. The data were recorded on per cent sprouting and total phenol exudation into the media and a correlation coefficient was also worked out between total phenol exudation into the media and per cent bud sprouting. The experiment was laid out in CRD and repeated for three times. The data were analyzed statistically.

Results and discussions

The effect of different techniques for controlling phenolic browning on explants survival and phenol exudation into medium was found to be significant (Table 1). The genotypic differences were significant in respect to per cent sprouting and phenol exudation with Allahabad Safeda showing higher sprouting and lesser phenolic browning as compared to Aneuploid No. 82. Among different treatments, agitation of explants with 0.5% PVPP and 2% sucrose for 40 minutes followed by a quick dip in anti oxidant solution (T₆) before inoculation resulted in maximum sprouting and lower phenol exudation in both the genotypes. The lowest phenol exudation was however,

Table 1. Effect of different treatments on total phenol exudation and per cent bud sprouting during culture initiation of guava genotypes

Treatments	Total phenol exudation (µg ml ⁻¹ medium)		Bud-sprouting (%)	
	Allahabad Safeda	Aneuploid No.82	Allahabad Safeda	Aneuploid No.82
T ₁ Control	9.66	41.00	72.00(58.18)	33.33(35.17)
T ₂ Incubation in dark for 48 hrs	9.55	39.00	61.66(51.92)	28.33(32.01)
T ₃ Addition of 0.4% PVP to the media	9.22	32.55	53.33 (47.96)	10.00 (18.43)
T ₄ Agitation in 0.5% PVPP & 2 % Sucrose for 40 minutes at 100 rpm.	6.11	30.02	71.66 (59.54)	40.00 (39.15)
T ₅ Rapid rinse in CA & AA (75&50 mg L ⁻¹)	5.95	25.45	78.33 (62.47)	36.66 (37.26)
T ₆ , T ₃ & T ₅	4.11	21.00	80.00 (63.92)	50.66 (45.38)
T ₇ Sealing basal ends of explants with wax	10.6	3.55	31.66 (34.02)	20.00 (26.45)
T ₈ Media supplementation with 75&50 mg L ⁻¹ CA & AA	10.11	36.78	55.00 (47.96)	15.58 (23.16)
Mean	6.97	28.66	69.44	34.20
CD(P=0.05)	4.30	8.64	14.11	14.95

CA-Citric Acid, AA-Ascorbic acid, PVP-Polyvinyl pyrrolidone, PVPP-Poly vinyl polypyrrolidone; Figures in parenthesis- Angular transformed values

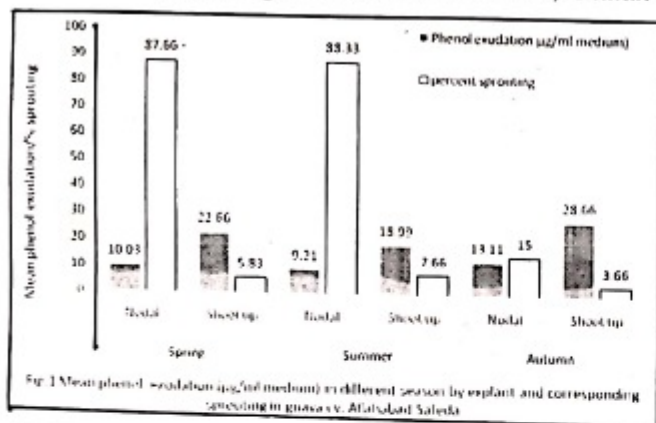


Fig. 1 Mean phenol exudation (µg/ml medium) in different season by explant and corresponding sprouting in guava cv. Allahabad Safeda

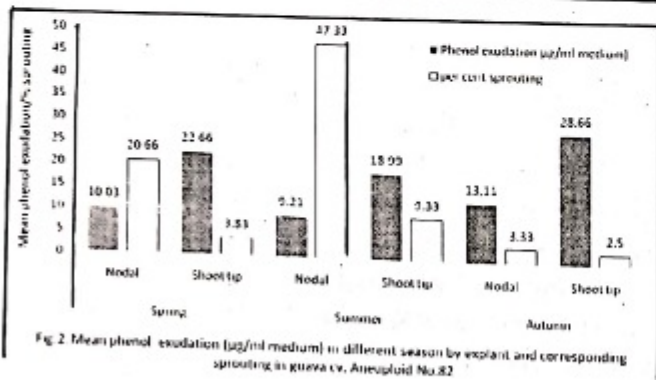


Fig. 2 Mean phenol exudation (µg/ml medium) in different season by explant and corresponding sprouting in guava cv. Aneuploid No. 82

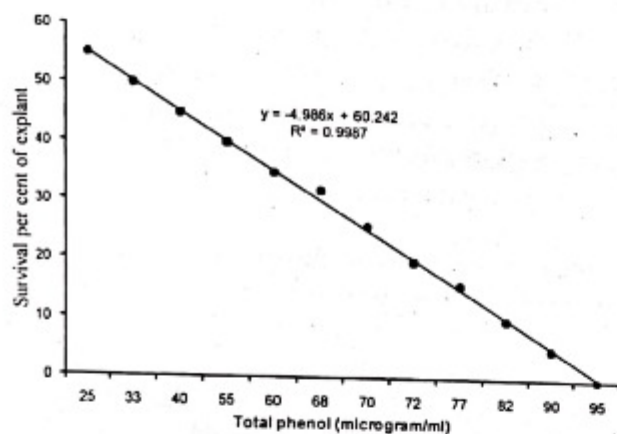


Fig. 3. Correlation between total phenol exudation into the medium and explant survival of guava

recorded by sealing basal cut end (T_1) with wax in both the genotypes but per cent sprouting was drastically reduced in that case. The positive effect of PVPP, ascorbic acid and citric acid on reduced phenolic browning have also been reported earlier in apple (Walkey, 1972), chestnut (Vieitez & Vieitez, 1980) and guava (Amin & Jaiswal, 1988). Media supplementation of PVP, citric acid and ascorbic acid resulted in reduced sprouting per cent as compared to control. This might be probably due to detrimental effect of these compounds. The toxic effect of citric acid and ascorbic acid were recorded by Broome and Zimmerman (1978) in black berry and in teak (Gupta *et al.*, 1980). Mean

phenol exudation in different seasons from two types of explants and corresponding bud sprouting have been illustrated in Fig. 1 & 2 for Allahabad Safeda and Aneuploid No. 82 genotypes respectively. It was indicated that in general phenol exudation in the media was much less in Allahabad Safeda as compared to Aneuploid No. 82 in all the seasons and accordingly higher per cent bud sprouting was recorded in this variety. The difference in phenol exudation as well as per cent sprouting were non significant between spring and summer season but it was highly significant when compared with the values of these parameters recorded during autumn season in both the genotypes. The lesser phenol release from Allahabad Safeda explants might be due to lower tissue content of phenolic compound as compared to those in Aneuploid No. 82. This implied that phenol content of explants and phenolic browning of explants and media may be positively correlated. Although phenol content of explants was not estimated but the release of phenol in the medium and corresponding sprouting was found to be negatively correlated in Aneuploid No. 82 genotype (Fig. 3). In this context it is imperative to mention that many plants are naturally rich in polyphenolic compounds, which are commonly, regarded as inhibitory agents. Preece and Compton (1991) emphasized that these inhibitory agents have various phyto toxic effects on plants. It is possible that Aneuploid No. 82 being dwarfing in nature might have high level of inhibitory phenols, which would also have leached into the medium.

References

- Amin, M.N. and Jaiswal, V.S. 1987. Rapid clonal propagation of guava through *in vitro* shoot proliferation on nodal explants of mature trees. *Plant Cell Tissue and Organ Culture*, 9:235-243.
- Amin, M.N. and Jaiswal, V.S. 1988. Micropropagation as an aid to rapid cloning of guava cultivars. *Scientia Horticulture*, 36(1-2): 89-95.
- Broome, O.C. and Zimmerman, R.H. 1978. *In vitro* propagation of blackberry. *HortScience*, 13: 151-153.
- Chevre, A.M., Gill S.S., Mauras, A. and Saleses, G., 1983. *In vitro* vegetative multiplication of chestnut. *Journal of Horticultural Science*, 17:259-268.
- Gupta, P.K., Nadir, A. L., Mascarenhas, A.F. and Jagannathan, V., 1980. Tissue culture of Forest trees: Clonal propagation of teak by tissue culture. *Plant Science Letters*, 17: 259-268.

- Hu, C.Y. and Wang, P. J. 1983. Meristem shoot tip and bud culture, In: Handbook of plant cell culture Vol. 1. (Eds D.A Evans *et.al.*) Macmillan, New York.
- Loomis., W.O. and Battlaile, J. 1966. Plant phenolic compounds and the isolation of plant enzymes. *Physiolgia Plantarum*, 18:100-127.
- Mayer, A.M. and Hasel, T. 1979. *In vitro* morphogenetic studies. *Photochemistry*, 18: 193-215.
- McComb, J.A. 1978. Clonal Propagation of woody plants using tissue culture with special reference to apples. *Combined Proceedings of International Plant Propagator's Society*. 28:413-426.
- Meghwal, P.R., Singh, S.K. and Sharma, H.C. 2003. Micropropagation of Aneuploid guava. *Indian Journal of Horticulture*. 60(1): 29-33.
- Murashige, T. and Skoog, F. 1962. A revised medium for rapid growth and bioassay with tobacco tissue culture. *Physiolgia Plantarum*. 15:473-497.
- Prakash, H. 1992. Micropropagation of guava. Ph.D. Thesis, submitted to G.B. Pant University of Agriculture and Technology, Pant Nagar.
- Preece, J. E. and Compton, M.E. 1991. Problem with explant exudation in micropropagation. In: Biotechnology in Agriculture and Forestry Vol. 17(ed.YPS Bajaj), Springer-Verlag, Berlin pp. 169- 189.
- Robbinson, T. 1983. The organic constituents of higher plants. 5th ed. Cordus Press Amherst, Muss.
- Rugini, E. and Fontanazza, G. 1981. *In vitro* propagation of Dolce Agogia oliva, *HortScience*. 16: 492-493.
- Sharma. R.R. 1993. *In vivo* and *in vitro* polyphenol oxidase activity in grapes. Thesis submitted to Post Graduate School IARI, New Delhi.
- Sharma, R.R. Sharma, H.C. and Goswami, A.M. 1997. *In vitro* Polyphenol oxidase activity and phenolic content pattern during shoot development of grapes. *Annals of Agricultural Research*. 20(11):9-13.
- Singleton, V. L. and Rossi Jr. J.A. 1965. Colorimetry of total phenol with phosphomolybdic phosphotungstic acid reagents. *American Journal of Enology and Viticulture*, 16: 144-158.
- Vieitez, A.M. und Vieitez, M.L. 1980. Culture of chestnut shoots from buds *in vitro*. *Journal of Horticultural Science*. 55:83-84.
- Walkey, D.G. 1972. Production of apple plantlets from axillary bud meristems. *Canadian Journal of Plant sciences*, 52: 1087-1097.
- Ziv, M. and Halevy, A.H. 1983. Control of oxidative browning and *in vitro* propagation of *Strelitzia reginae*. *HortScience*. 18: 434-436.

Study on physico-chemical properties of aonla (*Emblica officinalis* Gaertn.) cultivars during fruit growth and development

Virendra Singh*, Prabhakar Singh, L.K. Dashora and S.S. Lakhawat

Department of Horticulture, Indira Gandhi Krishi Viswavidhyalaya, Raipur-492 006

Abstract

To evaluate the aonla cultivars in Chhattisgarh the physico-chemical characters of eight aonla cultivars viz. Banarasi, Chakaiya, Francis, Kanchan, Krishna, NA-6, NA-7 and NA-10 were studied. Significant variation in average weight, volume, length, diameter and stone weight of different cultivars were found coupled with a similar variation in their contents of TSS, acidity, ascorbic acid and total sugars. Among the physical characters at maturity the maximum dimensions of fruit weight, fruit volume, fruit diameter, fruit length and stone weight respectively were possessed by the cvs. Banarasi (57.74 g), Krishna (57.97 ml), NA-7 (4.38 cm), Banarasi (4.76 cm) and Krishna (5.03 g). Similarly, among the chemical characters at maturity the maximum chemical content of TSS, acidity, ascorbic acid and total sugars respectively were possessed by the cvs. Banarasi (15.71%), Banarasi (2.32%), Banarasi (882.11 mg/100g of pulp) and Krishna (8.23%). Thus, from the overall physical characteristics point of view the cv. Banarasi may be declared to be of best fruit size (fruit weight = 57.74 g, fruit volume = 56.68 ml, fruit diameter = 4.10 cm, fruit length = 4.76 cm) followed by Krishna, Kanchan, Chakaiya and Francis, with the fruit of most inferior size to be the cv. NA-6. Similarly, from the chemical characteristics point of view, the best chemical composition at maturity may be attributed to Banarasi (TSS = 15.71%, acidity = 2.32%, total sugars = 8.09%, ascorbic acid = 882.11 mg/100g of pulp) followed by the cvs. Chakaiya and Francis. However, no single cultivar stands out to be of most inferior chemical quality.

Key words: Aonla, growth and development and physico-chemical characteristic.

Introduction

Aonla (*Emblica officinalis* Gaertn.) is an important fruit crop of India, which belongs to the family *Euphorbiaceae*, sub-family *Phyllanthoideae*. Next to Barbados cherry (*Malpighia glabra*) aonla is the richest and cheapest source of Vitamin 'C' among fruits (Asenjo, 1953), and a fair source of minerals, carbohydrates, carotene, thiamin and riboflavin (Pillay and Mahadeva, 1958). Looking to better prospects created by some medicinal corporates in recent years, which are encouraging the local farmers for cultivation of aonla in their wastelands, the scope of cultivation of this crop is increasing day by day in wasteland situations. Further, considering the high productivity per unit area, hardy nature of the plant, high medicinal and nutritional value of aonla, there is a high possibility that it will be one of the most important fruit of

the future. Its cultivation has increased in wasteland situations during recent years because it can be successfully grown in variable agro-climatic areas and variable soil conditions like that of Chhattisgarh as its plant is resistant to hardy and opposite actions of nature. It is the native of tropical south eastern Asia, particularly central or south India (Firminger, 1947; Mortan, 1960). It is being cultivated since ancient times of India. Seedling trees in large numbers are common in Vindhyan hills (M.P. and U.P.) and Himalayan hills up to an elevation of 1350 M (Anon., 1960; Ram, 1974). Its cultivation is more common in central Uttar Pradesh apart from some western and eastern segments (Bajpai, 1965; Ram, 1971). It is also cultivated in Gujarat, Maharashtra, Haryana and Rajasthan. Chhattisgarh is situated between 17°14'N-24°45'N latitude and 79°30'E-84°15'E longitude. Raipur falls between 26°16'N latitude and 80°36' longitude at an altitude of 289.6 meters above the mean sea level. Aonla cultivation suits very well to all the soil conditions of Chhattisgarh, namely, Bhatta (morrum soil), Matasi, sandy loam and clayey soils. It has great tolerance to salinity and sodicity and can be successfully cultivated in pH range of 6.0 to

* Corresponding author's email:

virendrahorti_2008@yahoo.com

8.0. It can be grown in irrigated as well as un-irrigated rain fed area, because the plant of aonla is resistant to hardy and opposite actions of nature. Since its roots penetrate into deep soil and absorb the moisture, it can also be grown easily in unfavorable conditions. The leaves of aonla are narrow in size so the evaporation of water is less. The bark of aonla is thick and semi-dry, which makes it resistant to water evaporation. These traits of aonla make it suitable for dry land areas.

Raipur is classified under dry and sub-humid agro-climatic region. The annual rainfall of this region ranges between 1200-1400mm, of which about 85% is received from third week of June to mid September and very little during October to February. May is the hottest month and December is the coolest. The maximum temperature of this region may reach as high as 46°C during summer and minimum may fall to as low as 6°C during winter. The atmospheric humidity is higher from June to October. The available cultivars in Chhattisgarh so far are not ideal for commercial cultivation because they do not fulfill domestic or export requirements. Therefore, it has been felt necessary to evaluate aonla cultivars in Chhattisgarh. The knowledge about the physico-chemical changes in the fruit at various stages (say, Initial, Middle and Maturity) of its growth and development may be helpful in evaluating the cultivars. The available cultivars so far are not ideal for commercial cultivation because they do not fulfill domestic or export requirements. Sufficient information on physico-chemical changes during growth and development of aonla cultivars, especially in Chhattisgarh, is not available. Hence the present study has been conducted at Raipur, Chhattisgarh.

Materials and methods

The investigations were carried out in the Horticulture Department, Indira Gandhi Agricultural University, Raipur, Chhattisgarh. The experiment was conducted on the layout of Randomized Block Design, wherein 2 trees of each of above eight cultivars have been randomly grown within each replication. Some of the observations were recorded in percent, like in case of total soluble solids (%), titrable acidity (%) and sugars (%). Such percent variables do not follow normal distribution; therefore, a direct analysis of variance for these variables will be invalid. Thus, to maintain the validity of the analysis, arcsine-transformation of the above per cent characteristics were done and then subsequent analyses of variance were carried out for the transformed variables, following Snedecor and Cochran (1967). But for the ease of interpretation, means of these transformed values are presented along with their inverse transformed means in original units.

The observations were recorded at three stages, one at 10 days from the initiation of fruit growth (i.e. initial stage), second at 85 days during fruit development (i.e.

middle stage) and third at 145 days (i.e. maturity stage or harvesting stage of fruit). Ten fruits of uniform physiological age from each plant were randomly selected on the date of observation from three side branches of the tree. These fruits were used for recording the physiological characters and then subsequently utilized for chemical analysis. The fruits were thoroughly washed and their weights were measured with the help of electronic balance. Similarly, the fruit volume was ascertained through water displacement method. The length and diameter of each fruit was measured with the help of Vernier Callipers. The pulp of fruit was separated and relative weight of seed was determined with the help of electronic balance. Total soluble solids content was determined by hand refractometer (0-32° Brix). Acidity was determined by alkali titration method and expressed in terms of percent citric acid. Vitamin 'C' was estimated in accordance with A.O.A.C. (1980) method using 2, 6 dichlorophenol indophenol dye and expressed as mg/100g of pulp. Total sugars were determined by the method of Lane and Eynon (1960).

Results and discussion

The observations on various characters, which have been recorded during the course of the experiment, are presented in Table 1 and 2. While, discussing the results of the experiment it may already be borne in mind that although most of the cultivars started their fruiting normally, the cultivars Chakaiya and Francis started their fruiting very late compared to other cultivars, so late that their 10-days-after-fruit-growth-initiation coincided with 55-days-after-fruit-growth-initiation of other cultivars.

Physical characteristics of aonla at different growth stages:

The perusal of data on average fruit weight in Table 1 indicates that Banarasi cultivar maintained uniformly highest average fruit weight at the middle (47.19 g) and maturity (57.74 g) stages of fruit except that it was second to NA-7 in the initial stage. It also significantly differed at 5% level of significance from all the cultivars at all the three stages. The findings of Pathak (1965), which states that fruit weight of aonla increases continuously from early stage to maturity stage, supports the present finding. Table 1. indicates that the average pattern of growth of fruit volume was similar to the growth of average fruit weight as also obtained earlier by Udai Raj (1994). Both the fruit weight as well as fruit volume increased significantly from one stage to the other stage of growth. Comparing fruit diameter of all the cultivars based on Table 1, it was found that the average fruit diameter of aonla cv. NA-7 was uniformly maximum at all the stages of growth (i.e., initial stage, 2.09 cm; middle stage, 3.79 cm and maturity stage 4.38 cm) and was significantly more than those of other cultivars. As for the minimum fruit diameter is

concerned, it was found to be different at different stages, however, at maturity it was minimum in the case of cv. Chakaiya and NA-6. In terms of average length (Table 1), though, the cv. NA-7 had maximum length (2.23 g /fruit), which was also significantly different from others at the initial stage, the cv. Banarasi maintained uniformly and significantly highest fruit length at the middle and maturity stages (4.39 g and 4.76 g respectively) closely followed by the cv. Krishna. These results are in conformity with the observations made by Bajpai (1963) and Pathak (1965). Taking the aggregate view of different sizes of cultivars, i.e., in terms of fruit weight, fruit volume, fruit diameter and fruit length, at the maturity stage the cv. Banarasi may be declared to be of the best fruit size followed by Krishna, Kanchan, Chakaiya and Francis, respectively and similarly the cv. NA-6 may be declared to be of most inferior fruit size. Perusal of Table 1, shows that, although, the cv. Krishana possessed the maximum stone weight at maturity stage (5.03 g), if we consider all the stages of fruit growth, we find the cv NA-7 to be possessing in general a maximum stone weight, leaving apart the cvs. Chakaiya and Francis, as they had late fruit-growth-initiation. However, the stone weight of Banarasi was at par with that of NA-7 at all the stages. Similarly, the stone weight of NA-6 was minimum at all the stages of fruit growth followed by that of NA-10.

Chemical characteristics of aonla at different growth stages:

The total soluble solids (TSS), titrable acidity and total sugars were all measured in the percent units. As the

percent units do not follow normal distribution, they invalidate the F-test of the analysis of variance and the subsequent t-tests for means. Therefore, to validate these tests, arcsine transformation of all the percentage data were carried out and then subsequent analyses of variance were performed. The average arcsine values of different chemical parameters under study are given in Tables 2, along with the relevant critical differences and standard errors of difference between two cultivar's means. However, to comprehend the average arcsine values in the original percent units, the same were also presented into brackets in the tables after transforming back the average arcsine values into percent units by inverse arcsine transformation. The Table 2 gives the estimated values of TSS contents of different cultivars. More TSS in cultivars causes less moisture content leading to their enhanced disease resistance capacity and increased storage life because lack of moisture creates an anti-microbial environment within the fruits. Consequently, TSS in a sense is an indicator of storage life of the cultivars. The perusal of Table 2 clearly indicates that, even though, initially the cv. NA-7 possessed the uppermost TSS (transformed average arcsine value 18.37, i.e., 9.93% TSS), later it was taken over by the cv. Banarasi, which uniformly maintained the highest TSS contents during the middle (23.04, i.e., 15.31%) as well as maturity (23.35, i.e., 15.71%) stages. These TSS contents were also significantly different from those of other cultivars at the middle stage; however, the same were at par with those of cvs. Chakaiya, Francis, Kanchan and Krishna at the maturity stage. Analogous

Table 1. Average fruit weight, Fruit volume, Fruit diameter, fruit length and weight of stone of aonla cvs. at different growth stages.

Cultivars	Fruit weight (g)			Fruit volume (ml)			Fruit diameter (cm)			Fruit length (cm)			Weight of stone (g)		
	10 days	85 [40]	145 [100]	10 days	85 [40]	145 [100]	10 days	85 [40]	145 [100]	10 days	85 [40]	145 [100]	10 days	85 [40]	145 [100]
Banarasi	4.47 ^c	47.19 ^e	57.74 ^c	4.27 ^c	46.31 ^f	56.68 ^d	2.02 ^c	3.78 ^f	4.10 ^c	2.01 ^d	4.39 ^f	4.76 ^f	0.42 ^c	3.82 ^e	4.09 ^d
Chakaiya	✧	11.50 ^a	41.00 ^b	✧	10.72 ^a	38.67 ^a	✧	2.39 ^a	3.40 ^a	✧	2.78 ^a	4.20 ^c	✧	0.81 ^a	3.40 ^c
Francis	✧	14.13 ^a	45.92 ^c	✧	13.31 ^b	42.68 ^b	✧	2.66 ^b	3.73 ^b	✧	2.82 ^a	4.15 ^c	✧	1.41 ^b	3.21 ^b
Kanchan	2.88 ^b	36.37 ^{cd}	53.91 ^d	2.61 ^b	34.93 ^d	52.03 ^c	1.74 ^c	3.58 ^e	4.10 ^c	1.58 ^b	4.06 ^c	4.39 ^d	0.29 ^b	2.43 ^c	2.93 ^a
Krishna	2.69 ^a	38.94 ^d	56.68 ^{de}	2.42 ^a	37.55 ^e	57.97 ^d	1.63 ^a	3.52 ^{de}	3.78 ^b	1.58 ^b	4.34 ^f	4.62 ^e	0.23 ^a	3.41 ^d	5.03 ^c
NA-6	3.89 ^c	32.22 ^b	36.40 ^a	3.62 ^c	31.68 ^c	35.15 ^a	1.73 ^b	3.33 ^c	3.40 ^a	1.51 ^a	3.46 ^b	3.84 ^a	0.22 ^a	3.79 ^c	4.13 ^d
NA-7	5.83 ^f	35.74 ^c	45.95 ^c	5.67 ^f	34.11 ^d	44.19 ^b	2.09 ^f	3.79 ^f	4.38 ^d	2.23 ^c	3.77 ^d	4.30 ^{cd}	0.42 ^c	3.98 ^e	4.25 ^d
NA-10	4.23 ^d	33.01 ^{bc}	43.59 ^{bc}	4.01 ^d	31.39 ^c	41.14 ^b	1.83 ^d	3.45 ^{cd}	3.50 ^a	1.98 ^c	3.60 ^c	3.97 ^b	0.22 ^a	3.87 ^c	4.20 ^d
Sem±	0.04	0.96	0.99	0.02	0.60	1.31	0.007	0.04	0.04	0.02	0.02	0.03	0.01	0.07	0.07
CD (5%)	0.11	2.77	2.83	0.07	1.76	3.96	0.01	0.13	0.13	0.08	0.09	0.10	0.03	0.2	0.18

Note

1. The symbol ✧ indicates that there was no fruiting upto 40 days in cvs. Chakaiya and Francis.
2. Figures in brackets [] indicate days after fruit growth initiation for Chakaiya and Francis cultivars.
3. The superscripts letters indicate that the treatment means with same letters are at par at 5% level of significance, while the means with different letters are significantly different at 5% level. These letters have been affixed based on CD-value comparisons of treatment means.

remarks with TSS contents of aonla cultivars were reported by Pathak (1965) and Pathak et al. (1985). The cv NA-10 performed with minimum TSS content at the initial and maturity stages. Acidity along with sugar is an indicator of good taste of the fruit. Furthermore, its presence also discourages microbial growth leading to its better keeping quality. Just as in case of TSS, both cultivars NA-7 and Banarasi maintained the same pattern in terms of highest acidity too (Table 2). However, at the maturity stage the Banarasi (8.76, i.e., 2.32% acidity) had at par acidity with those of Chakaiya, Francis, NA-7 and NA-10. In case of lowest acidity there was no such pattern. The other thing that was uniformly true for all the cultivars was that the acidity increased up to the middle stage of growth; thereafter it continuously decreased up to the maturity stage. This observation in aonla is in harmony with those of Pathak (1965), who recorded a gradual increase in citric acid content upto 28th November and thereafter, a gradual decline till the harvest at maturity stage in Banarasi and Deshi cultivars. Mukherjee (1959) also likewise reported rise in acid percentage during the early period of fruit growth followed by a continuous decline till the final harvesting of mango fruit. A similar observation is reported in the findings of Singh and Singh (1995) in case of Litchi cvs. Muzzafarpur and Calcuttia.

Ascorbic acid is genuine "Vitamin C" whose presence provides the power of resistance in fruits against the diseases like scurvy, diarrhea, dyspepsia, chronic dysentery, cough and cold etc. The perusal of Table 2 shows that the ascorbic acid content increased continuously from the initial to final maturity stage in respect of all the cultivars, however, the rates of increase differed among different cultivars. Although, in the initial (82.39 mg/100g of pulp) and middle (572.24 mg/100g) stages of development the cv. NA-7 recorded the highest ascorbic acid content, in the maturity stage it was dislodged by the cv. Banarasi (882.11 mg/100g of pulp) from the first rank followed by Krishna, Chakaiya, NA-7 and others. Bajpai (1969) reported similar observation with the developing fruits of Banarasi. Aonla is a fruit well known for the richest source of Vitamin 'C' derived from its ascorbic content. At maturity, it was observed to vary from 702.48 to 882.11 mg/100g of pulp among different cultivars (Table 2) in different cultivars. The minimum ascorbic acid content was observed in the cv. Kanchan. At all stages of development, the ascorbic content of all cultivars were in general significantly different from each other, except that at initial stage Kanchan and NA-6 were at par, Krishna, NA-6 and NA-10 were at par; while at maturity NA-7 and NA-10 were at par in terms of ascorbic content. A wide variation in ascorbic acid content in different aonla cultivars at the time of maturity of fruits were also reported by Teotia et al. (1968) and Pathak et al. (1985).

Sugar along with acidity is an indicator of sweetness with a typical blend of sourness leading to a

good flavoured taste. A perusal of Table 2 indicates that the total sugars content gradually increased from the initial stage to maturity stage in respect of all cultivars under study. More than 70 per cent of the total sugars approximately were gathered up to the middle stage of fruit growth, the remaining being gathered till the maturity stage. Further, while the cv. Krishna possessed minimum sugar at the initial stage, it topped in the total sugars at the middle (14.33, i.e., 6.12% total sugars) and maturity (16.67, i.e., 8.23%) stages, which was also significantly different from those of all other cultivars. This was followed closely by the cv. Banarasi both in the middle (14.03, i.e., 5.87%) as well in the maturity (16.53, i.e., 8.09%) stages. Banarasi was followed by Kanchan (15.51, i.e., 7.15%), Francis (15.47, i.e., 7.11%) and Chakaiya (15.02, i.e., 6.72%), respectively at the maturity stage. Pathak (1965) also observed gradual augment, up to maturity stage, in the amount of reducing, non-reducing as well as in total sugars content in Banarasi and Deshi cultivars of aonla. Singh and Singh (1995) also observed a similar pattern of total sugars in Litchi cvs. Muzzafarpur and Calcuttia. Udai Raj (1994) observed the same thing in aonla cv. NA-7.

References

- A.O.A.C. 1980. Official methods of analysis. Association of official analytical chemicals. 12 Ed. Washington, D.C.
- Anonymous. 1965. Agriculture in Ancient India. Ray Chaudhari, SPP (Tech. Ed.), ICAR, New Delhi.
- Asenjo, C. F. 1953. The story of West Indian Cherry. Buletin del Calegio de Qumicos de Puerto Rico, 10 : 8-10.
- Bajpai, P. N. 1963. Studies on the bearing habit of aonla (*Emblca officinalis* Gaertn, Syn. *Phyllanthus emblica* L). Doctoral thesis, Agra University, India.
- Bajpai, P. N. 1965. Studies on vegetable growth and development of male and female genotype in aonla (*Emblca officinalis* Gaertn.). *Agra Univ. J. Res. Sci.*, 14 : 167-186.
- Bajpai, P.N. 1969. Seasonal variation in Vitamin 'C' content of aonla fruits. *Horticultural Advances*. 8: 15-16.
- Firminger, T.A. 1947. Firminger's manuals of gardening for India, 8th Ed. Thacker Spink and Co. Ltd. Calcutta.
- Lane, J.H. and Eynon, L. 1960. Determination of sugars by Fehling's solution with methyl blue as an indicator. *Journal of Science and Chemistry of India*, 42: 327-329.
- Mortan, J.F. 1960. The *Phyllanthus emblica* L. Ecological Botany. 14 : 119-127.
- Mukherjee, P.K. 1959. Bio-chemical and physiological studies during development of Mango fruits. *Horticultural Advances*. 3: 95-101.
- Pathak, R.K. 1965. Studies on Physico-chemical changes of aonla (*Phyllanthus emblica* Linn) during fruit

Table 2. Arcsine transformed values of average TSS, Acidity, Ascorbic acid and total sugar of aonla cvs. at different growth stages.

Cultivars	TSS (%)			Acidity (%)			Ascorbic acid (mg/100 ml)			Total sugar (%)		
	10 days	85 [40]	145 [100]	10 days	85 [40]	145 [100]	10 days	85 [40]	145 [100]	10 days	85 [40]	145 [100]
Banarasi	*16.66 ^d (8.22)	23.04 ^d (15.31)	23.35 ^b (15.71)	*5.28 ^b (0.85)	9.86 ^e (2.93)	8.76 ^b (2.32)	32.59 ^c	454.93 ^a	882.11 ^a	*8.40 ^{ab} (2.13)	14.03 ^e (5.87)	16.53 ^d (8.09)
Chakaiya	◇	17.58 ^a (9.12)	22.04 ^b (14.08)	◇	8.29 ^b (2.08)	8.62 ^b (2.25)	◇	176.49 ^b	783.43 ^c	◇	8.57 ^a (2.22)	15.02 ^b (6.72)
Francis	◇	19.24 ^b (10.86)	22.19 ^b (14.26)	◇	7.58 ^a (1.74)	8.14 ^a (2.01)	◇	164.17 ^a	720.93 ^b	◇	9.73 ^b (2.86)	15.47 ^c (7.11)
Kanchan	15.91 ^c (7.52)	21.55 ^c (13.50)	22.84 ^b (15.07)	4.66 ^a (0.66)	9.25 ^d (2.59)	8.16 ^a (2.01)	24.09 ^a	365.70 ^d	702.48 ^a	7.30 ^a (1.62)	12.62 ^d (4.78)	15.51 ^c (7.15)
Krishna	15.61 ^b (7.24)	20.89 ^c (12.72)	23.07 ^b (15.36)	5.28 ^b (0.85)	9.67 ^c (2.82)	8.43 ^a (2.15)	29.77 ^b	440.22 ^f	844.85 ^f	7.05 ^a (1.51)	14.33 ^f (6.12)	16.67 ^c (8.23)
NA-6	14.47 ^a (6.24)	17.96 ^a (9.51)	19.89 ^a (11.57)	5.37 ^b (0.88)	8.76 ^c (2.32)	8.33 ^a (2.10)	26.25 ^{ab}	285.83 ^c	750.31 ^c	7.94 ^a (1.91)	11.33 ^c (3.86)	12.03 ^a (4.34)
NA-7	18.37 ^c (9.93)	19.26 ^b (10.88)	20.89 ^a (12.72)	8.20 ^c (2.03)	8.95 ^{cd} (2.42)	8.54 ^b (2.21)	82.39 ^d	572.24 ^b	770.42 ^d	10.52 ^b (3.34)	11.85 ^c (4.22)	12.30 ^a (4.54)
NA-10	14.40 ^a (6.18)	19.04 ^b (10.65)	19.77 ^a (11.44)	5.36 ^b (0.87)	8.81 ^c (2.35)	8.43 ^{ab} (2.15)	27.88 ^b	395.96 ^c	765.76 ^d	7.94 ^a (1.91)	11.40 ^c (3.91)	12.09 ^a (4.39)
Sem±	0.05	0.28	0.41	0.12	0.13	0.12	0.96	1.97	2.94	0.75	0.06	0.15
CD(5%)	0.15	0.86	1.23	0.38	0.39	0.35	2.78	5.67	8.48	2.36	0.18	0.44

Note:

1. Note the symbol ◇ indicates that there was no fruiting upto 40 days in cvs. Chakaiya and Francis.
 2. The symbol * indicates the mean arcsine transformed value.
 3. Figures in brackets [] indicate days after fruit growth initiation for Chakaiya and Francis cultivars.
 4. The superscripts letters indicate that the treatment means with same letters are at par at 5% level of significance, while the means with different letters are significantly different at 5% level. These letters have been affixed based on CD-value comparisons of treatment

development. Thesis submitted for the Master of Science in Agriculture (Horticulture) to Agra University, India.

Pathak, R.K., Hariom, Pandey, S.D. and Singh, I.S. 1985. Survey, Classification and Identification of promising strains of aonla (*Emblica officinalis* Gaertn.) paper presented at 3rd annual workshop held at Rahauri on Arid zone fruits.

Pillay, P.P. and Mahadeva, I. 1958. A chemical experimentation of *Emblica officinalis* Gaertn. *Current Science*, 27: 266-267.

Ram, S. 1974. Aonla tree you must grow. *International Agriculture*, 12: 6-8.

Singh, Prabhakar and Singh, I.S. 1995. Physico-chemical characteristics of fruit in two cvs. of aonla

(*Phyllanthus emblica* Linn.). *Haryana Journal of Horticultural Science*, 13 (3-4): 133-134.

Snedecor, G.W. and Cochran, W.G. 1967. Statistical methods (Sixth edition). Oxford and IBH Publishing Co. New Delhi, Pp 325-330.

Teaotia, S.S., Singh, D.B., Singh, R.D. and Singh, R.N. 1968. Studies of some varieties of aonla of eastern U.P., *Punjab Horticulture Journal*, 8 : 241-244.

Udai Raj 1994. Studies on the changes in nutrients and bio-chemical constituents during growth and development of fruit in aonla (*Emblica officinalis* Gaertn.) cv. NA-7. Thesis submitted for the Master of Science in Agriculture (Horticulture) to NDUAT, Faizabad, U.P.

Evaluation of drip irrigation to *kinnow* in south-west Punjab

C. J. S. Sethi*, C. B. Singh, Ajay S. Sidhu, A. S. Sidhu and H. S. Gulati
PAU, Regional Station, Bathinda - 151001

Abstract

Kinnow is a major fruit crop in southwest Punjab, mainly canal irrigated, as the ground water is brackish. The inadequacy of the canal water warrants the use of the improved methods of irrigation including the drip system. Field experiments to evaluate drip and basin system versus basin were laid out in quadruplicate with a unit of five trees per replication and three levels of irrigation 35, 55, 75 per cent of pan evaporation. Drip system saved similar amount of water under all levels of irrigation allowing 142% net additional area irrigable on replacing basin irrigation.

Drip irrigation increased the water content in the wetted zone, which increased the rooting density. Use of sodic water for over 2.5 years increased the soil pH and the electrical conductivity. The method could not become popular for lack of field verification of experimental results. Field verification of productive orchards drip irrigated from the beginning supported the experimental data. Thus the amount of water to be applied to *kinnow* through drip irrigation has been recommended. The recommendation is likely to increase the orchard area under drip system in the region.

Key words: Drip irrigation, pipe irrigation, root density, soil moisture profile, soil salinity

Introduction

Flooding is a common practice for irrigating field crop and orchards in the state. Flooding not only leads to the wastage of the precious irrigation water through conveyance and distribution, but also attracts fungal diseases in fruit plants. In southwest Punjab, surface water resources are inadequate and the ground water is brackish. There has been long felt need to change the prevalent method of flooding basins around fruit plants to cover larger areas with the available water. The drip irrigation system has a great potential to use water judiciously and efficiently along with improvement in the crop yields and its quality (Goldberg and Schumeli, 1969, Nakayama and Buchs, 1986, Sivanappan 1992, Annant Kumar and Bojappa, 1994). Though efforts on introduction of technology in the state was initiated in the early eighties, the benefits of the technology in terms of water and fertilizer saving could not be fully exploited because of a lack of technical know-how/ advisory system and uncertainties associated with canal water / power supply in the region (Singh, 2003). A study was therefore conducted to compare drip/pipe and basin method of irrigation in water saving, scheduling irrigation to *kinnow* and its effects on soil parameters.

Materials and methods

The drip, pipe and basin irrigation systems were laid out in 1983 in quadruplicate, with a unit of five *kinnow* plants per replication with three levels of irrigation viz. 35, 55, 75 per cent of pan evaporation and two levels of water quality viz. canal water and RSC 6 me/l and EC 1.5 dS m⁻¹, representative of the region, arranged in a randomized block design. The canal water was applied periodically stored in a tank and pumped as per requirements of different treatments. The test water was artificially prepared every day during summer. The soil was non-saline, non-sodic, sandy loam, low in organic carbon and phosphorus and high in potash. The water requirement was worked out in liter per day (lpd) following (Doorenbos and Pruitt, 1975).

Water required (lpd) = Pan coefficient X crop coefficient X
Evaporation (mm/day) X Spread of
the tree m² ÷ application efficiency (%)

The evaluation of the method was done during 1993-94. The growth and yield parameters in the experiment have already been detailed and discussed by Dhindwal *et al* 1999. The soil moisture content was determined gravimetrically with depth in 15 cm to 30 cm increments upto 180 cm depth in the center and periphery of both the basin and the drip irrigated volume. Likewise the rooting density was measured by sampling in the center (Drip 1), periphery (Drip 2) and between the drippers (Drip 3). In case of basin irrigation the measurements were made along the stem (Basin 1), mid of the basin (Basin 2) and the

Corresponding author's email:
charanjeet.sethi@gmail.com

periphery of the basin (Basin 3). The variation of drip discharge was measured for known periods on farmers' fields. The pH and EC were measured in the center and periphery of the drip irrigated volume at different depths.

Results and discussion

Water applied/saved

The data pertaining to the water saved by drip, and pipe irrigation systems as compared to that under flood irrigation are shown in table 1. It is evident that irrigation water requirement, during the ninth year, for April 15-30 increased from 30 lpd at 35% Pan-E to 64 lpd at 75% Pan-E. Further, it also increased the water saving from 138 thousand liters to 295 thousand liters per hectare if irrigated by pipe/drip system. The water applied and the water saved during the 10th and 11th year corresponded the open pan evaporation fluctuations with the season. Over the three years, the water applied was 16.6, 24.1 and 35.1 thousand liters per plant under 35, 55 and 75 per cent pan evaporation, respectively. As compared to 18395 liters under 100% Pan-E flooding, the drip/pipe system saved 6395, 10060, 13705 thousands liters ha⁻¹. The results show that drip irrigation saves, nearly 60% water allowing irrigation of 142% additional area. But the drip system may not perform equally well under field

conditions. To check this a survey was conducted in the orchards with working drip systems wherein the measured discharge of the drippers (Table 2) was usually found to be lower than that prescribed by the manufacturing company. This was due to inadequate pressure, choked filters and/or choked drippers. It emphasizes the need for proper maintenance of the drip system for which the requisite instructions have been approved for inclusion in the package of practices for fruit crops of Punjab.

Soil moisture distribution

The soil moisture in the profile under basin and drip irrigation is shown in fig. 1. The data revealed that the moisture content at the periphery of the basin could be 1.4% higher in 0-90 cm and 5.3% higher in 90-180 cm depth. In case of drip system, the water content in the center of the bulb is higher than at the periphery and further higher than at the periphery of the basin upto 120 cm depth. This variation in moisture content is due to tendency of water to move downwards more than the laterally. Blaine *et al* (2003) reported similar observations.

Root distribution

The data in figures 2 and 3 revealed that more of roots concentrate in the center of the area wetted by the

Table 1. Mean open pan evaporation, water applied per tree per day and water saved per hectare with pipe and drip system at different irrigation levels

Age (Yrs) Period	Pan-E, mm/day	Water (000 L) Flooding at 100% Pan-E	Water applied, litre/day/plant			Water saved (000L) Drip/pipe irrigation		
			35	55	75	35	55	75
9. Apr 15-30	10.5	420	30	47	64	138	218	295
10. Dec 1-15	2.2	123	6	10	13	43	65	88
May 16-31	1.6	673	45	71	96	225	350	478
11. Dec 1-15	2.1	22	12	19	25	75	118	160
May 1-15	8.7	653	46	72	98	215	338	463
Sep 15-30	3.5	263	18	29	49	88	138	188
Jan1, 93- Sep30, 95	4464	18395	41.5	60.3	87.8	6395	10061	13705

Table 2. Comparison of specified and measured discharge of the emitters on farmers' fields

Farmer	Discharge, litre/hour	
	Specified	Measured
S. Ranbir Singh	8.0	4.7
S. Sukhpal Singh	14.0	6.0
Sh. Ramesh Setia	8.0	5.3
Sh. Pradeep Dawra	8.0	4.1

drips especially 0-60 cm depth. Further root concentration along the periphery and between the drips decreases successfully. More rooting is encouraged under irrigation at 75% of pan evaporation than with 35% of pan evaporation. Under basin system, the rooting density decreases away from the plant, though with 35% of evaporation, this is more in the middle of the basin. As more of roots concentrate in the drip irrigated volume, which remains continually wet, they are able to meet the water requirements of the plants

Soil salinity

A comparison of the pH and the electrical conductivity of the soil under drip irrigation with fresh and saline water is given in figures 4 and 5 for pH & 6 and 7 for electrical conductivity (EC). The use of saline water raised both the pH and the EC of the soil. The pH was raised to the marginal value of 9.3, but the EC value was

still normal. Similar observations were also reported by Blaine *et al* (2003), Charles *et al* (2003) and Choi and Suarez (2004).

One of the apprehensions in popularizing the drip irrigation system has been that the root system of the trees under the system may be different, which may not be productive and economic. The survey further revealed that the ground cover of *kinnow* trees, drip irrigated from the beginning, at full maturity is only 50% instead of 70%, which was presumed earlier to work out the water requirement (Doorenbos and Pruitt, 1975). Similarly, under limited water conditions, farmers were supplying only 40-50 liters water per day per plant without any adverse effect on growth though their yield was effected some what. In support of the rooting density observation in the study, the data in table 3 reveals that the production level of drip irrigated *kinnow* trees has been satisfactory. On the basis of this information, the water requirement (Table 4) for

Table 3. Actual water applied to drip irrigated *kinnow* and returns per hectare

Farmer	Plant age, yrs	Water applied, liter/plant/day	Returns per acre, Rupees
S. Ranbir Singh	9	31	-
S. Bhagwant Singh	6	55	-
S. Ranjit Singh	10	45	-
S. Sukhpal Singh	15	56	1,25,000
S. Robinder Singh	16	80-160	2,00,000
Sh. Somnath	3	20	-
Sh. Ramesh Setia	6	32	1,00,000
Sh. Rai Singh	5	57	1,00,000
Sh. Pradeep Dawra	8	82	>2,00,000

Table 4. Amount of water (litre/day/plant) to be applied to *kinnow* through drip irrigation

Month	Age of the plant (Yrs)				
	0-2	3-4	5-6	7-8	9 and above
Jan	3	6	9	12	15
Feb	6	12	18	24	30
Mar	9	18	27	36	45
Apr	13	26	39	52	65
May	16	32	48	64	80
Jun	17	34	51	68	85
Jul	13	26	39	52	65
Aug	12	24	36	48	60
Sep	11	22	33	44	55
Oct	8	16	24	32	40
Nov	5	10	15	20	25
Dec	3	6	9	12	15

Note:

1. Follow the instructions for use of drip irrigation system (Singh, *et al* 2005)
2. Amount of irrigation water may vary by 10-15% depending upon the prevailing weather conditions
3. For lifting water from canal storage tank, a booster pump with solar/electric motor of 2 HP will be sufficient for 4 ha *kinnow* orchard. However, for 6 and 10 ha a booster pump with electric motor of 3 and 5 HP will be required for lifting water.
4. In the beginning, 1-2 drippers per plant/tree. For efficient use of water sub lateral loops of the drippers should be used around each plant/tree.

drip irrigation of kinnow in the state has been suggested (Singh *et al* 2005). It is hoped that the adoption of these will help increase the area under this technology in the state. Since the pipe system is equally efficient, those with smaller land holding may take up the system initially.

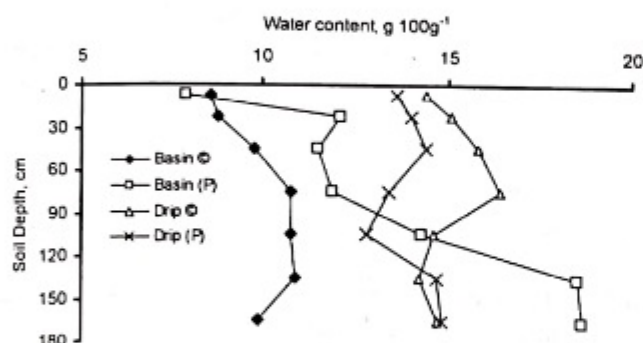


Fig. 1 Soil moisture profile in the centre © and the periphery (P) of basin and drip system at 0.75 Pan-E (May 1993)

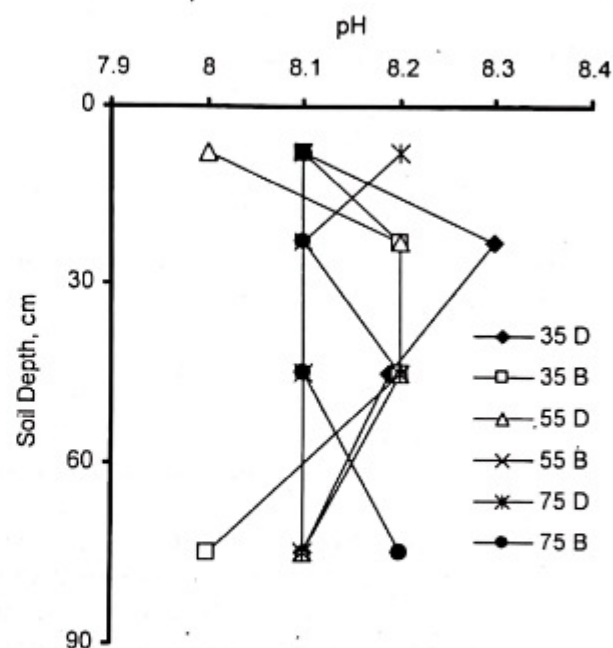


Fig. 4 Soil pH under different levels of irrigation in the centre and periphery of drip irrigated volume

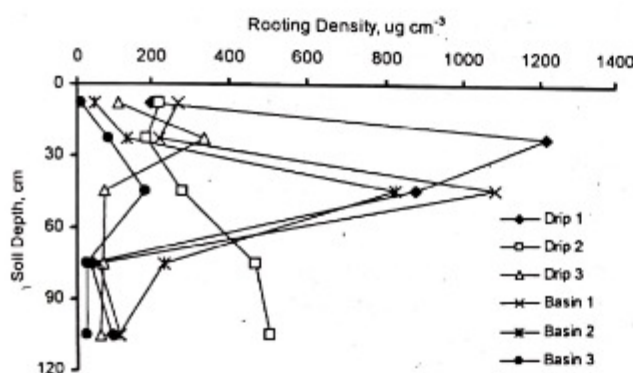


Fig. 2. Rooting density of kinnow at 0.35 Pan-E under drip and basin irrigation

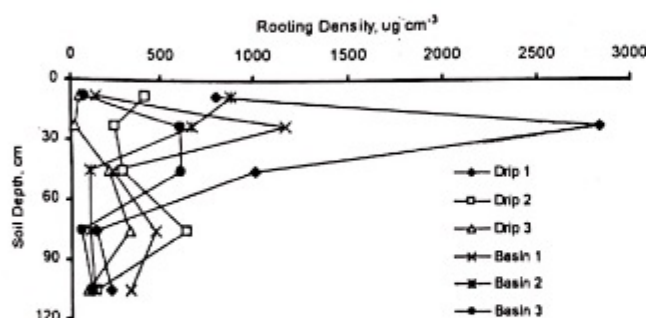


Fig. 3. Rooting density of kinnow at 0.75 Pan-E under drip and basin irrigation

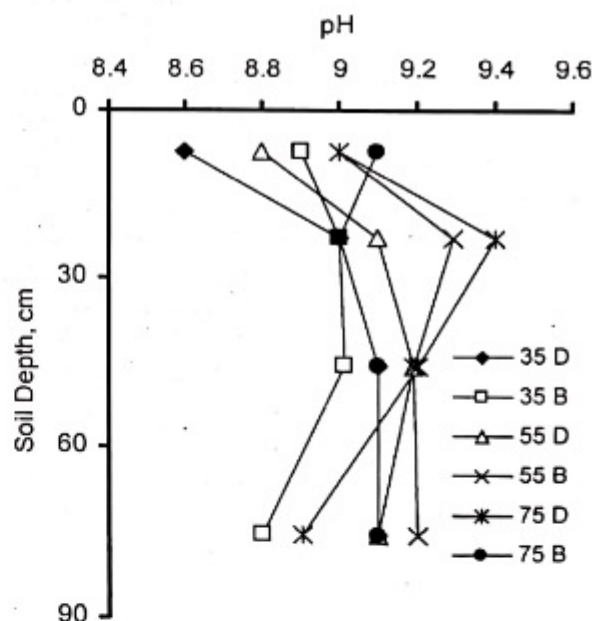


Fig. 5 Soil pH under drip irrigation with saline water, D (s), in the centre and periphery of drip irrigated volume

References

- Ananth Kumar, A. P. and Bojappa K. M. 1994. Studies on the effect of drip irrigation on yield and quality of fruits in sweet oranges (*Citrus sinensis* L. osbeck) and economy in water use. *Mysore J Agric. Sci.* 28:338-44
- Blaine, H. and Don, M. 2003. Drip irrigation increases tomato yield in salt-affected soil of San Joaquin Valley. *California Agriculture* 57(4): 132-137.

- C. J. S. Sethi, C. B. Singh, Ajab S. Sidhu, A. S. Sidhu and H. S. Gulati, *Indian Journal of Arid Horticulture*, 2008, Vol. 3 (1): 16-20
- Charles, M B., Brett, I. and Lisa, B. 2003. Long-term salinity buildup on drip/micro irrigated trees in California. Presented at the IA Technical Conference in San Diego, CA, Nov.18, 2003:1-11.
- Choi, C Y and Suarez R E M 2004. Surface drip irrigation for Bermuda grass with reclaimed water. Trans. ASAE:1943-1951.
- Doorenbos, J. and Pruitt, W. O. 1975. Guidelines for predicting crop water requirements. Irrigation and Drainage Paper FAO, UN, Rome
- Goldsberg, S. D. and Schumeli 1969. Trickle irrigation a method for increased agricultural production under conditions of saline water and adverse soils. In Proc. Conf. Arid lands in a changing world Tucson Arizona
- Dhindwal, A. S., Agarwal, M. C., Jaiswal, C. S., Ram Deo, Prabhakar, J. and Aujla M. S. 1999. Status of research on agricultural water management in Northern region. AICRP on water management. Directorate of water management research. Walmi complex. Patna.
- Nakayama, F. S. and Buchs, D. A. 1986. Scheduling trickle irrigation in trickle irrigation for crop production design, operation and management. Developments in Agril. Engg, 9. Elsevier Science Publishers. Amsterdam
- Sivanappan, R. K. 1992. New irrigation techniques for grapes. Drakshvritta Smamika pp: 7-13
- Singh, C. J. 2003. Efficient use of water in canal command area of Punjab. In Rao, CH Hanumantha, Ramprasad Sengupta, K Chopra (eds), Water Resources, Sustainable livelihood and Ecosystem services. Indian Society for Ecological Economics. Concept Publishing Company, New Delhi. Pp: 169-193
- Singh, C. J., Gulati, G. S. and Chahil, B. S. 2005. Installation and maintenance of drip irrigation system in orchards. Horticulture Newsletter, April-June 2005, 1 (II):3-

Management of post-harvest stem-end rot of kinnow (*Citrus deliciosa* Ten.) fruits through chemicals

R. N. Sharma, R. P. Maharshi¹ and R. B. Gaur

Deptt. Plant Pathology, Agricultural Research Station (Rajasthan Agricultural University), Sriganganagar - 335 001

Abstract

The stem-end rot of Kinnow (*Citrus deliciosa* Ten.) caused by *Botryodiplodia theobromae* is a major limiting factor in storage life of Kinnow fruits, responsible solely for 20 per cent of the total fruit loss occurred every year due to post-harvest rotting in Sriganganagar belt of Rajasthan. Nine fungicides were tested against the *B. theobromae* as well as incited rot. Prochloraz and carbendazim proved most effective against the pathogen, inhibited cent per cent mycelial growth and provided complete protection from the rot incidence in both pre- and post-inoculation treatments at 1000 ppm concentration. The mancozeb in association with carbendazim (saaf) and mancozeb alone were the next in order of efficacy where, 100 and 91.24 per cent growth inhibition, respectively was observed. These fungicides potentially reduced the incidence to the extent of 87.84 and 81.41 per cent, respectively as compared to control when applied as pre-inoculation treatment at 1000 ppm concentration. The fruit rot incidence correlated positively with incubation period, where the incidence at 8th day, after inoculation (DAI) was significantly higher than incidence occurred at 4th DAI.

Key words: Kinnow, *Botryodiplodia theobromae*, post-harvest, stem-end rot, fungicides.

Introduction

The major part of citrus produce in India is being marketed as fresh fruit and less than 1 per cent is being exported to our neighbouring countries and processed for juice and other products. The major limiting factor in successful trade of citrus in domestic and export market has been the considerable decay and quality deterioration of fruits incurred due to plant pathogens during storage and transit to distant markets (Singh, 2002). The situation is quite alarming especially in the conditions prevailing in India and other South-East Asian countries, where scientific post-harvest management of the pathogens during harvesting, handling, transit and storage are neglected to save the spoilage of citrus fruits. The conservative estimation on post-harvest losses (spoilage) of Kinnow fruits has been focussed around 25-30 per cent (Singh *et al.*, 2002). Most of the post-harvest losses eventually result from invasion and spoilage of fruit by microorganisms. Fungi are usually the primary agents in the spoilage of fresh fruits.

The Kinnow fruits are attacked by a variety of microorganisms that causes post-harvest rotting.

Botryodiplodia theobromae is one of the most destructive causal agent of post-harvest rotting of Kinnow fruits, causes stem-end rot, sharing 20 per cent of the total fruit loss (24%) occurred every year due to post-harvest rotting in Sriganganagar belt of Rajasthan. Post-harvest rotting of fruits can be suppressed by low temperature storage, a low oxygen atmosphere and treatment with growth regulators that delay tissue senescence. However, these beneficial practices may not be adequately protect fruits from microbial attack, especially during prolonged storage or movement of fruits through marketing channels. This is particularly true for mandarins which are injured by the near freezing temperature, the temperature required to inhibit pathogenic fungi for an extended period. In these situations, an antimicrobial chemical treatment may be the only means of extending the post-harvest life of a perishable crop (Bondad, 1974). Fungicides are primary antimicrobial chemical compounds to control the post-harvest rotting of fruits.

The present study was undertaken with a view to *in vitro* evaluate the fungicides of different groups including some newly developed for their fungitoxicity against *B. theobromae* Pat. (ID No. 6422.06 and ITCC NO. 6170) and further explored the efficacy to manage the incited post-harvest stem-end rot incidence in Kinnow fruits.

¹Deptt. Plant Pathology, SKN College of Agriculture (Rajasthan Agricultural University, Jobner, Rajasthan

Materials and methods:

Nine fungicides viz., Carbendazim (Bavistin), Fosetyl-Al (Aliette), Prochloraz, Thiophanate methyl (Roko), 12% Carbendazim + 63% Mancozeb (Saaf), Captan (Captra), Copper oxychloride (Blitox-50), Mancozeb (Indofil M-45) and Propineb (Antracol) were selected to evaluate their fungitoxicity against the mycelial growth of the *B. theobromae* and further use of the most effective fungitoxicants to manage the incited stem-end rot incidence in Kinnow fruits

(1) *In vitro* evaluation of fungicides against the mycelial growth of the *B. theobromae*:

The effect of fungicides at different concentrations (25, 50, 100, 250, 500 & 1000 ppm of a.i.) was tested against the *B. theobromae*, using "Poisoned Food Technique" (Nene and Thapliyal, 1997). The principle involved in this technique is to 'poison' the nutrient medium with a fungitoxicant and then allow a test fungus to grow on such a medium.

The Potato Dextrose Agar (PDA) medium was sterilized in flasks. Appropriate amount of the fungicides were separately mixed with molten PDA to get final concentrations of 25, 50, 100, 250, 500 & 1000 ppm of the fungicides. The medium was then poured aseptically into sterile Petri plates. After solidifying the medium, mycelial discs (5 mm dia.) of 7 days old actively growing culture of the *B. theobromae* were placed in the center of the individual plate. Suitable control was maintained where the culture disc was grown under the same conditions on PDA without fungicides. Each treatment was replicated thrice. After inoculation, Petri plates were incubated at $25 \pm 1^\circ\text{C}$ in BOD incubator. Observations were taken when the control plates were fully covered with mycelial growth of the *B. theobromae*. The per cent inhibition in mycelial growth of the *B. theobromae* as compared to control was calculated as described by Bliss (1934). The data were statistically analysed using a factorial randomized block design.

(2) Management of the stem-end rot of Kinnow fruits through chemicals:

The fruits were surface sterilized [dipping in 0.1 per cent mercuric chloride (HgCl_2) solution for 1 minute followed by three washing with sterile distilled water] and pricked through 'pin prick method' (Tomkins and Trout, 1931) upto the depth of 2 mm, making 5 wounds/fruit.

These fruits were separately inoculated by dipping them in spore suspension (10^6 spores ml^{-1}) of the pathogen (*B. theobromae*) for 2 minutes. Each fungicide was dissolved in sterile distilled water so as to get desired concentration (500 & 1000 ppm of a.i.) and used for dip treatment (Thompson, 1996) as pre- as well as post-inoculation treatments. In case of pre-inoculation treatment, the fruits were first dipped in the test fungicide for 5 minutes, air dried for 15 minutes and then inoculated, while in the

post-inoculation treatment, the fruits were first inoculated with fungal spores and then treated with fungicide. Parallel control with fruits dipped in sterile distilled water was processed simultaneously. The interval between inoculation of fungal spores and treatment with fungicides or vice-versa was of 12 hr. Each treatment was replicated thrice, having seven fruits in each replication. The experimental design was a factorial randomized block design.

The inoculated fruits were enclosed separately in pre-sterilized perforated polythene bags partially sealed with paper pins and incubated at $25 \pm 1^\circ\text{C}$ and 90-100 per cent RH. The number of wounds showed rotting were recorded on 4th and 8th DAI. The per cent rot incidence was calculated as follows:

$$\text{Rot incidence (\%)} = \frac{\text{Number of rotted wounds}}{\text{Total number of wounds observed}} \times 100$$

The rot reduction index (RRI) was calculated as described by Gutter (1969).

Results and discussion:

(1) *In vitro* effect of fungicides on mycelial growth of the *B. theobromae*:

All fungicides significantly inhibited the mycelial growth of *B. theobromae* as compared to control even at low concentrations (25 ppm) except copper oxychloride and fosetyl-Al where, no growth inhibition was observed below 100 ppm concentration. Prochloraz, carbendazim and a combination of carbendazim 12% + mancozeb 63% (saaf) proved most effective, inhibited 100 per cent growth even at 25 ppm concentration. Mancozeb, thiophanate methyl and propineb were found next in order of efficacy against the *B. theobromae*, exhibited 91.24, 84.48 and 80.62 per cent growth inhibition, respectively. The least inhibition (21.17%) was observed in the case of copper oxychloride. The effectiveness of fungicides increased with higher concentrations. At 25, 50, 100, 250, 500 and 1000 ppm concentrations, the growth inhibition was observed as 52.45, 57.20, 62.26, 69.43, 79.07 and 82.50 per cent, respectively which differed significantly to each other (Table 1, Fig 1a & b).

(2) Efficacy of different fungicides against the stem-end rot incidence in Kinnow fruits:

The results presented in table 2 depicts that the fruits treated with fungicides showed significantly less incidence of the stem-end rot as compared to untreated ones. Among the fungicides tested, prochloraz and carbendazim proved most effective against the rot. The fruits remained completely free from infection upto 8th DAI when treated with prochloraz and carbendazim at 1000 ppm concentration in both, pre- as well as post-inoculation treatments. A combination of carbendazim 12% + mancozeb 63% (saaf)

Table 1. *In vitro* evaluation of different fungicides against the mycelial growth of the *B. theobromae*

	Fungicides / Conc. (ppm) Per cent inhibition (PI)* in mycelial growth					Mean
	25	50	100	250	500	
Copper oxychloride	0.00 (0.57)	0.00 (0.57)	5.55 (11.38)	14.81 (22.63)	47.41 (43.52)	21.17 (21.50)
Propineb	52.41 (46.38)	64.26 (53.29)	76.11 (60.75)	90.93 (72.48)	100.00 (90.00)	80.62 (68.82)
Thiophanate methyl	63.33 (52.73)	72.22 (58.19)	78.89 (62.65)	92.41 (74.00)	100.00 (90.00)	84.48 (71.26)
Captan	37.78 (37.92)	52.78 (46.59)	60.93 (51.31)	72.96 (58.67)	79.26 (62.91)	65.06 (54.33)
Mancozeb	70.93 (57.37)	82.78 (65.49)	93.70 (75.51)	100.00 (90.00)	100.00 (90.00)	91.24 (77.23)
Mancozeb	100.00	100.00	100.00	100.00	100.00	100.00
Carbendazim 12% + Mancozeb	100.00	100.00	100.00	100.00	100.00	100.00
63% (Saaf)	(90.00)	(90.00)	(90.00)	(90.00)	(90.00)	(90.00)
Carbendazim	100.00	100.00	100.00	100.00	100.00	100.00
	(90.00)	(90.00)	(90.00)	(90.00)	(90.00)	(90.00)
Fosetyl-Al	0.00 (0.57)	0.00 (0.57)	7.41 (15.39)	23.15 (28.76)	64.07 (53.17)	28.95 (26.87)
Prochloraz	00.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
Control	0.00 (0.57)	0.00 (0.57)	0.00 (0.57)	0.00 (0.57)	0.00 (0.57)	0.00 (0.57)
Mean	52.45 (46.61)	57.20 (49.53)	62.26 (54.26)	69.43 (61.71)	79.07 (70.02)	82.50 (72.23)

Source: Fungicides

Concentrations

Fungicides x Concentrations

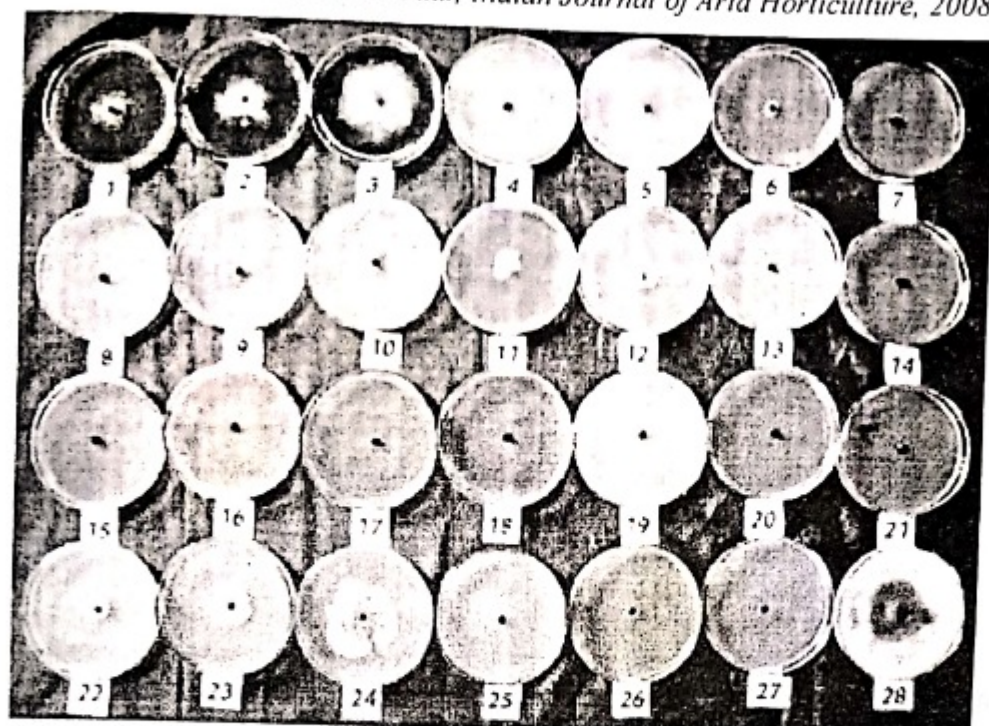
* Average of three replications

Figures in parenthesis are angular transformed values.

Table 2. Comparative efficacy of different fungicidal compounds on post-harvest rotting due to stem-end rot in Kinnow fruits

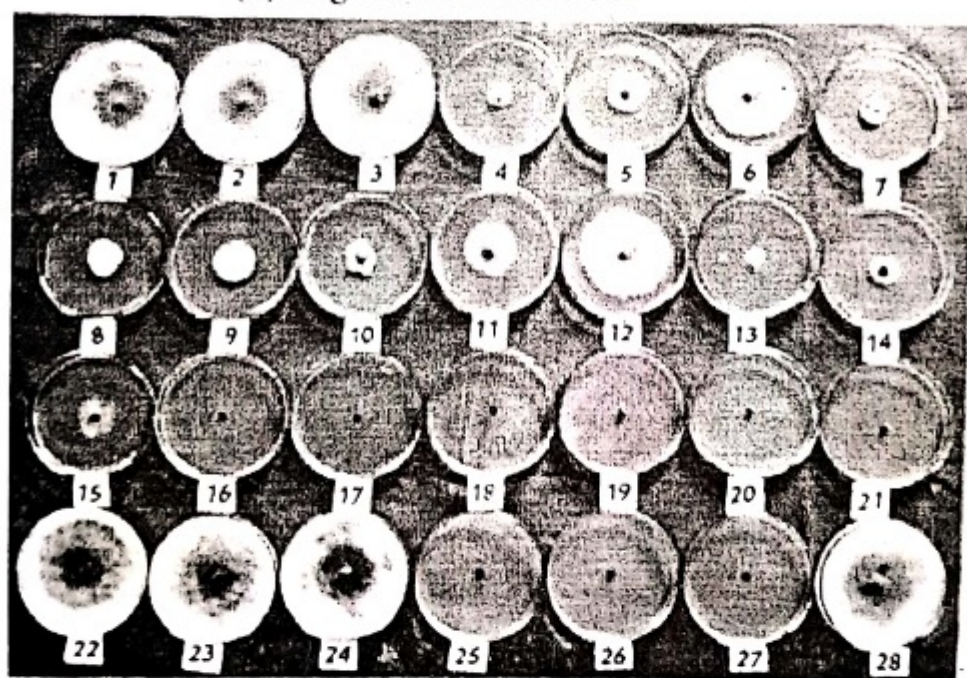
Fungicidal compounds	Conc. (ppm)	Per cent rot incidence in pre-inoculation treatment at different intervals (days)				Per cent rot incidence in post-inoculation treatment at different intervals (days)			
		4	8	Mean	RRI	4	8	Mean	RRI
Thiophanate methyl	500	32.39 (34.67)	46.19 (42.81)	39.29 (38.74)	44.25	36.19 (36.98)	50.48 (45.27)	43.34 (41.13)	40.32
Thiophanate methyl	1000	17.62 (24.77)	24.76 (29.82)	21.19 (27.30)	69.93	20.00 (26.55)	31.91 (34.39)	25.96 (30.47)	64.25
Mancozeb	500	18.58 (25.39)	26.67 (31.03)	22.63 (28.21)	67.89	21.43 (27.50)	34.77 (36.09)	28.10 (31.80)	61.31
Mancozeb	1000	10.48 (18.80)	15.72 (23.28)	13.10 (21.04)	81.41	14.76 (22.52)	22.38 (28.17)	18.57 (25.35)	74.43
Carbendazim 12% +		12.39 (20.53)	18.58 (25.43)	15.49 (22.98)	78.02	16.67 (24.04)	24.77 (29.47)	20.72 (26.76)	71.47
Mancozeb 63% 500									
Carbendazim 12% +		7.14 (15.42)	10.00 (18.39)	8.57 (16.91)	87.84	9.53 (17.93)	15.24 (22.93)	12.39 (20.43)	82.94
Mancozeb 63% 1000									
Carbendazim	500	5.71 (13.82)	8.10 (16.49)	6.91 (15.16)	90.20	6.66 (14.89)	10.48 (18.85)	8.57 (16.87)	88.20
Carbendazim	1000	0.00 (0.57)	0.00 (0.57)	0.00 (0.57)	100.00	0.00 (0.57)	0.00 (0.57)	0.00 (0.57)	100.00
Prochloraz	500	3.34 (10.42)	5.24 (13.14)	4.29 (11.78)	93.91	4.76 (12.46)	7.62 (15.95)	6.19 (14.21)	91.48
Prochloraz	1000	0.00 (0.57)	0.00 (0.57)	0.00 (0.57)	100.00	0.00 (0.57)	0.00 (0.57)	0.00 (0.57)	100.00
Control		57.15 (49.11)	83.81 (66.29)	70.48 (57.70)	0.00	59.05 (50.22)	86.19 (68.54)	72.62 (59.38)	0.00
Mean		14.98 (19.46)	21.73 (24.35)			17.19 (21.29)	25.80 (27.35)		
Source:		SE _{int}	CD at 5%	C.V (%)	SE _{int}	CD at 5%	C.V (%)		
Fungicidal compounds		0.30	0.87	3.41	0.45	1.28	4.51		
Days		0.13	0.37		0.19	0.54			
Fungicidal compounds x Days		0.43	1.23		0.63	1.81			

Figures in parenthesis are angular transformed values



<u>1000</u>	<u>500</u>	<u>250 ppm</u>	<u>Control</u>
1,4,7,10,13, 16,19,22,25	2,5,8,11,14, 17,20,23,26	3,6,9,12,15, 18,21,24,27	28

(a) Higher concentrations



<u>100</u>	<u>50</u>	<u>25 ppm</u>	<u>Control</u>
1,4,7,10,13, 16,19,22,25	2,5,8,11,14, 17,20,23,26	3,6,9,12,15, 18,21,24,27	28

(b) Lower concentrations

1-3 Copper oxychloride 4-6 Propineb 7-9 Thiophanate methyl

10-12 Captan 13-15 Mancozeb 16-18 Saaf

19-21 Carbendazim 22-24 Fosetyl-Al 25-27 Prochloraz 28 Control

Fig 1. Effect of fungicides at different concentrations on mycelial growth of *B. theobromae*

and mancozeb were the next fungicides in order of efficacy, provide 87.84 and 81.41 per cent protection from the incidence, respectively as compared to control when applied as pre-inoculation treatment at 1000 ppm concentration. The least reduction (40.32%) in incidence was noted when the fruit treated with thiophanate methyl as post-inoculation treatment at 500 ppm concentration.

The fruit rot incidence correlated positively with incubation period, where, incidence at 8th DAI was significantly higher to the incidence occurred at 4th DAI. In general, fungicides were more effective when applied as pre-inoculation as compared to post-inoculation treatment, which might be due to lack of time for establishment and multiplication of pathogen.

The present results are in conformity with those of Brown (1983) who reported that prochloraz was effective against the *Botryodiplodia* stem-end rots of citrus fruits. Prochloraz inhibit the growth of pathogenic fungi by interfering at C-14 demethylation step of ergosterol synthesis, the synthesis of which is vital to structural formation of fungal cell membranes. Both preventive and curative action have also been shown. Due to its non-systemic nature, should therefore be less affected by development of fungal resistance, than true systemics (Danderson, 1986).

Naqvi (1993) reported the efficacy of benzimidazole fungicides against the *B. theobromae*. The efficacy of carbendazim in controlling the *Botryodiplodia* rot of citrus fruits had also been proved by Godara (1994). The carbendazim rendered their lethal effect on pathogenic fungi through inhibition of mitosis by interfering with spindle formation at the level of tubulin biosynthesis (Thind, 2007). According to Beerh *et al.* (1976), fungicides might have checked the growth of fungi and resulted into change in biochemical constituents of the fruits. This in turn imparted resistance to the fruits against the penetration and growth of the pathogen resulting into less rotting of fruits.

Similar to present investigation, the effectiveness of mancozeb against the post-harvest rotting of Kinnow fruits has also been established by Singh and Thakur (2005). Mancozeb when applied with combination of carbendazim, showed however, more efficacious against the stem-end rot pathogen as well as rot incidence, which might be due to synergistic action of both fungicides in combination.

References:

Beerh, O.P., Narasimham, G.V., Glridhar, P. and Raghuramariah, B. 1976. Effect of pre-and post-harvest treatments to control some common disorders in Anab-e-Shahi grapes. *J. Fd. Sci. Tech.*, 13: 129.

- Bliss, C.L. 1934. The methods of probits. *Science*, 79: 38.
- Bondad, N.D. 1974. A note on the control of post-harvest diseases of fruits with benomyl and thiabendazole. *Philipp. J. Sci.*, 103: 21-27.
- Brown, G.E. 1983. Control of Florida citrus decays with guazatine. *Proc. Fla. State Hort. Soc.*, 96: 335-337.
- Danderson, M. 1986. Omega (Prochloraz), a fungicide for post-harvest control of anthracnose, the *Dothiorella/Colletotrichum* complex and stem-end rot in avocados. *South African Avocado Grower's Association yearbook*, 9: 27-30.
- Godara, S.L. 1994. Studies on post-harvest diseases of orange fruits. Ph.D. Thesis, Rajasthan Agricultural University, Bikaner.
- Gutter, Y. 1969. Effectiveness of pre-inoculation treatments with sodium or thiophenyl phenate, thiabendazole and benomyl for green mould control in artificially inoculated eureka lemons. *Pl. Dis. Repr.*, 53: 479-482.
- Naqvi, S.A.M.H. 1993. Benzimidazole fungicides in control of post-harvest diseases of Nagpur mandarin. *Pl. Dis. Res.*, 8: 19-24.
- Nene, Y.L. and Thapliyal, P.N. 1997. Fungicides in plant disease control, IIIrd ed. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India pp. 531.
- Singh, D. and Thakur, A.K. 2005. Effect of fungicides on spoilage caused by Mycoflora in Kinnow (*Citrus reticulata* Blanco) fruits during storage. *J. Mycol. Pl. Pathol.*, 35: 125-127.
- Singh, D., Thakur, A.K. and Jain, R.K. 2002. Management of post-harvest diseases of Kinnow (*Citrus reticulata* Blanco). *Proceedings of National Workshop on Post-harvest Management of Horticultural Produce*, held at National Productivity Council, Chandigarh (Feb. 7th-8th), pp. 117-123.
- Singh, S. 2002. Fungal diseases of citrus, diagnosis and management. Tech. Bull. No.5, National Research Centre for Citrus, Nagpur, India, pp.1
- Thind, T.S. 2007. Changing cover of fungicide umbrella in crop protection. *Indian Phytopath.*, 60: 421-433.
- Thompson, A.K. 1996. Post-harvest technology of fruits and vegetables. Blackwell Science Ltd., London.
- Tomkins, R.G. and Trout, S.A. 1931. The use of ammonium salts for the prevention of green mould in citrus. *J. Pomol. Hort. Sci.*, 9: 257-264.

Post-harvest effect of packaging material, neem leaf extract and fumigation on colour, texture, shriveling and rotting of aonla (*Emblica officinalis*)

R .P. Jakhar and Dheeraj Singh
College of Horticulture and Forestry, Jhalawar
Maharana Pratap University of Agriculture and Technology, Udaipur

Abstract

Aonla is non-climacteric fruit and each year a considerable proportion of aonla fruits are lost through spoilage mainly due to their faulty techniques of storage. Proper storage extends the period of availability of aonla by arresting the metabolic deterioration caused by fungal and microbial activities. In recent years, techniques which are commercially cheaper and require no energy have been developed to retain post-harvest quality of fruits and vegetables for longer period. Proper packaging of fruits and vegetables play a decisive role in reducing the post-harvest losses. Keeping the above facts in view, present investigation entitled "Post-harvest effect of packaging material, neem leaf extract and fumigation on colour, texture, shriveling and rotting of Aonla (*Emblica officinalis*)" was undertaken. The physiological loss in colour, texture, shriveling and rotting of "Chakaiya" cultivar of aonla fruit was significantly affected by packaging materials, neem leaf extracts and diphenyl fumigation and their combinations throughout the storage period up to 21st days.

Key words: Aonla, post harvest, packaging materials, neem leaf extracts, diphenyl fumigation.

Introduction

Commercial cultivation of aonla is becoming important and its production is increasing rapidly in Rajasthan. The high acceptability of aonla fruit is due to their high medicinal values and the fact that they are rich source of vitamin 'C'. Aonla is non-climacteric fruit and each year a considerable proportion of aonla fruits are lost through spoilage mainly due to their faulty techniques of storage. Under ordinary room temperature conditions aonla fruits are liable to be spoiled quickly by microbial and fungal infection. Thus, the problem of post-harvest spoilage of fruits is a challenge to the scientists of the country. Dealers and consumers of aonla incur great economic losses due to improper storage conditions. Proper storage extends the period of availability of aonla by arresting the metabolic deterioration caused by fungal and microbial activities. In recent years, techniques which are commercially cheaper and require no energy have been developed to retain post-harvest quality of fruits and vegetables for longer period. Among these techniques, the use of im-

proved packaging materials and plant extracts has been found to be quite effective and economical. However, little or no research has been done to extend post-harvest shelf life of aonla using these techniques. Proper packaging of fruits and vegetables play a decisive role in reducing the post-harvest losses. A bright possibility, therefore, exist for adoption or use of commercially cheaper techniques to extend shelf life of aonla under Rajasthan conditions. With the above facts in view, present investigation entitled "Post-harvest effect of packaging material, neem leaf extract and fumigation on colour, texture, shriveling and rotting of Aonla (*Emblica officinalis*)" was undertaken.

Material and methods

Fresh and fully ripe fruits of aonla cultivar "Chakaiya" were obtained from the orchard of aonla growers, village Dabok district Udaipur and brought to the laboratory for the purpose of experiment. Bruised and immature fruits were discarded. The details of the various materials used for extending shelf-life of aonla are given below:

- (A) Packaging material
Symbols
(a) Gunny bag (Control)
 P_0
(b) Corrugated paper boxes
 P_1
(c) Bamboo basket
 P_2
- (B) Neem leaf extract:
(a) No neem leaf extract
 N_0
(b) Neem leaf extract 10%
 N_1
(c) Neem leaf extract 20%
 N_2
- (C) Fumigation:
(a) No fumigation
 F_0
(b) Diphenyl (1 g)
 F_1

randomly taken from each replication and the marks were allotted according to the category at the time of storage. Colour of the fruits was observed by panel of four judges by visual method i.e., greenish, greenish yellow, yellowish, yellow with white strips and dull green etc. Shrivelling of fruits was observed by visual method and giving marks out of 10 points.

S.No.	Shrivelling	Marks (Range)
1.	No shriveling	10.00
2.	Very low shriveling	9.99-7.5
3.	Low shriveling	7.49-5.00
4.	Medium shriveling	4.99-2.50
5.	High shriveling	Less than 2.5

Rotten fruits were usually counted out of total fruits at an interval of 7th, 14th and 21st day of storage and rotting was expressed on percentage basis. The experiment was laid out in a factorial completely randomized design (CRD). There were three replications. The analysis of

Details of treatment combination:

Treatment combinations	Symbols
Gunny bag without neem leaf extract and diphenyl fumigation (control)	P0N0F0
Gunny bag + Diphenyl fumigation (1g)	P0N0F1
Gunny bag + Diphenyl fumigation	P0N1F0
Gunny bag + Neem leaf extract (10%) + Diphenyl (1g)	P0N1F1
Gunny bag + Diphenyl fumigation (20%)	P0N2F0
Gunny bag + Neem leaf extract (20%) + Diphenyl (1g)	P0N2F1
Corrugated paper box	P1N0F0
Corrugated paper box + Diphenyl fumigation (1g)	P1N0F1
Corrugated paper box + Neem leaf extract (10%)	P1N1F0
Corrugated paper box + Neem leaf extract (10%) + Diphenyl (1g)	P1N1F1
Corrugated paper box + Neem leaf extract (20%)	P1N2F0
Corrugated paper box + Neem leaf extract (20%) + Diphenyl (1g)	P1N2F1
Bamboo basket	P2N0F0
Bamboo basket + Diphenyl fumigation (1g)	P2N0F1
Bamboo basket + Neem leaf extract (10%)	P2N1F0
Bamboo basket + Neem leaf extract (10%) + Diphenyl (1g)	P2N1F1
Bamboo basket + Neem leaf extract (20%)	P2N2F0
Bamboo basket + Neem leaf extract (20%) + Diphenyl (1g)	P2N2F1

Standard plant extract solution was prepared as per the method developed by Parimelazhagan and Fransis (1999). In case of diphenyl (diphenylamine) 1g was dissolved in 5ml acetone and the blotting papers were dipped in the solution and air dried. The diphenyl treated blotting papers were used for lining in the corrugated paper box and bamboo baskets. The treated fruits were stored at ambient room temperature (17 to 20°C) and subjected to various physico-chemical observations as per detail given. The texture of the aonla fruit was judged by the thumb and nail (thumb and finger) method. For this purpose fruits were

variance technique of Cochran and Cox (1950) was used to determine significance/non-significance among data of the results.

Result and discussion

Colour: The data presented in Table 1 indicate that the colour of fruit was significantly affected by packaging material, neem leaf extract and diphenyl fumigation treatments during the entire period of storage. The maximum value of colour were recorded in P_1 (5.41) and P_2 (5.4) treatments which were almost at par as compared to the mini-

imum in P_0 (3.30) at the end of the 21st days of storage. Similarly, combined application of packaging materials, neem leaf extracts and diphenyl fumigation helped in the retention of attractive light yellowish green colour of fruits. This can be seen from the fact that the maximum high colour value (5.43) was recorded in $P_1N_0F_0$ and $P1N1F0$ treatment as against the minimum value (Table 2). It implies that the effect of combined application of $P_1N_0F_0$ and $P_1N_1F_0$ is almost at par with individual treatments of packaging material and neem leaf extracts. Thus, it is clear from the present results that aonla fruits of "Chakaiya" cultivar packed in corrugated paper boxes/bamboo basket and treated 10% neem leaf extract retained natural yellowish green colour for 21st days during storage.

Retardation in physiological change by treatments with plant extracts during storage has been reported by Babu and Reddy (1986). Perhaps biochemical changes in colour are slowed down by these treatments thereby resulting in retention of usual fruit colour during storage. In the present investigation, plant extracts i.e., neem leaf extract was found to affect the colour retention of fruit, during storage. Neem leaf extract might have helped indirectly in slowing down the process of change in colour. In other words, those compounds which are responsible for deterioration in fruit colour might have been reduced by plant extracts. Packaging materials were found to affect fruit colour, might have been reduced by plant extracts. Packaging materials were found to affect fruit colour. A possible reason for this could be that packaging materials form a

cover over the fruits leading to reduction in oxygen concentration. As a result, the respiration in fruits may be slow down due to which the degeneration of colour in treated fruit is reduced. Packaging material prevents the fruits from the direct sun rays which may also results in less fading of colour.

Texture: The texture of the fruit was significantly affected by packaging material, neem leaf extract and diphenyl fumigation treatments during the entire period of storage (Table 1). The maximum texture value was recorded in P_2 (3.44), N_1 and N_2 (each 2.10) and F_1 (2.70) treatment 21st day of storage as compared to minimum in P_0 (1.22), N_0 (2.69) and F_0 (2.69). The combined application of packaging material, neem leaf extract and diphenyl fumigation significantly affected fruit texture during storage (Table 2). This is evident from the fact that maximum texture value (3.45) was recorded when combined application of bamboo basket +20% neem leaf extract with or without diphenyl ($P_2N_2F_1$, $P2N2F0$) was applied. It implies that the effect of combined application ($P_2N_2F_1$, $P_2N_2F_0$) was almost at par with the individual treatment of packaging material, neem leaf extracts and diphenyl fumigation. Thus, it is clear from the present result that Chakaiya aonla fruits packed in bamboo/corrugated paper boxes with or without 20% neem leaf extract can retain natural texture of fruits for 21st days during storage. Retardation in physiological changes by treatments with plant extracts during storage has been reported by several researchers (Khanna, and Chandra, 1989,

Table 1. Effect of packaging material, neem leaf extract and diphenyl fumigation on reduction in fruit colour and texture. -

Treatments	Colour* loss (%)			Texture loss (%)		
	Storage days			Storage days		
Packaging material	7	14	21	7	14	21
P_0	8.02	5.28	3.30	3.47	3.42	1.22
P_1	8.73	7.43	5.41	8.72	6.22	3.43
P_2	8.73	7.43	5.40	8.69	6.22	3.44
SEm±	0.009	0.014	0.019	0.007	0.007	0.008
CD at 5%	0.026	0.039	0.057	0.021	0.022	0.024
Neem Leaf Extracts						
N_0	8.49	6.61	4.43	6.95	5.28	2.69
N_1	8.50	6.76	4.84	6.96	5.29	2.70
N_2	8.50	6.76	4.83	6.96	5.29	2.7
SEm±	0.007	0.014	0.019	0.007	0.007	0.008
CD at 5%	NS	0.039	0.057	NS	NS	NS
Fumigation						
F_0	8.49	6.66	4.57	6.96	5.28	2.69
F_1	8.50	6.76	4.83	6.96	5.29	2.70
SEm±	0.007	0.011	0.016	0.006	0.006	0.007
CD at 5%	NS	0.032	0.047	NS	NS	NS

Initial Colour Value = 10

*Values derived from 0-10 point scale.

Table 2. Effect of combined application of packaging material, neem leaf extract and fumigation on reduction in fruit colour and texture.

Treatments	Colour Loss (%)			Texture loss(%)		
	Storage days			Storage days		
	7	14	21	7	14	21
P ₀ N ₀ F ₀	24.0	4.53	1.29	3.46	3.42	1.21
P ₀ N ₀ F ₁	24.1	5.43	3.71	3.47	3.42	1.22
P ₀ N ₁ F ₀	24.1	5.43	3.71	3.47	3.43	1.23
P ₀ N ₁ F ₁	24.1	5.43	3.71	3.47	3.43	1.23
P ₀ N ₂ F ₀	24.1	5.43	3.71	3.47	3.43	1.22
P ₀ N ₂ F ₁	24.1	5.43	3.71	3.47	3.43	1.22
P ₁ N ₀ F ₀	26.2	7.43	5.43	8.71	3.51	3.43
P ₁ N ₀ F ₁	26.2	7.43	5.40	8.72	6.22	3.43
P ₁ N ₁ F ₀	26.2	7.43	5.40	8.72	6.22	3.43
P ₁ N ₁ F ₁	26.2	7.43	5.40	8.72	6.22	3.44
P ₁ N ₂ F ₀	26.2	7.43	5.40	8.71	6.22	3.43
P ₁ N ₂ F ₁	26.2	7.43	5.40	8.68	6.22	3.44
P ₂ N ₀ F ₀	26.2	7.43	5.40	8.68	6.22	3.44
P ₂ N ₀ F ₁	26.2	7.43	5.40	8.68	6.21	3.44
P ₂ N ₁ F ₀	26.2	7.43	5.40	8.68	6.21	3.44
P ₂ N ₁ F ₁	26.2	7.43	5.40	8.71	6.22	3.44
P ₂ N ₂ F ₀	26.2	7.43	5.40	8.71	6.21	3.45
P ₂ N ₂ F ₁	26.2	7.43	5.40	8.71	6.23	3.45
SEm±	0.022	0.033	0.049	0.018	0.019	0.021
CD at 5%	NS	0.096	0.140	NS	NS	NS

Initial Colour Value = 10

* Values derived from 0-10 point scale.

Purohit, 2000 and Rameshwar 2000).

Shrivelling: Shrivelling of fruits is also directly related to the moisture loss and thus affects the physical appearance. Shriveling of fruits was significantly affected as a result of packaging material, neem leaf extract and diphenyl fumigation treatment from 0-21st day of storage (Table 3). The mean minimum shriveling value was found in fruits packed in bamboo basket at various storage intervals. The treatments with bamboo basket packaging had significantly less shriveling as compared to P₀ (control). It is clear that after 14th days of storage bamboo basket packaging was more effective in retarding the shriveling of aonla, followed by neem leaf extracts 10% and 20%, respectively. Very high shriveling was found in P₀ packaging material (3.13) and in combined treatment only value was (1.28) in P₀N₀F₀ (Table 4). Shrivelling of aonla increased with the advancement of storage days. Very low shriveling was observed on the 7th day of storage as against the medium shriveling which occurred at the end of 21st days of storage. Sharma, *et al.*, (1991) reported that shriveling was reduced by HDPE bag and diphenyl fumigation in okra during storage and thus supports to some extent the present findings. It is likely that moisture escapes through the cell wall during storage by the process of evapo-transpiration and shriveling of

fruits occurs. Furthermore, at room temperature, respiration rate of aonla fruits is very high hence better results in terms of low shriveling with bamboo baskets and neem leaf extract treatments may be attributed to their effectiveness in reducing PLW.

Rotting: Rotting of fruits was significantly affected as a result of packaging material, neem leaf extract and diphenyl fumigation treatments from 0-21st days of storage (Table 3). Among the effects of individual treatments, minimum rotting was recorded with bamboo basket packaging material (28.80%) followed by 20% neem leaf extracts as compared to the maximum rotting (39.53%) in control. When main treatments were combined together, the rotting of fruits was further reduced. Only 28.36 per cent rotting was recorded at bamboo basket 20% neem leaf extract+1 g diphenyl fumigation treatment followed by 28.45 per cent rotting at corrugated paper box + 20% neem leaf extract+1 g diphenyl fumigation treatment as compared to control (39.53%) at the end of 21st days of storage (Table 4). Chopra *et al.* (1965) reported the therapeutic use of a number of plant extracts and suggested that plant extracts alter the metabolism and physiology of fruits. Moreover, growth, sporulation and spore germination of rot causing fungus is also inhibited by the plant extracts. (Bhowmick and

Table 3. Effect of packaging material, neem leaf extract and fumigation on rotting and shriveling of fruit.

Treatments	Shrivelling*			Rotting		
	Storage days			Storage days		
Packaging material	7	14	21	7	14	21
P ₀	7.87	5.44	3.13	5.41(0.80)	24.09(16.66)	31.11(26.70)
P ₁	7.87	7.28	5.29	4.23(0.54)	21.62(13.58)	29.30(23.95)
P ₂	7.87	7.33	5.77	4.84(0.71)	21.42(13.34)	28.80(23.21)
SEm±	0.008	0.020	0.098	0.004	0.038	0.030
CD at 5%	NS	0.058	0.282	0.074	0.111	0.087
Neem Leaf Extracts						
N ₀	6.16	5.62	3.58	5.28(0.86)	23.76(16.24)	50.96(26.46)
N ₁	8.73	7.22	5.30	4.67(0.66)	22.20(14.23)	29.38(24.70)
N ₂	8.73	7.22	5.30	4.54(0.63)	21.18(13.60)	28.88(23.23)
SEm±	0.080	0.020	0.098	0.004	0.038	0.030
CD at 5%	0.023	0.058	0.282	0.074	0.111	0.087
Fumigation						
F ₀	7.87	6.57	4.31	9.67(2.82)	23.40(15.68)	30.65(25.19)
F ₁	7.87	6.79	5.15	0.00(0.00)	21.36(13.26)	28.83(23.24)
SEm±	0.006	0.016	0.080	0.003	0.031	0.024
CD at 5%	NS	0.047	0.230	0.071	0.070	0.071

Initial Colour Value = 10

*Values derived from 0-10 point scale.

Table 4. Effect of combined application of packaging material, neem leaf extract and fumigation on rotting and shriveling of fruits.

Treatments	Shrivelling*			Rotting		
	Storage days			Storage days		
	7	14	21	7	14	21
P ₀ N ₀ F ₀	6.16	3.72	1.28	13.56(5.50)	33.49(30.28)	39.53(40.52)
P ₀ N ₀ F ₁	6.16	5.72	2.63	0.00(0.00)	22.05(14.09)	29.62(24.43)
P ₀ N ₁ F ₀	8.73	5.80	3.72	10.77(3.49)	23.84(16.34)	30.87(31.07)
P ₀ N ₁ F ₁	8.73	5.80	3.72	0.00(0.00)	21.53(13.46)	28.93(23.00)
P ₀ N ₂ F ₀	8.73	5.80	3.72	8.16(2.02)	22.10(14.15)	29.19(23.80)
P ₀ N ₂ F ₁	8.73	5.80	3.72	0.00(0.00)	21.53(13.46)	28.52(22.80)
P ₁ N ₀ F ₀	6.16	6.00	1.25	8.15(2.02)	22.38(14.50)	29.73(24.60)
P ₁ N ₀ F ₁	6.16	6.00	6.00	0.00(0.00)	21.55(13.49)	28.99(23.49)
P ₁ N ₁ F ₀	8.73	7.93	6.13	8.14(2.01)	22.61(14.78)	29.73(24.60)
P ₁ N ₁ F ₁	8.73	7.93	6.13	0.00(0.00)	21.64(13.60)	29.41(24.12)
P ₁ N ₂ F ₀	8.73	7.93	6.13	9.12(2.51)	21.21(13.10)	29.53(24.30)
P ₁ N ₂ F ₁	8.73	7.93	6.13	0.00(0.00)	20.35(12.10)	28.45(29.70)
P ₂ N ₀ F ₀	8.73	6.13	4.42	9.69(2.43)	21.55(13.49)	29.40(24.00)
P ₂ N ₀ F ₁	8.73	6.13	5.93	0.00(0.00)	21.35	28.47
P ₂ N ₁ F ₀	8.73	7.93	6.06	9.12(2.51)	21.89(13.90)	28.63(22.94)
P ₂ N ₁ F ₁	8.73	7.93	6.06	0.00(0.00)	21.69(13.66)	28.72(23.10)
P ₂ N ₂ F ₀	8.73	7.93	6.06	9.98(3.00)	21.53	29.24
P ₂ N ₂ F ₁	8.73	7.93	6.06	0.00(0.00)	20.35(12.10)	28.36(22.48)
SEm±	0.020	0.049	0.241	0.011	0.094	0.074
CD at 5%	NS	0.143	0.692	0.034	0.271	0.213

Initial Colour Value = 10

Values derived from 0-10 point scale.

Figures in parentheses are retransformed values.

Vardhan, 1981). Effectiveness of packaging materials in reducing the rotting and prolonging the shelf life of fruits in comparison to FONOFO treatment as found in the present study can be corroborated by the findings of other researchers (Sharma, *et al.*, 1991). From the present result it is clear that 20% neem leaf extract seems to be effective for this diphenyl fumigation in reducing rotting of fruits. Singh, *et al.*, (1993) also reported that diphenyl 0.50 g/box is effective in reducing the decay loss of aonla fruits cv. Chakaiya. The present findings are also supported by the results obtained by several another researchers who have also found reduction in the loss of fruit by rotting by diphenyl fumigation (Singh, *et al.*, 1993 and Sharma, *et al.*, 1992).

References

- Babu, K.J. and Reddy, S.M. 1986. Efficacy of some indigenous plant extracts in the control of lemon rot by two pathogenic fungi. *National Academy of Science Letter* 9(5):133-134.
- Bhowmick, B.N. and Vardhan, V. 1981. Antifungal activity of some leaf extract of medicinal plants on *Curvularia lunata*. *Indian Phytopath.* 34:385.
- Chopra, R.N.; Badhwar, R.L. and Gosh, S. 1965. Poisonous plants of India. ICAR, New Delhi (1&2):972.
- Cochran, W.G. and Cox, G.M. 1950. Experimental Designs. Pub. John Willey Inc. New York.
- Khanna, K.K. and Chandra, S. 1989. Further investigation on the control of storage rot mango, guava and tomato fruits with homeopathic drugs. *Indian Phytol.* 42(3):436-440.
- Kumar, S. and Chouhan, K.S. 1990. Effect of fungicides and calcium compounds on shelf-life of kinnow mandarin during low temperature storage. *Horticulture Abstracts, Haryana J. Hort. Sci.* 19 (12):112-121.
- Perimelazhang, T. and K. Fransis. 1999. Antifungal activity of *Clerodendrum viscosum* against *Curvularia lunata* in rice seed. *J Mycol Pl Pathol.* 29(1):139-141.
- Purohit, C.K. 2000. Efficacy of post-harvest treatment with plant extract, oil emulsion and plant growth regulators on the shelf-life of mango cv. Langra. M.Sc. (Ag.) Thesis, RCA, Udaipur.
- Rameshwar. 2000. Effect of post-harvest treatments with plant extract, ultraviolet radiation and rice starch on the shelf-life of sweet orange cv. Mosambi. M.Sc. (Ag.) Thesis, RCA, Udaipur.
- Sharma, R.K.; Jitendra Kumar and Ram Singh. 1991. Shelf-life of grapes as affected by various packaging materials and chemical. *Haryana J. Hort. Sci.* 20(1-2):39-43.
- Sharma, R.K.; Sidhu, S.S.; Sandooja, J.K. and Singhrot, R.S. 1992. A note on the effect of various forms of diphenyl on the shelf-life of grapes in cold storage. *Haryana J. Hort. Sci.* 21(1-2):60-63.
- Singh, H.N.P.; Prasad, M.M. and Sinha, K.K. 1993. Efficacy of leaf extracts of some medicinal plants against disease development in banana. *Letters in Applied Microbiology.* 17:269.

The effect of plant growth regulators and urea on physico-chemical parameters of custard apple (*Annona squamosa* L.) cv. Sindhan

M. M. Masu and L. R. Varma

Department of Horticulture, C. P. College of Agriculture,
SDAU, Sardarkrushinagar, Dist. Banaskantha, Gujarat

Abstract

The experiment was conducted to maximize of yield with good quality of fruits in custard apple at Horticulture Instructional farm, Department of Horticulture, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Dist. Banaskantha, Gujarat during the year 2005 and 2006. The experiment involved fourteen treatments comprising of three levels each of NAA and GA₃ (50 ppm, 100 ppm and 150 ppm) and their combinations with 2 % Urea, 2 % Urea alone and Control. Seventeen year old custard apple plants of uniform growth and size were selected. Plants were planted at distance of 6 m x 6 m. The experiment was laid out in Randomized Block Design (RBD) with three replications. The combined effect of GA₃ ppm + Urea 2 % recorded significantly maximum fruit volume (208.33 ml), pulp weight (122.03 g), pulp : peel ratio (1.78), total soluble solids (27.67 %), reducing sugars (18.93 %), non-reducing sugars (3.91 %) and total sugars (22.87 %) while significantly minimum number of seeds per fruit (29.21), peel weight (69.07g) and titrable acidity (0.081 %) as compared to control and all other treatments. The combined effect of GA₃ ppm + Urea 2 % proved to be the best treatment for the improvement of fruit quality of custard apple.

Introduction

Custard apple is mostly subtropical fruit preferring warm climate with moderate winter and humidity for higher production. The tree remains dormant during cold season for a short period, yet frost and prolonged cool weather adversely affect its growth. It can also tolerate adverse weather conditions, such as extreme temperature, high and low humidity, heavy and scanty rainfall and desiccating winds. Custard apple is delicious fruit. The fruits composed of pulp, peel and seed on varying proportions. The black seeds are surrounded by white, creamy or custard like pulp that is very sweet and pleasantly flavoured. Custard apple is used as table fruit, the pulp can be used in Juice, Ice-cream, confectionary, beverages and certain milk products. The seeds are abortifacient and roots are drastic purgative. The seeds contain about 30 per cent oil which can be used in soap and paint industry. It contains alcohol anconin, which possess insecticidal properties. Due to presence of annonaine the leaves, stem and other parts of the plants are bitter. One hundred gram edible pulp composition of custard apple fruit contains 75.97 g Moisture, 1.89 g Protein, 0.57 g Fat, 20.82 g Carbohydrate, 17.0 g Calcium, 22.0 g Magnesium, 54.0 g Phosphorus, 142.0 g Potassium,

2.0 g Sodium, 0.30 g Iron, 35.90 g Ascorbic acid, 0.10 g Thiamine, 0.06 g Riboflavin and 0.89 g Niacin.

Auxin promotes apical dominance and thus suppresses development of lateral buds into branches. It also inhibits abscission of leaves and fruits. It means leaves and fruits must continuously produce auxins to prevent formation of the abscission zone which cuts off their nutrient and water supply. Naphthalene Acetic Acid (NAA) prevent formation of abscission layer panicle. Gibberellic acid promote fruit growth and development and induce parthenocarp in pome fruits and help in enlargement of seedless grape berries. The plant growth regulators like GA₃ and NAA are used because they reduce flower drop. Gibberellic acid is present in seed so, seeds produce antitrop hormone i.e. Gibberellin. Naphthalene Acetic Acid (NAA) and Gibberellic acid (GA₃) increase fruit weight, size and number of fruits because they increase the rate of cell elongation, cell division and more inter cellular space. Nitrogen in plants performs several functions like growth, formation of flowers, fruits and fruit production. Therefore, foliar application of nitrogenous fertilizers is bound to affect the growth and production in custard apple. Urea provides sufficient nutrition at time of enzymatic activity.

Materials and methods

The experiment was laid out in Randomized Block Design (RBD) with three replication and two plants in each replication. The experiment was conducted to maximize of yield with good quality of fruits in Custard apple at Horticulture Instructional farm, Department of Horticulture, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar, Dist. Banaskantha, Gujarat during the year 2005 and 2006. Sindhan variety of custard apple was taken under investigation as this variety is promising one and most of cultivators of North Gujarat regions are growing extensively. The experimental field was loamy sand in texture and good drainage property. Seventeen year old custard apple orchard uniform in growth and size which were planted at the distance of 6 x 6 meters. All the plants were subjected to uniform application of cultural practices like irrigation, weeding and fertilizer etc. Farm Yard Manure was applied at the rate of 50 Kg to each plants uniformly, while chemical fertilizers were applied at the rate of 250 g : 125 g : 125 g NPK/plant/year. Three irrigation were given during experimentation.

The experiment comprising of three levels each of NAA and GA₃ (50 ppm, 100 ppm and 150 ppm) alone and their combinations with 2 % Urea, 2 % Urea alone and Control thus fourteen number of treatment combinations were T₁ - NAA 50 ppm, T₂ - NAA 100 ppm, T₃ - NAA 150 ppm, T₄ - GA₃ 50 ppm, T₅ - GA₃ 100 ppm, T₆ - GA₃ 150 ppm, T₇ - Urea 2 %, T₈ - NAA 50 ppm + Urea 2 %, T₉ - NAA 100 ppm + Urea 2 %, T₁₀ - NAA 150 ppm + Urea 2 %, T₁₁ - GA₃ 50 ppm + Urea 2 %, T₁₂ - GA₃ 100 ppm + Urea 2 %, T₁₃ - GA₃ 150 ppm + Urea 2 %, T₁₄ - Control.

Result and discussion

Effect of GA₃ and GA₃ with Urea

It was observed that all the treatments of GA₃ with 2 % Urea as well as GA₃ alone significantly increased the fruit volume of custard apple fruit cv. Sindhan. Gibberellins are phytohormones known to contribute to growth by both ways, namely cell division and cell expansion. After anthesis, it is the cell expansion and cell density which contribute the most for fruit growth. The probable reason behind the increase in fruit weight and volume might be the rapid cell division and cell enlargement and accumulation of more sugar and water under the influence of exogenous application of growth promoting substances. Specific gravity of fruits was not influenced significantly by the sprays of different chemicals. The findings are supported with the results Brahmachari *et al.* (1995) in Guava and Rani and Brahmachari (2004) in Mango.

The maximum pulp weight and pulp : peel ratio was recorded under the treatment GA₃ 50 ppm + Urea 2 % and minimum pulp weight under the control during the individual years and pooled year also. It might be due to enhanced uptake of water and accumulation of sugar and other food reserves in greater amount as well as increased

volume of intercellular spaces in the pulp of fruit. These results are in accordance with the findings of Chaudhari *et al.* (1992) and Rani and Brahmachari (2004) in Ber.

The lower concentration of treatments was found beneficial for reduction in peel weight. The lowest peel weight was recorded under the treatment GA₃ 50 ppm + Urea 2 % and highest under the control treatment. The findings are in conformity with those of Pradhan *et al.* (1988) in Banana and Kaur *et al.* (2000) in Kinnow mandarin.

The foliar application of GA₃ and GA₃ + urea treatment was found to be effective for reduction in number of seeds per fruit. GA₃ 50 ppm + 2 % urea treatment recorded significant recorded significantly minimum number of seeds per fruit as compared to control and other treatments. This could be attributed to an exogenous supply of gibberellins. The results are supported by Verma and Verke (1973) in Grape and Kumar *et al.* (1975) in Lime.

Amongst different concentrations, GA₃ 50 ppm with 2 % urea and GA₃ 50 ppm alone significantly increased Total Soluble Solid (T. S. S.) during the experimental years. The concentration of GA₃ significantly reduced the acidity of fruit as compared to controls during individual and pooled years. It might be attributed to the early degradation of acid had occurred. It also appears that acid might have either been fastly converted into sugars and their derivatives are utilized in respiration or both. The findings are in accordance with the results of Singh *et al.* (1995) in Mango and Ahmad and Zargar (2005) in Grape.

The application of GA₃ 50 ppm + 2 % urea followed by GA₃ 50 ppm significantly increased total sugar as well as reducing and Non reducing sugar in custard apple cv. Singhan. The increase in total soluble solids and sugar percentage is a result of more accumulation of metabolites during the fruit development and that gibberellins are known for their capacity to quick metabolism of starch and pectin into soluble compounds and enhanced conversion of organic acids into sugar. Increase in endogenous gibberellins and auxin levels may have promoted hydrolysis/ conversion of starch into sugar and thus resulted in higher sugar content in treated fruits. The findings are in agreement with the results of Singh *et al.* (1995) in Mango and Ahmad and Zargar (2005) in Grape.

Effect of NAA and NAA with Urea

The application of NAA with 2 % urea and NAA alone did not significantly enhance the fruit volume. It might be due to the activity of cell enlargement and division. The results are in agreement with those of Bhaghel *et al.* (1987) in Mango and Rema and Sharma (1991) in Phalsa.

It was observed that all the treatments of NAA with urea as well as NAA alone improved the pulp weight but failed to reach the level of significance. It might be due to the greater diversion of photosynthates from source to fruit. These results are in conformity with Bhaghel *et al.*

Table 1. Effect of plat growth regulators and urea on fruit volume (ml), pulp weight (g) and peel weight (g) and of custard apple cv. Sindhan

Treatment	Fruit volume (ml)			Pulp weight (g)			Peel weight (g)		
	Year 2005	Year 2006	Pooled	Year 2005	Year 2006	Pooled	Year 2005	Year 2006	Pooled
T ₁	173.18	170.26	171.72	82.14	77.11	79.62	92.78	90.75	91.77
T ₂	174.39	171.42	172.91	87.94	82.51	85.23	89.68	88.39	89.04
T ₃	176.26	175.13	175.70	89.83	85.46	87.65	87.05	85.87	86.46
T ₄	206.44	203.31	204.88	118.77	117.05	117.91	70.77	69.34	70.06
T ₅	200.38	194.42	197.40	114.70	113.62	114.16	75.23	73.11	74.17
T ₆	187.92	184.31	186.11	100.12	96.97	98.54	78.24	76.52	77.38
T ₇	168.28	165.86	167.07	74.13	71.21	72.67	96.61	95.07	95.84
T ₈	170.02	168.61	169.32	78.18	74.07	76.13	94.73	92.84	93.78
T ₉	182.41	178.07	180.24	92.55	87.72	90.13	84.78	82.81	83.80
T ₁₀	184.54	181.07	182.81	96.89	91.41	94.15	82.48	79.26	80.87
T ₁₁	209.77	206.89	208.33	123.23	120.83	122.03	69.89	68.24	69.07
T ₁₂	198.39	191.59	194.99	112.45	110.42	111.44	73.22	71.22	72.22
T ₁₃	192.61	187.91	190.26	105.27	101.52	103.40	74.26	72.25	73.25
T ₁₄	167.08	163.44	165.26	71.17	69.15	70.16	99.56	97.89	98.73
S. Em +	7.67	7.79	4.90	5.98	6.18	3.86	4.56	5.00	3.03
C.D. at 5%	22.31	22.64	13.91	17.38	17.96	10.95	13.25	14.54	8.59
Y x T Interaction									
S. Em. +	-	-	7.73	-	-	6.08	-	-	4.79
C.D. at 5%	-	-	NS	-	-	NS	-	-	NS
C. V. %	7.18	7.43	7.30	10.76	11.53	11.14	9.45	10.61	10.03

Table 2. Effect of plat growth regulators and urea on pulp : peel ratio and number of seeds per fruit of custard apple cv. Sindhan

Treatment	Pulp : peel ratio			Number of seeds per fruit		
	Year 2005	Year 2006	Pooled	Year 2005	Year 2006	Pooled
T ₁	0.89	0.85	0.87	51.24	49.00	50.12
T ₂	0.99	0.94	0.97	48.64	47.92	48.28
T ₃	1.04	1.02	1.03	48.34	46.48	47.41
T ₄	1.69	1.70	1.70	31.80	30.73	31.27
T ₅	1.54	1.58	1.56	36.13	35.17	35.65
T ₆	1.28	1.29	1.29	43.30	42.26	42.78
T ₇	0.77	0.75	0.76	54.64	53.96	54.30
T ₈	0.84	0.80	0.82	53.56	52.18	52.87
T ₉	1.09	1.09	1.09	46.38	45.70	46.04
T ₁₀	1.19	1.15	1.17	45.26	44.32	44.79
T ₁₁	1.78	1.78	1.78	29.80	28.62	29.21
T ₁₂	1.54	1.55	1.55	38.86	37.57	38.21
T ₁₃	1.44	1.42	1.43	41.67	40.45	41.06
T ₁₄	0.72	0.71	0.71	57.20	54.31	55.76
S. Em +	0.11	0.12	0.07	3.52	3.67	2.28
C.D. at 5%	0.32	0.34	0.20	10.22	10.66	6.46
Y x T Interaction						
S. Em. +	-	-	0.11	-	-	3.59
C.D. at 5%	-	-	NS	-	-	NS
C. V. %	15.73	17.12	16.43	13.60	14.60	14.10

Table 3. Effect of plat growth regulators and urea on total soluble solids (%) and titrable acidity (%) of custard apple cv. Sindhan

Treatment	Total Soluble Solids (%)			Titrable acidity (%)		
	Year 2005	Year 2006	Pooled	Year 2005	Year 2006	Pooled
T ₁	22.67	22.33	22.50	0.134	0.136	0.135
T ₂	23.00	22.67	22.83	0.131	0.131	0.131
T ₃	23.67	23.33	23.50	0.129	0.131	0.130
T ₄	27.67	26.67	27.17	0.084	0.087	0.086
T ₅	27.00	26.00	26.50	0.092	0.095	0.093
T ₆	25.67	25.00	25.33	0.105	0.108	0.107
T ₇	21.67	21.00	21.33	0.139	0.142	0.140
T ₈	22.00	21.33	21.67	0.136	0.139	0.138
T ₉	24.33	24.00	24.17	0.118	0.121	0.120
T ₁₀	25.00	24.33	24.67	0.113	0.116	0.115
T ₁₁	28.00	27.33	27.67	0.079	0.082	0.081
T ₁₂	26.33	25.67	26.00	0.097	0.100	0.099
T ₁₃	26.00	25.33	25.67	0.100	0.105	0.103
T ₁₄	21.33	20.67	21.00	0.147	0.152	0.150
S. Em +	1.04	0.99	0.64	0.005	0.005	0.003
C.D. at 5%	3.02	2.88	1.82	0.014	0.013	0.008
Y x T Interaction						
S. Em. +	-	-	1.01	-	-	0.004
C.D. at 5%	-	-	NS	-	-	NS
C. V. %	7.31	7.15	7.23	7.047	6.682	6.864

Table 4. Effect of plat growth regulators and urea on reducing sugar (%), non-reducing sugar (%) and total sugar (%) of custard apple cv. Sindhan

Treatment	Reducing sugar (%)			Non-reducing sugar (%)			Total sugar (%)		
	Year 2005	Year 2006	Pooled	Year 2005	Year 2006	Pooled	Year 2005	Year 2006	Pooled
T ₁	17.56	17.56	17.56	3.15	3.18	3.16	20.71	20.74	20.72
T ₂	17.87	17.91	17.89	3.19	3.21	3.20	21.06	21.12	21.09
T ₃	18.06	18.09	18.08	3.25	3.24	3.25	21.31	21.34	21.32
T ₄	18.82	18.91	18.87	3.87	3.72	3.79	22.69	22.63	22.66
T ₅	18.73	18.79	18.76	3.80	3.68	3.74	22.53	22.47	22.50
T ₆	18.40	18.37	18.39	3.48	3.47	3.47	21.88	21.84	21.86
T ₇	16.83	16.89	16.86	3.11	3.11	3.11	19.93	20.00	19.97
T ₈	17.20	17.32	17.26	3.13	3.15	3.14	20.32	20.47	20.40
T ₉	18.21	18.25	18.2	3.31	3.30	3.31	21.52	21.55	21.54
T ₁₀	18.36	18.32	18.34	3.41	3.43	3.42	21.77	21.74	21.75
T ₁₁	18.98	18.94	18.96	3.99	3.83	3.91	22.97	22.77	22.87
T ₁₂	18.70	18.64	18.67	3.54	3.57	3.55	22.24	22.21	22.22
T ₁₃	18.48	18.40	18.44	3.53	3.54	3.54	22.01	21.95	21.98
T ₁₄	16.34	16.44	16.39	3.10	3.09	3.09	19.44	19.53	19.49
S. Em +	0.48	0.47	0.30	0.15	0.17	0.10	0.48	0.84	0.30
C.D. at 5%	1.40	1.37	0.86	0.44	0.49	0.29	1.38	1.39	0.86
Y x T Interaction									
S. Em. +	-	-	0.48	-	-	0.16	-	-	0.48
C.D. at 5%	-	-	NS	-	-	NS	-	-	NS
C. V. %	4.63	4.53	4.58	7.71	8.53	8.13	3.84	3.87	3.86

(1987) in Mango and Singh *et al.* (2001) in Ber.

It was also found that the fruit peel weight decreased significantly under treatment NAA 150 ppm + Urea 2 % but remained non-significant during both the years and in pooled of two years. The results are in agreement with Singh *et al.* (2001) in Ber.

The higher pulp : peel ratio was observed under NAA 150 ppm + Urea 2 % treatment. It might be due to the increase in pulp weight under NAA treatments. This suggests that probably there was a greater diversion of photosynthates to fruit which ultimately added to the pulp weight. The result are accordance with Bhati and Yadav (2004) in Ber.

The number of seeds per fruit were significantly influenced by NAA with and without 2 % urea during both the years of experimentation. The superior results were obtained under NAA 150 ppm + 2 % urea treatment as compared to control. These results are in agreement with the findings of Bhaghel *et al.* (1987) in Mango and Rema and Sharma (1991) in Phalsa.

The quality of custard apple fruit was improved with varying concentration of NAA. Among different concentration, NAA 150 ppm + Urea 2 % significantly increased Total Soluble Solids percentage during both the years. It might be due to the auxin synthesis which increased the metabolites available for total soluble solids formation. The results are in accordance with those of Yadav *et al.* (2001) in Guava and Singh *et al.* (2002).

The higher concentration of NAA recorded reduction in acidity of fruit as compared to controls. It might be due to increased sweetness of the fruit pulp. The present findings are in conformity with those reported by Singh *et al.* (2002) and Bhati and Yadav (2003) in Ber.

The sugar content increases in the developing fruits probably due to increase in endogenous auxin levels which might have promoted hydrolysis conversion of starch into sugar and thus resulted in higher sugar content in the treated fruits. The results are in conformity with those of Yadav *et al.* (2001) in Guava, Singh *et al.* (2002) and Bhati and Yadav (2004) in Ber.

Effect of urea

The application of 2 % urea increased fruit volume, Pulp weight, peel weight, Pulp : peel ratio but failed to reach the level of significance. It might be due to the accumulation of food materials which leads to better development of fruits. The findings are supported by the results of Baghel *et al.* (1987) in Mango.

The effect of urea on number of seed was non-significant during both the years and in pooled of two year data. It might be due to the reason that urea is a nitrogenous fertilizer and is known for its growth promoting activity in plant tissues.

The treatment of urea improved the fruit quality of custard apple in terms of total soluble solids, titrable

acidity (%), reducing sugar, Non reducing sugar and total sugar percentage but did not reach to the level of significance. The increased total soluble solids due to foliar applications of 2 % urea might be due to the result of more nitrogen availability to the fruit trees. Nitrogen is the constituent of various energy sources like amino acids and amino sugars which increased total soluble solids content in fruits. The findings are in agreement with results of Singh and Ahlawat (1995) in Ber and Malik *et al.* (2000) in Kinnow. The acidity content of fruits decreased with urea treatment which might be due to increased total soluble solids. The findings are accordance with result of Singh *et al.* (1991) in Guava and Malik *et al.* (2000) in Kinnow.

The foliar application of 2 % urea increased sugar content due to increase in rate of photosynthesis as a result of which fruit accumulated more sugars. The similar results are reported by Singh *et al.* (1994) in Mango, Singh and Ahlawat (1995) in Ber and Malik *et al.* (2000) in Kinnow.

Reference

- Ahmad, M. F. and Zardar, G. H. (2005) Effect of trunk girdling, flower thinning, GA₃ and ethephon application on quality characteristics in Grape cv. Perlette under temperate Kashmir Valley conditions. *Indian J. Hort.*, 62 (3) : 285-287.
- Baghel, B. S., Sharma, R. K. and Nair, P. K. R. (1987) Efficacy of pre-flowering spray of urea and NAA on physical standards of Mango fruits. *Prog. Hort.*, 19 (3-4) : 231-234.
- Bhati, B. S. and Yadav, P. K. (2004) Effect of foliar application of Urea and NAA on the yield parameters of Ber (*Ziziphus mauritiana* Lamk.) cv. Gola. *Haryana J. Hort. Sci.*, 33 (3-4) : 189-190.
- Brahmachari, V. S., Mandal, A. K., Rajesh Kumar and Rani, R. (1995) Effect of growth substances on fruit set and physiological characters of Sardar Guava. *Recent Hort.*, 2 (2) : 127-131.
- Chaudhari, A. S., Singh, Moti and Singh, G. N. (1992) Effect of plant growth regulators on Loquat var. Herds Mammoth. *Punjab Hort. J.*, 32 (1-4) : 99-102.
- Kaur, N., Monga, P. K., Thind, S. K., Thatai, S. K. and Vij, V. K. (2000). Effect of growth regulators on periodical fruit drop in kinnow mandarin. *Haryana J. Hort. Sci.*, 29 (1 & 2) : 39 - 41.
- Kumari, R., Singh, J. R. and Gupta, O. P. (1975) Effect of growth regulators on fruit set, fruit drop and quality of Sweet lime (*Citrus limettioides* Tanka). *Haryana J. Hort. Sci.*, 4 (3/4) : 123-129.
- Malik, R. P., Ahlawat, V. P. and Nain, A. S. (2000) Effect of foliar spray of Urea and Zinc Sulphate on yield and fruit quality of Kinnow: A mandarin hybrid. *Haryana J. Hort. Sci.*, 29 (1-2) : 37-38.
- Pradhan, S. K., Bandyopadhyay, A., Mitra, S. K. and Sen, S. K. (1988). Effect of growth substances on fruit size, yield and quality of Banana var. Giant Gover-

- nor. *Prog. Hort.*, 20 (3-4): 326-330.
- Rani, R. and Brahmachari, V. S. (2004). Effect of growth substances and calcium compounds on fruit retention, growth and yield of Amrapalli Mango. *The Orrisa J. of Horticulture*, 32 (1): 15-18.
- Rema, J. and Sharma, V. P. (1991). Effect of plant growth regulators on yield and quality of Phalsa (*Grewia subnaequalis*). *South Indian Hort.*, 39 (6): 327-331.
- Singh, J. N., Rajput, C. B. S. and Prakash, S. (1991). Effect of urea spray on fruit retention and physico-chemical composition of Mango (*Mangifera indica* L.) cv. Amrapalli. *Haryana J. Hort. Sci.*, 20 (1-2): 35-38.
- Singh, R., Godara, N. R. and Ahlawat, V. P. (2002). Qualitative attributes as affected by foliar sprays of nutrients and growth regulators in Ber (*Ziziphus mauritiana* Lamk.) cv. Umran. *Haryana J. Hort. Sci.*, 31 (1-2): 23-25.
- Singh, R., Godara, N. R., Singh, R. and Dahiya, S. S. (2001) Response of foliar application of growth regulators and nutrients in Ber (*Ziziphus mauritiana* Lamk.) cv. Umran. *Haryana J. Hort. Sci.*, 30 (3 & 4): 161-164.
- Singh, S. and Ahlawat, V. P. (1995) Physico-chemical attributes and mineral composition of Ber leaves as affected by foliar application of Urea and Zinc Sulphate. *Haryana J. Hort. Sci.*, 24 (1): 94-97.
- Singh, S., Kumar, P., Bramchari, V. S. and Singh, D. N. (1995) Effect of pre-harvest spray of GA₃ and ethtel on storage life of Mango cv. Amrapalli. *Orrisa J. Hort.*, 23 (1-2): 112-118.
- Verma, R. M. and Verke, D. C. (1973) Response to Gibberellin of Anab-E-Shahi Grapes. *RKV Res. J.*, 1(2): 172-175.
- Yadav, S., Bhatia, S. K., Godara, R. K. and Rana, S. G. (2001) Effect of growth regulators on the yield and quality of winter season Guava cv. L-49. *Haryana J. Hort. Sci.*, 30 (1-2): 1-2.

Post-harvest health maintenance of grapes -a review

P. P. S Gill, S. K. Jawandha and Navjot

Department of Horticulture, Punjab Agricultural University, Ludhiana

Abstract

Grape is a highly perishable fruit and can not be stored for longer time under ambient conditions. Many workers had tried to increase its shelf-life by pre-cooling, fumigation, pre and post-harvest chemical treatments, packaging, controlled atmosphere and cold storage which are reviewed in this paper.

Key words: *Grape, storage, quality, pre-cooling, fumigation, chemicals, packaging and controlled atmosphere*

Introduction

Grape is a delicious, refreshing and nourishing fruit. Although it is a temperate fruit of India but can also be grown successfully in southern and coastal areas of India. Area under grape cultivation has increased which leads to the glut of grapes in the market and hence lower return to the growers. Grape is a highly perishable fruit and can not be stored for a longer time at room temperature. There are heavy post harvest losses in grapes mainly due to loss in weight and decay. Many attempts have been made by various research workers to increase the shelf-life and maintain the quality of grapes which are reviewed in this paper. Factors affecting the post-harvest life of grapes are discussed below :

Climate and culture practices

Prevailing environmental conditions at the time of ripening and harvesting plays the major role in determining storage life of the fruits. Similarly cultural practices such as soil type, quality of available water, variety, time of irrigation, fertilization, harvesting and handling have a great influence on keeping quality of grapes. Rains during the ripening season and at harvesting time increased the post-harvest losses (Beattie and Outhred, 1970). Reich (1979) reported that different irrigation regimes altered the rate of fruit ripening thus affected the keeping quality of grapes. The berry cracking during storage was more in thin skinned varieties like Thompson seedless and Tokay (Ryall and Harvey 1959). Chadha and Randhawa (1974) reported that Anab-e-Shahi and Angur Kalan grapes have poor keeping

quality due to their weak pedicel. Nelson (1951) observed that varietal difference for botrytis infection and susceptibility to various rots. Thompson seedless which has maximum storage life of 3 months respire more rapidly and evolve more vital heat from Emperor and Almeria cultivars at 0°C (Winkler, *et al.*, 1974). The shelf-life of the berries grown in the desert region was far superior to those grown on the clay soil, due to negligible losses in weight, juice or decay after one week at room temperature. Berries grown in the desert region had lower rates of berry shatter than on clay soil. Fungal decay was greatest in berries from the clay soil (Hegazi and Barkoki, 1994).

Pre-cooling

Pre-cooling means rapid cooling after harvest. Pre-cooling of the produce soon after harvesting helps in maintaining of the produce quality and is an essential component of cold chain. Pre-cooling of produce reduces field heat, rate of respiration, rate of ripening, loss of moisture, production of ethylene and spread of decay. Various methods of pre-cooling used for fruits and vegetables includes room cooling, forced air cooling, hydro cooling and evaporative cooling. Pre-cooling removed the field heat of commodity and increased the storage life (Maini, 1985). Pre-cooling of fruits within 48 h after harvesting is essential for long storage life (Dewey, 1950). Nelson (1955) reported that a reduction in temperature to 9.5°C halved the rate of respiration and doubled the shelf life of grapes. It also checked stem desiccation, browning, berry shattering and softening. Precooling of perlette grapes maintained berry firmness (Ber - Arie, *et al.*, 1984). Vacuum precooling was the most rapid and beneficial method for table grapes (Andre, *et al.*, 1977). Lowest quality deterioration in cultivars Coarna Neagra and Muscat of Hamburg was observed with Packing after 4 h of harvest and stored at 2-4°C for 120

days (Papa and Fugel, 1982). Minimum physiological loss in weight and decay loss were recorded in the fruits dipped for 5 min. in cold at water and 5°C followed by 10 min dipping at 5°C (Nain, *et al.*, 1996). Forced air cooling reduced temperature from 27°C to -0.5°C within 6 hrs (Ginsburg, *et al.*, 1977). The optimum wind speed for cooling for 2-3 hrs was 4 m/s (Mongelli, 1982). Rapid cooling caused the moisture loss. The grape consignments for air shipment need to be cooled below 10°C, for rail road and sea shipment to below 4-5°C and for cold storage to -0.5 to 0°C (Arve, 1985).

Fumigation

Fumigation is an important step of post-harvesting handling chain of grapes. Storage and transit rots can be reduced by fumigation. SO₂ treatment reduced the activity of decay causing organisms and retained the natural condition of berries and stem structures during handling of grapes (Lutz, 1938; Harvey, 1956). It also influenced the physiological processes of table grapes. Respiration rate (Pentzer, *et al.*, 1933) and ethylene production (Singh and weaver 1982) were remarkably reduced in sulphur dioxide treated fruits. Spread of *Botrytis* on grapes in storage can be inhibited by SO₂ fumigation exposure of 5-10 minutes (Malan, 1955). Fumigation is usually done before the grapes are precooled because the warm fruit assess more gas than cold fruit (Roy, 1985). Pentzer and Barger (1941) used a large number of fungicides in various forms and found that fumigation with 1% SO₂ for 20 min was most effective. King (1986) obtained the control of storage rots in wrapped and unwrapped grapes by weakly fumigation with 0.1% SO₂ in the cold storage. Higher concentrations (0.5% and 1.0%) of SO₂ caused injury and fruit.

Stem drying, browning and berry rot can be reduced by use of 'Quick Release' grape guard (Mansour *et al.* 1984). Storage life of Thompson seedless and Anab-e Shahi increased upto 80 and 70 days by use of 'Dual Release' sulphur dioxide generators in vented polyliner under cool condition. Perlette grapes can be successfully stored for upto 40 days by enclosing quarter size, 'Dual Release' SO₂ generators in polyliners having 1.12% perforation in cold storage (Sandhu, *et al.*, 1990). With 'Dual Release' SO₂ generators Beauty Seedless Grapes could be stored upto 80 days in refrigerated conditions (Ladania and Dhillon, 1987). Quality of Thompson seedless was maintained during cold storage of 105 days by using just one bag/pack of SO₂ generation (UVAS) for 6, 8 or 10 kg packs wrapped in perforated polyethylene bags (PPE) (Soylemezoglu and Agaoglu, 1994). Two SO₂ generators comprising (1) polyethylene sachets with 15 ml of a 7% sodium metabisulfite solution and (2) SYS paper diffusers containing sodium metabisulfite powder were found equally effective in conserving grape quality for at least two months at 0°C temperature (Benkhemmar, *et al.*, 1993). SO₂ fumigation was very effective in reducing decay during ambient

and cold storage of Campbell Early, Kyoho, Nuscat Bailey A, Tano Red, and Daebong grapes (Yun, *et al.*, 1995). The activities of catalase (CAT), SOD, peroxidase (POD) in grain, fruit stalk and spikelet stalk all increased when Thompson seedless grapes were fumigated with SO₂ for 1 h. The rate of membrane damage being lower with the lower concentration than the higher (Ge-Yiqiang, *et al.*, 1998).

Grape guard inhibited fungal infection and discolouration of cluster stems and pedicels effectively during 45 days cold storage of Campbell early grapes (Kim, 1994). Red globe grapes can be stored for 6 weeks at 4°C with quick release grape guard. It reduced the incidence of decay and weight loss during storage (Castro, *et al.*, 1998). After 10 days of storage grapes inoculated with *Botrytis cinerea* and non-inoculated stored with UVAGAS or UVAS pods (Both are SO₂ releasing pads) were in sound and commercially acceptable condition (Mustonen, 1992). Postharvest fumigation of seedless table grapes (cv. Crimson seedless) with the natural volatile compound (E)-2-hexenal shows promise for decay control (Archbold, *et al.*, 1999). Potassium metabisulphite significantly reduced the decay losses in Thompson seedless grapes during storage and transportation when use as an in-package fumigant (2g/2kg grapes) (Mangasuli, *et al.*, 1998). Kosanova (1963) obtained the maximum storage of 97 days without damage to fruits by using sawdust mixed with metabisulphite and mustard. Malhi (1968) obtained best results using perforated poly-ethylene bags (150 gauge) containing 10 g each of potassium metabisulphite and silica gel (1:1). Efforts were also made to get uniform release of sulphur dioxide over required period by entrapping powdered bisulphite in various types of papers and plastic materials. Encouraging results were obtained with sodium bisulphate containing tissue paper packs or paraffin coated tubes in unvented containers (Nelson and Gentry, 1966). The release and distribution of sulphur dioxide was fairly uniform when potassium metabisulphite tablets were fixed under top and bottom pads (Nelson, *et al.*, 1969). No external, internal injuries, sensory disorders of berries or discoloration of the peduncle and laterals were observed in fruit fumigated units methyl bromide and packed in PE bags with gas absorbent (Soma, *et al.*, 1991).

Possible alternatives of SO₂ have been investigated and include solution of ammonium bicarbonate and sodium bicarbonate, each with the addition of chlorine at 200 g/ml, which gave acceptable results; controlling O₂ and CO₂ levels; immersing fruit in ethanol, exposure to UV light and to ozone (Crisosto and Smilanick, 2002).

Growth Regulators

Pre and post harvest use of growth regulators increased the shelf-life of fruits. Growth regulators reduces the loss in weight, spoilage percentage of respiration rate of fruits (Kumar and Gupta, 1988). Peroxidase and polyphenol oxidase (PPO) activities were markedly reduced with

the pre-harvest application of NAA and GA (Kumar and Gupta, 1985a). Post-harvest berry shatter of Anab-e-Shahi grapes was reduced with a combination of α -NAA @ 25 ppm and 0.05% urea (Prakash, *et al.*, 1983). Singh (1979) reported that 100 ppm of PCPA was equally effective to that of α -NAA in controlling berry shatter in Himrod grapes. Pre-anthesis spray of gibberellic acid @ 20-40 ppm increased berry size, pedicel attachment and reduced berry shatter in Thompson seedless grapes during storage (Mavrikios, 1977). Spray of 100-150 ppm kinetin at pre-bloom and second rapid growth stage of berry development reduced berry shatter and other losses in stored Himrod (Dhillon, *et al.*, 1975) and perlette grapes (Randhawa *et al.*, 1976; Ladanania and Bhullar, 1989). Application of Alar and CCC at 500-5000 ppm to perlette and Anab-e-Shahi Grapes reduced the storage losses due to weight loss, shatter and decay (Kahlon and Dhillon, 1980; Ladanania and Bhullar, 1985; Dhillon, *et al.*, 1985). Medhi and Singh (1983) reported that polyphenol oxidase activity reduced by 400 ppm GA treatment. The treatment of Alar, CCC, NAA and GA decreased total amino acids and increased protein content in different grape varieties during ripening and storage (Rao and Panday, 1975; Medhi and Singh, 1983b; Kumar and Gupta, 1985).

Perlette bunches dipped in cycocel 5000 ppm, GA₃ 10 ppm and 25 ppm and kinetin 150 ppm were marketable upto 4 days of storage at room temperature (93.2°F±2°F) as compared to 2 days in untreated bunches and also reduced berry rot and physiological loss in weight (Kumar and Chharia, 1990). Berry drop in Thompson seedless grapes, during harvest and storage was reduced by pre-harvest spray of GA₃ (Copper, *et al.*, 1992). Pre-harvest spray of Cycocel (1000 ppm) showed the least weight loss, reduced incidence of berry drop, berry rot and total spoilage during ambient storage (Singh, *et al.*, 1989). Post harvest berry abscission in Kyoho grapes was inhibited by treating with GA and NAA and was promoted by ABA and ethrel (Wu, *et al.*, 1992). Spraying clusters (Flame seedless) with GA₃ (5, 10 or 15 ppm) before flower opening increased fruit quality and shelf life (Hammady, 1998). Pre-harvest and post-harvest treatments of GA₃ (25 ppm) and CPPU (5-20 ppm) delayed ripening during storage (0°C for 3-5 weeks) in Perlette, Superior and Thompson seedless grapes. CPPU decreased berry shatter and disease susceptibility also (Ben-Arie, *et al.*, 1998). Pre-harvest spray of GA₃ and kinetin at 25 or 50 ppm increased berry weight and increased the storage life upto 10 weeks (2 weeks longer than control fruits) (Hussein, *et al.*, 1998). Dormex treated Perlette vines recorded significantly lower level of PLW and berry rot during storage (Dhillon, *et al.*, 1991).

Fungicides

Many field born and storage born pathogen causes the decay of fruits and leads to heavy economic losses. The post-harvest fungal decays is mainly caused

by *Botrytis cinerea*, but depending upon the storage conditions other pathogen also cause losses (Fourie, 2008).

Various types of fungicides have been used to check these losses. Narasimhan *et al.* (1968) and Subramanian *et al.* (1973) reported that pre-harvest spray of 0.2% Captan reduced the decay of Anab-e-Shahi during storage. Pre-harvest applications of benomyl and TBZ each at 400 ppm were found to minimize *Botrytis* and *Penicillium* rots of Sultanania grapes (Kokkalas, 1976). Pre-harvest sprays of Bavistin (300 and 600 ppm) and Captaf (0.2 and 0.3%) controlled decay of berries for 4-7 days under ambient conditions (Landania, 1986). Chadha (1985) reported that a waiting period of 30 days is required between spraying of Captan and harvesting. The antifungal solutions of ammonium lauryl sulphate and per-acetic acid were not effective in controlling storage rots of grapes (Andre, *et al.*, 1977).

The mixture of CaCl₂ 1.2%, Bayleton 0.025% and Topsin M @ 0.13% gave the best control of storage decay in cv. Muscat Hamburgsky and Moldova (Cooper, *et al.*, 1993). Pre-harvest spray of Dithane M-45 and Dithane Z-78 @ 0.2% improved the organoleptic quality, reduced the weight loss and decay of berries during storage (Pillania, *et al.*, 1993). Spray of iprodione (500 µg/ml) on grapes 65 days and 9 days before harvest markedly decreased berry shattering during storage at 5°C for 2 months (Ling, *et al.*, 1999). Sawant (2002) studied the effect of pre-harvest spray of Benomyl on post harvest decay of Thompson seedless grapes and found that pre-harvest spraying of Benomyl (0.05-0.10%) at 20 or 10 days before harvest effectively controlled post harvest decay (0.04-2.78% decayed fruits after 30 days of cold storage and 3 days of storage on shelves at 30-35°C). The post harvest treatment of Carbendazim, Captafol, Thiophanate-methyl, Mancozeb and Potassium metabisulphite were significantly effective in controlling spoilage of grape bunches during storage (Padule and Shinde, 1994).

Other Chemicals

Chemicals other than growth regulators and fungicides are also used to increase the shelf life of fruits. Calcium salts are the important chemicals which are used commercially in post-harvest handling of fruits. Calcium reduced the respiration rate and retards the other ripening processes (Kumar and Gupta 1985a). Total wastage of grapes as loss in weight, berry drop, berry rot was negatively correlated with calcium content (Kumar and Gupta 1985b). The quality of grapes appreciably increased during storage by pre-harvest spray of calcium nitrate (0.75%) (Kumar and Gupta 1985c; Kumar, *et al.*, 1990). 51.1% sound fruits were found after 8 days of ambient storage sprayed with a 6% CaCl₂ before harvest (Subburamu, 1990). Preharvest spray of Ca(NO₃)₂ reduced PPO activity and decreased the losses of tannins and ascorbic acid so that there was less internal browning of berries. The solute leak-

age was reduced and berry calcium content increased by upto 39% (Lu and Ouyang, 1990).

The best results were obtained with CaCl_2 1.2% + 0.025%, Bayleton (spray 30 day before harvesting) during conventional storage of Muscat grapes for 3.5-6.5 months (Khitron and Lyublinskaya, 1991). Calcium application (1.5% CaCl_2 pre harvest spray) reduced polyphenoloxidase activity and symptoms of mechanical injuries, resulting in better appearance. Storage life was approximately 5-6 days. The weight loss of Kyoho fruits after 60 days of cold storage was reduced by both liquid Ca fertilizer (LCF) vine spray and cluster dipping treatments. Berry shattering of Kyoho and Campbell Early after 90 days of storage by LCF treatment was significantly decreased (Moon, *et al.*, 2003). Vapour phase hydrogen peroxide (VPH) reduced the decay of Thompson seedless and red globe grapes by 73% and 28%, respectively after 12 days of storage at 10°C (Fomey, *et al.*, 1991). With CT-3 (oxygen remover) (@ 2 g/kg of grapes) Longyan grapes can be stored satisfactorily for 98-126 days either in cold storage or in ordinary cellars, the amount of rotted berries did not exceed 6.25 (Lu, *et al.*, 1993). Sorbilen (ethylene absorbent) prolonged storage life by 1.7-2.5 time without noticeable loss in quality (Strel'tsov, *et al.*, 1992). Wilting of pedicels and stalk, was less in F-6S-A1 and F-6S-A₂ preservative treated Red Globe grapes than control and the disease incidence, rotten fruit rate and weight loss rate were also lower (Zhou, *et al.*, 1998).

Packaging

Packaging plays a vital role in the export trade of most of the commodities. Adequate packaging is necessary for the successful export of grapes. Grapes should be handled with utter care before and during packaging since there is danger of bruising and cracking of berries and destroying the attractive appearance of fruits. Gupta and Singh (1985) revealed that bamboo basket as package and paper cutting as cushioning material were found suitable for storage. The high density packs reduced shatter during handling (Nelson, *et al.*, 1970). In India use of paper lining with paper shreds cushioning in wooden and card board boxes reduced bruising and decay of grapes (Mir Ibrahim 1975; Sharma 1971; Singh and Kainsa 1983). The cellophane film of 60 μ thickness was effective in reducing weight losses (Dalgat, 1968). Polyliner of 100 gauge with 2 kg pack of perlette grapes with 20 perforations using - 'Dual Releases' SO_2 generator gave the best results (Dhillon and Sandhu, 1987).

Grapes packed in perforated plastic bags 'Ever fresh bags' could be stored for up to 6 weeks while maintaining good quality at 4°C (Castro, *et al.*, 1999). Kyoho grapes packed in PE film and Bio-PE film retained the excellent flavour upto 60 days of cold storage (0°C+90% RH) (Sangyoung, *et al.*, 1998). Grapes packaged under ambient conditions in LDPE and PP pouches maintained the sensory qualities 7 days (Deshpande and Shukla, 2008). The

best results were obtained when grapes were packed in boxes in a single layer without any packing materials. Storage losses were generally higher in large-capacity stores (150 t) than in those holding (25-40 t) (Dzheneev and Ivanchenko 1991). Clusters of Wanhong and Aushan Hongbaoshi placed in 0.03 mm thick polyethylene bags with 4 strips of CT - 3 grape fresh-keeping agent and stored in a semi-underground mechanical cooling cellar, could be stored well for 150 days with 97.6% fine grade berries (Sushua, *et al.*, 1998). Anab-e-Shahi and Thompson seedless fruits packed in wire - bound boxes with fumigant had more firmness after 15 of storage in cool chamber (13.0-15.6°C + 85%RH) followed by cool store (1.8°C + 61% RH) and room temperature (23.3 - 24.4°C + 5.7%) as compared to fruits packed in CFB boxes with or without fumigant (Shankaraiah and Roy, 1991).

Storage

Low temperature storage/CA/MAP

Storage temperature, humidity and air composition governs the shelf - life and quality of fruits. Physiological loss in weight, respiration rate and decay percentage can be reduced by storing at low temperature. Siddapa *et al* (1954) successfully stored grapes for about 7 weeks in cold storage chamber at a temperature range of 0.0 to 1.65°C. Nelson (1955) reported that a temperature below 4.5°C retarded the development of all fungi and also checked stem desiccation, browning, berry softening and shatter. Gupta (1967) reported that at 1.1°C Anab-e-Shahi grapes can be stored for 70 days when wrapped in polyethylene bags along 1 g of sodium metabisulphite for 1½ kg of grapes. Storage life of Perlette, Thompson seedless and Beauty seedless can be extended upto 60 days at 1.7°C to 2.4°C and 85-90% RH, when wrapped in polyethylene bags containing 10 g each of potassium metabisulphite and silica gel (1:1) (Malhi 1968). Dhillon and Sandhu (1987) stored perlette grapes upto 40 days at 0-3°C and 85-90% RH. During the storage of grape cv Itelia the highest aldehyde and alcohol content were obtained under 5% CO_2 + 3.1% O_2 and 8% O_2 + 5% CO_2 conditions (Zhao, 2003). In cv. Agadai after 6 months of storage the total amino acid content had fallen by 17% in normal air but by only 7% in CA (8% CO_2 , 5% O_2) storage (Mukailov, 1992). 114 volatile CA were found, when Agiorgitiko grapes were stored at 100% CO_2 for 10 days as where as only 60 were found in the control fruits (Dourtoglon, *et al.*, 1994).

Muscadine grapes can be stored for 3 weeks under cold controlled atmosphere storage conditions (20% CO_2 + 3% O_2 at 1-2°C temperature and 90-95% RH) with no appreciable damage (Basiouny, 1998). 8% CO_2 + 2-3% O_2 composition was the best for Muscat storage for 3-7 months (Khitron and Lyublinskaya, 1991). A combination of 10 kPa CO_2 with 3, 6 or 12 kPa O_2 is suggested for up to 12 weeks storage for late-harvested Red globe grapes. An atmosphere of 10 kPa CO_2 + 6 K Pa O_2 it suggested for early

harvested Red globe grapes, but not to exceed 4 weeks (Crisosto, *et al.*, 2002). Chlorine gas (Cl_2) produced by a salt mixture and combined with 25 days of storage at $0^\circ C$ significantly reduced *B. cinerea* decay in artificially inoculated flame seedless, Thompson seedless and Ribier grapes. No deleterious effect due to chlorine gas generation was observed. These results suggest that this is a sound alternative to SO_2 for post harvest control of decay: (Zoffoli, 1999). Fruits stored in modified atmosphere, zero energy chamber showed lowest physiological loss in weight and decay loss and maintained fruit quality. Whereas maximum PLW and decay loss were observed in fruit packed in unmodified atmosphere without diphenyl and kept at room temperature (Nain, *et al.*, 1999). Artes, *et al.*, (2003) stored the 'Napoleon' table grape in sealed plastic baskets up to 41 days at $0^\circ C$ followed by 4 days in air at 0° and 3 days at $15^\circ C$. Microperforated polypropylene (pp) of 35 μm thickness and macroperforated polypropylene (MPP) films (as control) were used. Before sealing, soaked filter paper with 15 or 10 μl hexenal was added to baskets, steady state modified atmosphere (MA) was 17% O_2 and 3% CO_2 . Best results for keeping 'Napoleon' quality during long-term cold storage were obtained by hexenal fumigation combined with MA.

Reference

- Al-Bachia, M. Use of gamma irradiation and sulphur dioxide to improve storability of two Syrian grape cultivars (*Vitis vinifera*). *Int. J. Fd. Sci. Tech.* 33 (6): 521-526.
- Anthre, P., Bures, M., Chambroy, Y., Baquple, P., Flanz, C., Pelisse, C. and Blanc, R. 1977b Essai de conservation de raisin de table. In: Table grapes and refrigeration. *Proceedings of the joint meetings of OIV and HF Paris*, pp 183-194.
- Archbold, D.D. Hamilton, T. R. Clements, A.M. and Collins, R. W. 1999. Fumigating 'Crimson Seedless' table grapes with E-2-hexenal reduces mold during long-term postharvest storage. *Hort Science*. 34 (4): 705-707.
- Arin, A. and Akdemir, S. 2004 Quality properties changing of grape during storage period. *J. Bio. Sci.* 4(2): 253-57.
- Artes, F. and Allende A. 2003 Sugar composition changes in 'Autumn Seedless' table grape during long term cold storage. *Acta Horticulturae*. 1(628): 363-66.
- Artez, F., Villaescusa, R., Tudela, J.A. and Oosterhaven, J. 2003 Combined effect of modified atmosphere packaging and hexanoal or hexenal fumigation during long-term cold storage of table grapes. *Acta Horticulturae*. 600: 401-04.
- ARVE, M.M. 1985 Precooling of grapes for effective marketing: 117-19
- Basiouny, F.M. 1998. Quality of muscadine grapes as influenced by elevated CO_2 and reduced O_2 atmosphere. *Acta Hort.* 464: 375-379.
- Beattie, B.B. and Outhred, N.I.. 1970 Packaging treatments for the storage and export of Australian grapes. *Aust. J. Exp. Agric. Anim. Hush.* 10: 124-128.
- Ben., A.R. Sarig., P. Cohen., A.Y. Zutkhi., Y. Sonego., L. Kapulonov, T. and Lisker, N. CPPU and GA3 effects on pre- and post-harvest quality of seedless and seeded grapes. *Acta Horticulturae*. 463: 349-355.
- Ben-Arie, Haas, R.A., Shoshani, Z., Bar-lev, E., Zeidman, M. and Zutkhi, Y. 1984. The effect of pre-cooling perlette table grapes wrapped in various plastic films on their keeping quality during air and sea export. *Hassadeh* 64(7): 1380-1387.
- Benkhemmar, O. Lahlou., H. Bompeix., G. Boubekri, C. and Mnai, E.H. 1993. Effectiveness of two types of sulphur dioxide generator for refrigerated storage of Moroccan table grapes. *Sciences Aliment.* 13 (3): 425-432.
- Castro., J.V. Park, K. and Honorio, S.L. 1999. Use of packaging for post harvest storage of grapes. *Revista Brasileira Engenharia Agrícola Ambiental*. 3 (1): 35-40.
- Castro., J.V. Park, K.J. and Honorio, S.L. 1998. Use of sulfur dioxide generators in storage of Red Globe grapes. *Engenharia Agrícola*. 18 (1): 66-75.
- Chadha, K.L. 1985. Grape harvest-factors affecting it. *Proceedings of the 1st National Workshop on Post-harvest Management of Grapes*, Pune, pp 3-24.
- Chadha, K.L. and Randhawa, G.S. 1974 Grape varieties in Indian: Description and classification, ICAR, New Delhi, *Tech. Bull.* 48, pp 221.
- Cooper, T. Retamales., J. Bangerth, F. and Goren, R. 1992. Berry drop occurrences as affected by GA3 and Promalin applications in Thompson Seedless grapes. *Acta Hort.* No 329, 134-136.
- Crisosto, C.H. and Smilamick, J. 2002 New technology to reduce damage by *Botrytis Cinerea* in the storage of table grapes. *Rivista-di-Frutticoltura-e-di-ortofloricoltura* 64(5): 30-38.
- Crisosto, C.H., Garner, D., Crisosto, G. 2002 Carbon dioxide-enriched atmosphere during cold storage limit losses from botrytis but accelerate rachis booming of 'Redglobe' table grapes. *Post-harvest Bio. and Tech.* 26(2): 181-89.
- Deshpande, S.D. and Shukla, B.D. 2008. Modified atmosphere packaging of table grapes in polymeric films under ambient conditions for increased storage life. *International symposium on grape production and processing. Acta Horticulturae*. 785:431-434
- Dewey, D.H. 1950. The effect of air blast pre-cooling on the moisture content of the stems of cherries and grapes. *Prov. Amer. Soc. Hort. Sci.* 56: 111-115.
- Dhillon, B.S., Randhawa J.S. and Mann, S.S. 1975 Effect of growth regulators on the storage of Himrod grapes. *J. Res. Punjab agric. Univ.* 12(3): 241-245.
- Dhillon, P.S. and Sandhu, S.S. 1990. Effect of packaging treatments and SO_2 generator on the post harvest losses of Perlette grapes. *Ind. J. Hort. Sci.* 47(4): 376-381.
- Dhillon, P.S. and Sandhu S.S. 1987. Effect of bunch tem-

- perature and perforations in the polyliner on the storage life of Perlette grapes. *Vitis* (in Preparation).
- Dhillon, W.S. Bindra, A.S. and Cheema, S.S. 1997. Influence of Dormex and harvesting dates on the storage of grapes. *J. Res. PAU* 34: 283-289.
- Dourtoglou, V.G. Yannovits, N.G. Tychopoulos, V.G. and Vamvakias, M.M. 1994. Effect of storage under CO₂ atmosphere on the volatile, amino acid, and pigment constituents in red grape (*Vitis vinifera* L. var. Agiagitiko). *J. Agric. Fd. Chem.* 42 (2): 338-344.
- Dzheneev, S.Y. and Ivanchenko, V.I. 1991. Reducing grape losses during storage and transport. *Sadovodstvo Vinogradarstvo*. No. 7, 15-19.
- El-Hammady, A.M. Shaltout, A.D. Hamid, A.N. and Kereamy, A.M.H. 1998. Effect of GA3 treatments on fruit quality of "Flame Seedless" grape cv. Arab univ. *J. Agric. Sci.* 6 (2): 531-542.
- Fomey, C.F. Rij, R.E. Deniz, A.R. and Smilanick, J.L. 1991. Vapor phase hydrogen peroxide inhibits postharvest decay of table grapes. *HortScience*. 26: 12, 1512-1514.
- Fourie, J.F. 2008. Harvesting, handling and storage of table grapes (with focus on pre- and post-harvest pathological aspects). International symposium on grape production and processing *Acta Hort.* 785:421-424.
- Ge, Y.Q. Ye, Q. and Zhang, W.Y. 1998. Effect of sulfur dioxide on some physiological and biochemical characters of postharvest grape. *Pl. Physiol. Cumminications*. 34 (3): 185-187.
- Ginsburg, L., Combrink, J.C. and Truter, A.B. 1977 Long and short term storage of table grapes in : Table grapes and refrigeration. Proceedings of the joint meeting of CIV and IIF Paris, pp 159-166.
- Gupta, O.P. and Singh, J.P. 1985 Studies of packages for storage of grapes : 107-09.
- Gupta, P.C. 1967. Studies on the cold storage of grapes. M.Sc. Thesis, PAU, Ludhiana.
- Harvey, J.M. 1956. Effect of frequency of sulphur dioxide fumigation during storage on decay and fumigation injury in Empereior grapes. *Phytopathology*. 46(12): 690-694.
- Hegazi, A. and Barkoki, E.F. 1994. Environmental factors affecting the shelf life of Flame seedless grapes. *Acta-Horticulturae*. 368: 97-105.
- Hussein, M.A. Mostafa, F.M.A. Adb., E.A.Y. and Mohamed, S.M. 1998. Studies on physiological effects of gibberellic acid and Kinetin application on Banaty (Thompson Seedless) grape during storage. *Assiut J. Agric. Sci.* 29 (4): 31-42.
- Khitron, Y.I. and Lyubinskaya, N.A. 1991. Increasing the effectiveness of storing table grapes. *Sadovodstvo Vinogradarstvo*. No. 7, 19-21.
- Khitron, Y.I. and Lyubinskaya, N.A. 1992. Decrease of table grape losses due to the fungal rots during storage. *Vestnil Sel skokhozyaistvennoi Nauki Moskva*. No. 1 155-158.
- Kim, C.C. 1994. Influence of harvesting time, Grape Guard, putrescine an dheat treatments on maintaining freshness in 'Cambell Early' grape (*Vitis labruscana* B) *J. Korean Soc. Hort. Sci.* 35 (4): 351-359.
- King, G. 1986 Table grape storage and some potential difficulties. *Orchadist of New Zealand* 59(3): 98-99.
- Kokkalos, T.I. 1976. Post harvest decay control of Cyprus-grown grapes. *Am. J. Enol. Vitic.* 27 : 114.
- Kosanova, N.I. 1963. Concerning grape storage. *Vinod-i-Vinogr.* 23(5): 40-42.
- Kumar, R. and Gupta, O.P. 1985 Storage studies in grapes - II Effect of pre-harvest application of fungicides, growth REGULATORS, A calcium nitrate on the biochemical changes in grape cv. Perlette 171-84.
- Kumar, R. and Gupta, O.P. 1985 Calcium in relation to storage behaviour of grapes (*V. vinifera*, L.).
- Kumar, R. and Gupta, O.P. 1985a Storage studies in grapes. I. Effect of pre-harvest application of fungicide, growth regulators and calcium nitrate on the storage behaviour of Perlette grapes. Proceedings of the 1st National Workshop on Post-harvest Manhagement of grapes. Pune-pp, 162-170.
- Kumar, R. and Gupta, O.P. 1985b Storage studies in grapes. II. Effect of pre-harvest application of fungicide, growth regulators and calcium nitrate on the storage behaviour of Perlette grapes. Proceedings of the 1st National Workshop on Post-harvest Manhagement of grapes. Pune-pp, 185-197.
- Kumar, R. and Gupta, O.P. 1985c Storage studies in grade-IV-effect of preharvest spray of different chemicals on the quality during storage at cold temperature. : 198-210.
- Kumar, R., Singh, S.P. and Chharia, A.S. 1990 Effect of pre-harvest application of different chemicals on the quality of grapes cv. Delight during storage. *Haryana J. Hort. Sci.* 19(1-2): 62-70.
- Kumar, S. and Chharia, A.S. 1990. Effect of different growth substances and pre-packing on storage life of grapes cv. Perlette. *Haryana J. Hort. Sci.* 19 (1-2): 122-128.
- Kumar, S. and Chharia, A.S. 1990 Effect of different growth substances and pre-packing on storage life of grapes cv. Perlette. *Haryana J. Hort. Sci.* 19(1-2) : 122-28.
- Kumar, R. Singh, S.P. and Chharia, A.S. 1990. Effect of pre-harvest application of different chemicals on the quality of grapes cv. Delight during storage. *Haryana J. Hort. Sci.* 19 (1-2): 62-70.
- Ladania, M.S. and Dhillon, B.S. 1987. Studies on long term storage of beauty seedless grapes. *Indian J. Hort. Sci.* 44:34-39.
- Ladania, M.S. and Bhullar, J.S. 1989 Effect of plant regulators on the storage behaviour of Perlette grapes. *J. Res. Punjab Agric. Univ. Ludhiana* 22 : 467-473.
- Ladania, M.S. and Dhillon, B.S. 1987 Studies on long term storage Beauty Seedless grapes. *Indian J. Hort.* 44 : 34-39.
- Lima, M.d., Alves, R.E., Arris, J.S., Filgueiras, H.A.C., Costa J.T.A. 2002 Appearance, Phenolic compounds and

- oxidative enzymes in Italia grape under effect of calcium and in cold storage.
- Lu, C.W. and Ouyang, S.R. 1990. The effects of Preharvest calcium sprays on the storage of table grapes. *Acta Hort. Sinica*, 17: 2, 103-110.
- Lu, C.W. Xiou, D.R. and Tian, Y. 1993. Effect of the storage life preservatives in the CT series on grapes. *China Fruits* 2: 28-29.
- Maini, S.B. 1985 Pre-cooling of grapes by evaporative cooling system. *Proc. Ist. Nat. Mangmt. Grapes*, Pune (India) pp. 113-116.
- Malan, H. 1955. Can the use of moisture proof wrappers improves the condition of grapes during long term storage. *Eng. S. Afr.* 30: 231-232.
- Malhi, G.S. 1968. Studies on cold storage of grapes. M.Sc. thesis PAU, Ludhiana.
- Mangasuli, N.S. Reddy, B.S. and Patil, D.R. 1998. Effect of packages and chemicals on physiological loss in weight and decay loss of transported Thompson Seedless grapes under different storage conditions. *Karnataka J. Agric. Sci.* 11 (1): 127-133.
- Mansour, K.M., El-Tobshy, Z.M., Nelson, K.E. and Fahmy, B.A. 1984 Effect of in-package SO₂ generator on post-harvest decay and quality of Banati grapes. *Egyptian J. Hort.* 11(1): 11-18.
- Mavrikios, Ch. 1977 La raisin de table et le froid: Utilization de regulateurs de croissance. In: Table grapes and refrigeration. Proceedings of the joint meeting of OIV and IIF Paris, pp 67-74.
- Medhi, G. and Singh, I.S. 1983a Effect of GA on catalase, peroxidase, polyphenol oxidase activity of Beauty Seedless grapes during storage. *Haryana J. Hort. Sci.* 12: 26-29.
- Medhi, G. and Singh, I.S. 1983b Effect of GA on total free amino acids, proline, and protein content of Beauty Seedless grape during development and storage. *Progre. Hort.* 15: 73-78.
- Mir, Ibrahim, A.A. 1965 Studies on packing and storage of Fruits M. Sc. Thesis, A. P. Agric. Univ. Hyderabad.
- Mongelli, G. 1982. Recent findings on the loss of water during pre-cooling in air, with special reference to certain fruit produce. *Fruticoltura* 44 (9/10): 39-46.
- Moon, B.W., Choi, J.S. and Kand, M.S. 2003 Effect of vine-spray of liquid calcium fertilizer on calcium contents and quality in stored grape fruits. *J. Korean Soc. Hort. Sci.* 44(3): 345-48.
- Mukailov, M.D. 1992. Long term storage and nutritive value of grapes. *Ernahrung* 16: 6, 342-343.
- Mustonen, H.M. 1992. The efficacy of a range of sulfur dioxide generating pads against *Botrytis cinerea* infection and on out-turn quality of Calmeria table grapes. *Aust. J. Exp. Agric.* 32: 3, 389-393.
- Nain, A.S., Sindhu, S.S. and Kumar, J. 1996 Effect of pre-cooling on the shelf life of grapes cv. Perlette. *Haryana J. Hort. Sci.* 25(4): 177-82.
- Nain, A.S., Sindhu, S.S. and Kumar, J. 1996 Effect of pre-cooling on the shelf life of grapes cv. Perlette. *Haryana J. Hort. Sci.* 28(1&2): 45-48.
- Nain, A.S. Sindhu, S.S. and Kumar, J. 1996. Effect of pre-cooling on shelf life of grapes cv Perlette. *Haryana J. Hort. Sci.* 25 (4): 177-182.
- Nain, A.S. Sindhu, S.S. and Kumar, J. 1999. Increased shelf-life of grapes (*Vitis vinifera* L.) by different storage conditions and antifungal fumigants. *Haryana J. hort. Sci.* 28 (1-2): 45-48.
- Nam, S. Y., Kim, K., Lee, Y. and Jong, S. 1998. Effect of PE film packing on storage of "Kyoho" grape. *RJA. J. Hort. Sci.* 11. 40 (2): 7-12.
- Narasimhan, P., Rao, M.M., Nagarajan, N. and Anandswamy, B. 1968 Effect of pre-harvest spray of sodium orthophenyl phenate and captan on the control of decay in Anab-e-Shahi grapes. *J. Fd. Sci. Technol.* 5: 63-64.
- Nelson, K.E. 1951. Factors influencing the infection of table grapes by *Botrytis cinera* (Pers) Phytopathology 41: 319-326.
- Nelson, K.E. 1955. High picking temperatures and rough handling can reduce consumer acceptability of California fresh table grapes. *Blue Anchor* 32(2): 6-10.
- Nelson, K.E. 1970. Packaging and handling trials on export grapes. *Blue Anchor* 47(9): 11-13.
- Padule, D.N. and Shinde, P.A. 1994 Efficacy of post-harvest fungicidal and chemical treatments on the control of microbial spoilage of grape berries stored at room temperature. *Maharashtra J. Hort.* 8(1): 15-21.
- Padule, D.N. and Shinde, P.A. 1994. Efficacy of post harvest fungicidal and chemical treatments on the control of microbial spoilage of grape berries stored at room temperature. *Maharashtra J. Hort.* 8(1): 15-21.
- Pentzer, W.T. and W.R. Barger. 1941. A comparison of fungicidal treatments for the control of *Botrytis* rot of grapes in storage. *Proc. Amer. Soc. Hort. Sci.* 39: 281-284.
- Pentzer, W.T., Asbury, C.E. and Hamner, K.C. 1933 The effect of sulphur dioxide fumigation on the respiration of Emperor grapes. *Proc. Amer. Soc. Hort. Sci.* 30: 258-261.
- Pillania, S.S. Chauhan, K.S. Narwal, A.K and Jakhar, S.S. 1993. Effect of pre-harvest spray of Dithane M-45 and Dithane Z-78 on shelf life of grapes cv. Perlette. *Ann. Biol. Ludhiana*. 9(1): 127-130.
- Popa, E. and Fugel, S. 1982 Some aspects of improving the technology of storing table grapes. Lueral Stiintifice, Institutul de Cercetari si Proiectari Pentru Valorificarea si Industrialize area-Legumelor si Fructelor 13: 129-136.
- Prakash, G.S., Reddy, B.M. and Dass, H.C. 1983 Effect of NAA with urea on the post-harvest berry drop of Anab-e-Shahi grape. *Singapore J. Prim. Indus.* 11: 49-51.
- Randhawa, J.S., Dhillon, B.S. and Mann, S.S. 1976 Effect of pre-harvest application of CCC and kinetin on the cold storage life of Perlette grapes. *J. Res. Punjab Agric. Univ., Ludhiana*.
- Rao, M.M. and Pandey, R.M. 1975 Organic acid metabolism during development and storage of Pusa

- seedless grapes. *Indian J. Pl. Physiol.* 18(1): 20-25.
- Reich, S.G. 1979. Effects of irrigation on fruit quality after harvest and during storage. *Bull. Inst. Int. Froid.* 59(4): 1130-1131.
- Roy, S.K. 1988 Development of Packing for export of grapes. : 103-08.
- Ryall, A.L. and Harvey, J.M. 1959 The cold storage of *Vinifera* grapes. *USDA Agric. Handbook* No. 159 pp 46-56.
- Samant, S.D., Samant, I.S. and Bareeye, K. 2002 Minimizing sulphur dioxide injury in table grapes (*Vitis vinifera*) for export by pre-harvest benomyl sprays. *Indian J. Agri. Sci.* 72(11): 635-38.
- Sandhu, S.S. Dhillon, P.S and Bindra, A.S. 1990. Effects of package and storage conditions on the keeping quality of Perlette grape. *Vitis*. 29: 97-107.
- Shankaraiah, V. and Roy, S.K. 1991. Effect of package material and in-package fumigant on biochemical changes and storage life of transported grapes. *Haryana J. Hort. Sci.* 20: 3-4, 203-209.
- Sharma, O.S. 1971. Determination of suitable packing for the transit of grapes. *Agric. Agro. Ind. J.* 4(11): 14-16.
- Siddappa, G.S., Mathur, P.V. and Johar, J.S. 1954. Preservation and processing of *South Indian* White grapes. *CFTRI Bull. Loza Vina*, 24(7): 10-15.
- Singh, I.S. and Weaver, R.J. 1982. Effect of pre-harvest application of ethephon (during stage-III) and SO₂ generation packing device on ethylene production and quality of Tokay grapes during cold storage. *Haryana J. Hort. Sci.* 11(3/4): 149-153.
- Singh, J.P. and Kainsa, R.L. 1983. Microbial flora of grapes in relation to storage and spoilage. *Indian Phytopath* 36(1): 72-76.
- Singh, T. 1979. Studies on berry shatter and storage of Himrod grapes. M.Sc. Thesis, Punjab Agric. Univ., Ludhiana.
- Singh, S.P. and Kumar, R. 1989. Effect of pre-harvest application of Cycocel, calcium nitrate and zinc sulphate on the storage behavior of Delight grapes. *J. Res. HAU*. 19: 4, 294-301.
- Soma, Y. Sunagawa, K. Kurokawa, K. Nakamura, M. Misumi, T. and Kawakami, F. 1991. Chemical injury of 'Kyoho' grapes fumigated with methyl bromide. *Res. Bull. Pl. Prot. Service Japan*. No. 27. 83-86.
- Soylemezoglu, G. and Agaoglu, Y.S. 1994. Research on the effect of grape guard during the cold storage of Thompson Seedless cv. *Acta Hort.* 368: 817-824.
- Strel, B. Rukavishnikov, A. and Kuleshova, E. 1992. The use of ethylene adsorbents for storage of fruit, vegetable and flower products. (6): 49-53.
- Subburamu, K. Singaravelu, M. Nazar, A. and Irulappan, I. 1990. Pre-harvest spray of calcium in grapes (*Vitis vinifera*). *South Indian Horticulture*. 38: 5, 268-269.
- Subramanian, T.M., Sadasivam, R., Raman, N.V. and Gowder, R.B. 1973. Controlling storage decay in Anab-e-Shahi. *Indian Hort.* 18(2): 10.
- Tiang, S.H. Cui, Z.C. Wang, S.Y. and Xu, Y.G. 1998. Experiments on storage of grapes. *China Fruits*. 4: 41-42.
- Winkler, A. J., Cook, J.A., Kliwer, W.M. and Lider, L.A. 1974. *General Viticulture*, Univ. Calif, Press.
- Wu, Y.M. Ren, J.C. Hua, X.Z. and Liu, Y. 1992. Postharvest berry abscission and storage of grapes. *Acta Phytophysiological Sinica*. 18: 267-272.
- Xu, L. Kusakari, S.I. Toyada, H. and Ouchi, S. 1999. Role of fungi in the shattering of grape berries during storage. *Bull. Inst. Comprehensive Agric. Sci. Kinki Univ.* (7): 97-706.
- Yun, S.D. Lee, S.K. and Ko, K.C. 1995. Effects of cultivars and various treatments on storability of grapes. *J Korean Soc. Hort. Sci.* 36 (2): 224-230.
- Zhao, Y.L., Zhang, H.Y., Xiu, D. Wang, S.G. and Wang, C. 2003. Effect of different atmospheres on the contents of alcohol and aldehyde in the berries of Italia grape variety during storage. *J. Fruit Sci.* 20(6): 459-62.
- Zhou, L. Cao, M and Zhu, Z.A. 1998. A study on effect of several new fresh keeping agents on grape fruits in cold storage. *Acta Agric. Shanghai*. 14 (4): 87-91.
- Zoffoli, J.P. Latorre, B.A. and Rodriguez, E.J. 1999. Modified atmosphere packaging using chlorine gas generators to prevent *Botrytis cinerea* on table grapes. *Postharvest Bio. Tech.* 15 (2): 135-142.

Physiological traits of Kinnow mandarin under Drip irrigation system

Prerak Bhatnagar* and M.K. Kaul**

Department of Horticulture, Agriculture Research Station
SriGanganagar-335001, Rajasthan Agriculture University

Abstract

Variation in plant environmental factors of Kinnow mandarin for at Agriculture Research Station, SriGanganagar district of Rajasthan state in India with respect to three differential irrigation treatments revealed that overall maximum carboxylation efficiency (A) was estimated in 70% Etc treatment from April to June with a linear trend and showed depression in September and October followed by a steady rise in November and December months. Stomatal conductance revealed oscillating trend being maximum in 70% Etc treatment for April and May months followed by steep rise in 40% Etc treatment for June–July months and remained static in August and September, a trend reversal in October–November with maximum stomatal conductance in 100% Etc treatment with a slight compared to 70% Etc. The cumulative overall high stomatal resistance in 40% treatment might have attributed to low photosynthetic rates followed by 100% treatment and the better assimilation rates under 70% treatment are correlated with low rates of stomatal resistance. The daily course of transpiration in all the three irrigation treatments does not closely linked to solar irradiation but rather to leaf temperature. Temperatures of 25–30°C are optimal for photosynthesis but temperatures above 30°C definitely reduce photosynthetic activity.

The annual trend for three consecutive years' data revealed occurrence of cyclic oscillations in photosynthesis, stomatal conductance, stomatal resistance, transpiration rate and photosynthetic active radiation under field conditions. Citrus belong to C_3 plants, with photosynthetic rates lower than C_4 plants. Assimilation rates ranging from 1.28 to 7.93 $\text{mmol m}^{-2} \text{s}^{-1}$ observed under differential irrigation treatments seem realistic under optimal irrigated conditions of Western Rajasthan.

Key Words: Kinnow, photosynthesis, carboxylation efficiency, stomatal conductance

Introduction

Carbon assimilation efficiency during the cumulative day hours of the year determines plant growth and productivity. This efficiency is a compound effect of net photosynthetic rate and photosynthate partitioning. Measurements of photosynthesis rate, transpiration rate, Stomatal conductance have been very important for understanding limitations in assimilation potential of plants. The weather parameters in conjunction with irrigation optima influence/cause these variations (Maroco *et al.*, 1997). Direct effect of leaf to air vapour pressure deficit in Stomatal regulation was reported in many woody crops (Flore and Lakso, 1989). There is no information available on how temporal variations in extreme.

Climate under irrigated aridisols of Western Rajasthan with respect to differential irrigation treatments. Hence, the study was undertaken to examine the gas exchange characteristics of Kinnow mandarin under drip irrigation system. Kinnow mandarin is grown under canal command areas of irrigated parts of North Western Rajasthan state. It is inevitable that any deficiency of water particularly during critical stages after fruit set in mandarin results in drastic reduction in dry matter and leads to significant low yield biomass. The relationship between weather parameters and month wise periodical changes in photosynthesis concurrent with water use efficiency and their interrelationships were not studied in Kinnow mandarin. In the present study, emphasis is laid on the month wise variation in photosynthetic parameters in relation to weather conditions and interrelationship in drip irrigation system at three irrigation treatments based on evapotranspiration coefficient.

* Corresponding author's address:

Asstt. Prof. (Pomology), COH & Forestry, Jhalawar

** Prof. (Hort.), ARS, Sri Ganganagar

Material and methods

Kinnow mandarin plants (2 years old after field planting) at 6x6 m budded on *Citrus jambhiri* were selected for study under drip irrigation system at the experimental site of Agriculture Research Station, SriGanganagar. These plants were grown in alluvial soils of sandy loam texture under drip system at 40, 70 and 100% evapotranspiration coefficient and have receive recommended doses of fertilisers. The irrigated Kinnow plants were watered continuously for a week as per irrigation scheduling prior to measurements. A total of twenty one Kinnow plants were taken for experimental study. Measurements on gas exchange characteristics under drip system (7 plants treatment⁻¹) were simultaneously taken during the day (8-10 am) from April 2002 to December 2004 successively for three years Vis a Vis 40, 70 and 100 % Etc treatments. With the initiation of new ambe bahar growth of Kinnow plants in March, the experimental observations were recorded from April to December month's i.e. the active growth period from flowering to fruiting cycle. Photosynthesis (A), stomatal conductance (g), substomatal CO₂ concentration (c), transpiration (E), photo synthetically active radiation (PAR) incidence on the leaf surface and leaf surface temperature were recorded using a ADC photosynthesis system (Model LCA 4, ADC, UK). Before the use of instrument, zero settings for H₂O and CO₂ made. The boundary layer resistance to vapour was typically 0.8 m²s⁻¹mol⁻¹. Air was drawn into the instrument from an air probe at the height of 3m above ground surface. The air pumped into the system was dried using anhydrous calcium sulphate. The gas flow to leaf chamber was maintained at 300±2μ mols⁻¹. The experimental area under drip and micro-sprinkler system of irrigation at the completion of two years(2003) came into bearing profusely and initially it was decided that the fruit of this year will be retained so the flowers were subjected to drop but while doing so re thought was given and finally decided to remove the flowers in half of the replications completely and in rest 50 per cent flowers were retained so as to see the impact of fruit bearing on the overall growth of the tree in all the three treatments in comparison to other Kinnow plants.

Results and discussion

The results in table-1 clearly elucidates that after onset of spring in the month of April maximum photosynthesis A(4.84) was recorded in 70% Etc treatment with a minimum of substomatal concentration c_i (101.10) in correlation with highest Stomatal conductance g_s (0.03) and maximum transpiration (1.45) rate as compared to 40 and 100% Etc treatments. The reason for this might be due to minimum stomatal resistance r_s in 70% Etc treatment with respect to 40 and 100% Etc treatment. The low photosynthesis in higher irrigation treatment 100% Etc might be attributed to increase in leaf temperature which results in damage to photosynthetic apparatus irrespective

of the fact that water use efficiency was higher(3.82) under 100% Etc treatment as compared to 70% treatment. Low assimilation rates of citrus are accompanied by low rates of transpiration and extreme sensitivity to moisture deficit (Kriedemann and Barrs, 1981).

The data in table-2 revealed that in the month of May, highest photosynthetic rate A for Kinnow plants (6.28) was observed in 70% Etc treatment along with maximum transpiration rate.

The higher photosynthetic rate in 70% Etc treatment might be due to better partitioning of assimilates in this treatment coupled with higher stomatal conductance (0.08) and minimum stomatal resistance (15.80) with respect to 40 and 100% Etc treatments. The perusal of data in table-3 for June depicts an increasing trend of carboxylation efficiency of Kinnow plants with respect to differentially increasing irrigation treatments being maximum in 100% treatment. Higher assimilation rate of Kinnow in May reflects the special genetic character of this citrus species that how well it is acclimatized in the extremes of irrigated aridisols with the saturation of photosynthesis at high light intensities. This might be due to the fact that water use efficiency was highest (2.78) in conjunction with lowest transpiration rate in 100% Etc treatment as compared to 40 and 70% treatments.

The data in table-4 for July depicted that maximum carboxylation efficiency of Kinnow (6.70) was recorded in 70% etc treatment and exhibited a significant increase in A as compared to 40 and 70% Etc treatments. The reason for this might be due to better uptake and utilization of water i.e. highest water use efficiency (2.58) was recorded in 100% Etc treatment which was significantly better than 40 and 70% treatments. The results of present findings are in accordance with those of (Sinclair and Allen, 1982) that better photosynthetic rates of citrus are attained at low PAR intensities. The data in table-5 for August depicted that highest photosynthate partitioning of Kinnow was recorded in 100% Etc treatment which showed a positive correlation with stomatal conductance and transpiration despite lowest water use efficiency as compared to 40 and 70% treatments.

The low PAR intensities recorded in all the three irrigation treatments are due to cloud effect at the time of recording of observations. The results are in conformity with the findings of (Vu and Yalenosky, 1988) that photosynthetic rates of citrus saturates at relatively low light intensities i.e. about 30% of full sunlight in outer parts of the tree canopy.

Table 1. Physiological parameters during April (2002-04)

Variable	Drip (per cent Etc)			C.D. at 5%
	40	70	100	
Photosynthetic Rate ($A = \text{mmolm}^{-2}\text{s}^{-1}$)	2.71	4.84	3.67	0.908
Stomatal conductance ($g_s = \text{m}^2\text{smol}^{-1}$)	0.01	0.03	0.02	N.S.
Stomatal resistance ($g_s = \text{rsm}^2\text{smol}^{-1}$)	67.11	32.60	56.14	14.01
Leaf Temperature ($^{\circ}\text{C}$)	38.33	39.39	40.28	N.S.
Transpiration rate ($E = \text{molm}^{-2}\text{s}^{-1}$)	0.68	1.45	0.96	0.252
Sub-Stomatal CO_2 concentration	122.10	101.10	101.30	N.S.
Photosynthetic Active Radiation ($Q = \text{mmolm}^{-2}\text{s}^{-1}$)	1840.66	1899.66	1749.66	N.S.
Relative Humidity (R.H. = %)	45.96	41.96	41.03	N.S.
Water Use Efficiency	3.98	3.33	3.82	N.S.

Table 2. Physiological parameters during May (2002-04)

Variable	Drip (per cent Etc)			C.D. at 5%
	40	70	100	
Photosynthetic Rate ($A = \text{mmolm}^{-2}\text{s}^{-1}$)	4.39	6.28	5.59	1.31
Stomatal conductance ($g_s = \text{m}^2\text{smol}^{-1}$)	0.05	0.08	0.05	0.01
Stomatal resistance ($g_s = \text{rsm}^2\text{smol}^{-1}$)	18.92	15.80	19.26	N.S.
Leaf Temperature ($^{\circ}\text{C}$)	39.29	38.94	38.27	N.S.
Transpiration rate ($E = \text{molm}^{-2}\text{s}^{-1}$)	2.52	3.43	2.41	0.71
Sub-Stomatal CO_2 concentration	228.52	202.50	189.3	N.S.
Photosynthetic Active Radiation ($Q = \text{mmolm}^{-2}\text{s}^{-1}$)	1137.60	1175	1093.2	N.S.
Relative Humidity (R.H. = %)	18.08	18.40	16.98	N.S.
Water Use Efficiency	1.74	1.83	2.31	N.S.

Table 3. Physiological parameters during June (2002-04)

Variable	Drip (per cent Etc)			C.D. at 5%
	40	70	100	
Photosynthetic Rate ($A = \text{mmolm}^{-2}\text{s}^{-1}$)	4.49	4.71	4.79	N.S.
Stomatal conductance ($g_s = \text{m}^2\text{smol}^{-1}$)	0.07	0.05	0.03	0.01
Stomatal resistance ($g_s = \text{rsm}^2\text{smol}^{-1}$)	15.16	18.69	28.59	4.73
Leaf Temperature ($^{\circ}\text{C}$)	39.50	39.32	39.5	N.S.
Transpiration rate ($E = \text{molm}^{-2}\text{s}^{-1}$)	3.15	2.54	1.72	0.69
Sub-Stomatal CO_2 concentration	225.74	203.32	134.66	51.83
Photosynthetic Active Radiation ($Q = \text{mmolm}^{-2}\text{s}^{-1}$)	1137.4	1106.2	1103.4	N.S.
Relative Humidity (R.H. = %)	19.42	19.46	19.10	N.S.
Water Use Efficiency	1.42	1.85	2.78	1.22

Table 4. Physiological parameters during July (2002-04)

Variable	Drip (per cent Etc)			C.D. at 5%
	40	70	100	
Photosynthetic Rate ($A = \text{mmol m}^{-2} \text{s}^{-1}$)	3.30	6.70	5.76	1.22
Stomatal conductance ($g_s = \text{m}^2 \text{mol}^{-1}$)	0.18	0.09	0.11	0.03
Stomatal resistance ($g_s = \text{rsm}^2 \text{mol}^{-1}$)	6.73	11.87	11.74	2.32
Leaf Temperature ($^{\circ}\text{C}$)	38.16	36.59	38.05	N.S.
Transpiration rate $E = \text{mol m}^{-2} \text{s}^{-1}$	3.82	2.59	3.03	0.83
Sub-Stomatal CO_2 concentration	326.8	233.38	252.48	72.14
Photosynthetic Active Radiation ($Q = \text{mmol m}^{-2} \text{s}^{-1}$)	1264.2	928.0	1314.2	297.03
Relative Humidity (R.H. = %)	25.20	26.48	27.46	N.S.
Water Use Efficiency	0.86	2.58	1.90	0.41

Table 5. Physiological parameters during August (2002-04)

Variable	Drip (per cent Etc)			C.D. at 5%
	40	70	100	
Photosynthetic Rate ($A = \text{mmol m}^{-2} \text{s}^{-1}$)	7.25	6.89	7.93	N.S.
Stomatal conductance ($g_s = \text{m}^2 \text{mol}^{-1}$)	0.06	0.04	0.07	0.01
Stomatal resistance ($g_s = \text{rsm}^2 \text{mol}^{-1}$)	17.72	27.92	13.80	1.36
Leaf Temperature ($^{\circ}\text{C}$)	34.23	34.53	34.59	N.S.
Transpiration rate $E = \text{mol m}^{-2} \text{s}^{-1}$	1.39	1.04	1.72	0.34
Sub-Stomatal CO_2 concentration	124.82	122.68	173.58	33.63
Photosynthetic Active Radiation ($Q = \text{mmol m}^{-2} \text{s}^{-1}$)	500.0	469.2	672.8	132.09
Relative Humidity (R.H. = %)	26.92	27.22	27.66	N.S.
Water Use Efficiency	5.21	6.62	4.61	1.42

Table 6. Physiological parameters during September (2002-04)

Variable	Drip (per cent Etc)			C.D. at 5%
	40	70	100	
Photosynthetic Rate ($A = \text{mmol m}^{-2} \text{s}^{-1}$)	2.48	2.53	3.15	N.S.
Stomatal conductance ($g_s = \text{m}^2 \text{mol}^{-1}$)	0.05	0.05	0.03	0.01
Stomatal resistance ($g_s = \text{rsm}^2 \text{mol}^{-1}$)	20.03	20.81	25.80	N.S.
Leaf Temperature ($^{\circ}\text{C}$)	33.74	33.67	34.03	N.S.
Transpiration rate $E = \text{mol m}^{-2} \text{s}^{-1}$	1.20	1.20	1.01	N.S.
Sub-Stomatal CO_2 concentration	255.50	277.17	207.82	N.S.
Photosynthetic Active Radiation ($Q = \text{mmol m}^{-2} \text{s}^{-1}$)	951.50	959.25	985.00	N.S.
Relative Humidity (R.H. = %)	50.77	50.92	51.00	N.S.
Water Use Efficiency	2.06	2.10	3.11	0.57

The data in table-6 for September revealed that highest photosynthetic rate of Kinnow was recorded in 100% Etc treatment which showed a positive correlation with comparative best water use efficiency as compared to 40 and 70% treatments. The low photosynthetic rates in all the three irrigation treatments in the month of September as compared to previous months are accompanied by low rates of transpiration and extreme sensitivity to soil moisture deficit and also due to translocation of assimilates from source to sink thereby having an impact of first bearing on the overall growth of the tree. These findings are in agreement with those of Kriedemann and Barrs, (1981) who reported that low assimilation rates of citrus are due to low substomatal concentration. The data in table-7 for October revealed that maximum carboxylation efficiency of Kinnow was estimated in 100% Etc treatment as compared to 40 and

70% irrigation treatments. The better A in 100% treatment might be due to increased stomatal conductance and maximum water use efficiency with respect to other treatments. The low photosynthetic rates in 40 and 70% Etc levels indicate the limitation of photosynthetic rates at the mesophyll level.

The data in table-8 for the month of November revealed that maximum assimilation of carbohydrates in Kinnow was recorded in 70% Etc treatment which showed a positive correlation with maximum water use efficiency in the same treatment coupled with lowest transpiration Vis a Vis 40 and 70% treatment. At low relative humidity, the transpiration reduced due to decrease in evapotranspiration driving forces.

The data in table-9 for the month of December depicted that highest photosynthetic rate was attained in 70% treatment which exhibited a positive correlation with

Table 7 Physiological parameters during October (2002-04)

Variable	Drip (per cent Etc)			C.D. at 5%
	40	70	100	
Photosynthetic Rate ($A = \text{mmol m}^{-2} \text{s}^{-1}$)	1.28	2.02	2.50	0.43
Stomatal conductance ($g_s = \text{m}^2 \text{mol}^{-1}$)	0.05	0.07	0.08	0.01
Stomatal resistance ($g_s = \text{rsm}^2 \text{mol}^{-1}$)	17.07	13.55	12.35	N.S.
Leaf Temperature ($^{\circ}\text{C}$)	33.39	33.42	33.83	N.S.
Transpiration rate $E = \text{mol m}^{-2} \text{s}^{-1}$	1.87	2.22	2.50	N.S.
Sub-Stomatal CO_2 concentration	323.1	314.32	306.40	N.S.
Photosynthetic Active Radiation ($Q = \text{mmol m}^{-2} \text{s}^{-1}$)	954	920	990.66	N.S.
Relative Humidity (R.H. = %)	29.55	30.62	32.33	N.S.
Water Use Efficiency	0.68	0.90	1.00	0.20

Table 8. Physiological parameters during November (2002-04)

Variable	Drip (per cent Etc)			C.D. at 5%
	40	70	100	
Photosynthetic Rate ($A = \text{mmol m}^{-2} \text{s}^{-1}$)	3.84	3.71	3.53	N.S.
Stomatal conductance ($g_s = \text{m}^2 \text{mol}^{-1}$)	0.05	0.05	0.06	N.S.
Stomatal resistance ($g_s = \text{rsm}^2 \text{mol}^{-1}$)	18.01	19.21	16.71	N.S.
Leaf Temperature ($^{\circ}\text{C}$)	30.55	29.73	27.26	N.S.
Transpiration rate ($E = \text{mol m}^{-2} \text{s}^{-1}$)	1.65	1.51	1.53	N.S.
Sub-Stomatal CO_2 concentration	257.74	274.65	286.05	N.S.
Photosynthetic Active Radiation ($Q = \text{mmol m}^{-2} \text{s}^{-1}$)	1259.0	1358.66	1165.83	N.S.
Relative Humidity (R.H. = %)	25.60	25.96	27.80	N.S.
Water Use Efficiency	2.32	2.45	2.30	N.S.

Table 9. Physiological parameters during December (2002-04)

Variable	Drip (per cent Etc)			C.D. at 5%
	40	70	100	
Photosynthetic Rate ($A = \text{mmol m}^{-2} \text{s}^{-1}$)	2.84	4.41	4.11	0.89
Stomatal conductance ($g_s = \text{m}^2 \text{mol}^{-1}$)	0.09	0.14	0.12	0.02
Stomatal resistance ($g_s = \text{rsm}^2 \text{mol}^{-1}$)	11.12	7.264	8.041	2.38
Leaf Temperature ($^{\circ}\text{C}$)	27.17	26.72	24.50	N.S.
Transpiration rate ($E = \text{mol m}^{-2} \text{s}^{-1}$)	1.84	2.53	2.04	N.S.
Sub-Stomatal CO_2 concentration	313.61	319.66	320.88	N.S.
Photosynthetic Active Radiation ($Q = \text{mmol m}^{-2} \text{s}^{-1}$)	717.00	1122.55	936.87	224.26
Relative Humidity (R.H. = %)	30.60	28.66	29.47	N.S.
Water Use Efficiency	1.54	1.74	2.01	N.S.

maximum stomatal conductance (0.14) value and minimum stomatal resistance as compared to 40 and 100% treatments. The better stomatal conductance in all the three treatments is predominantly influenced by low leaf temperature during the month of December. Fig 1 to 5 shows the occurrence of cyclic oscillations in photosynthesis, stomatal conductance, stomatal resistance, transpiration rate and photosynthetic active radiation under field conditions.

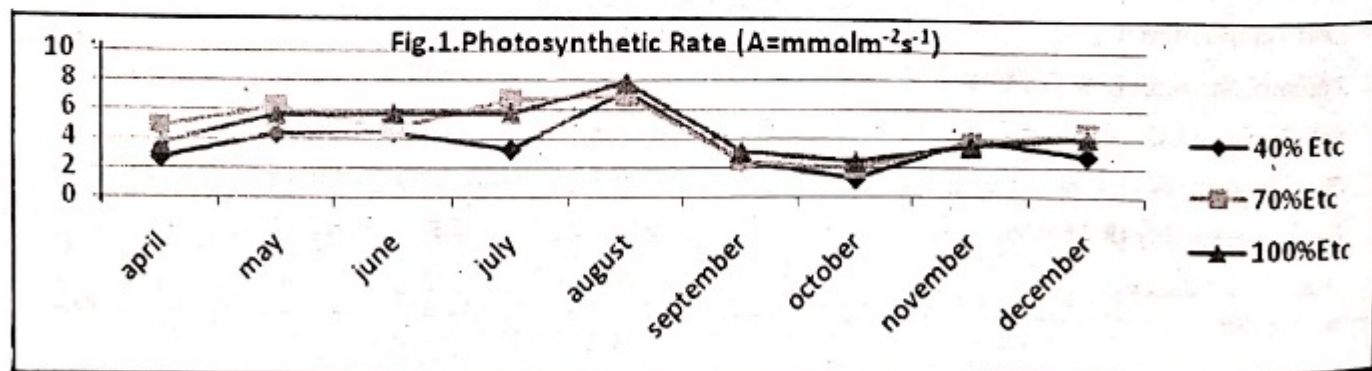
The data in table-10 revealed that during first bearing highest number of fruits (38.13) was recorded in 70% Etc which was significantly higher than 40 and 70% Etc treatments. The better fruit retention under 70% Etc might be due to better carboxylation efficiency, good stomatal conductance and minimum stomatal resistance as compared to 40 and 70% Etc treatments.

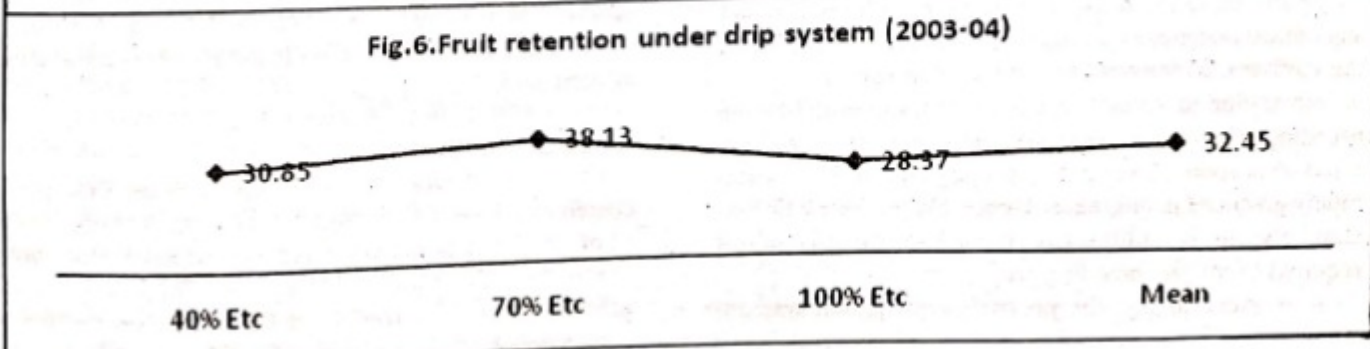
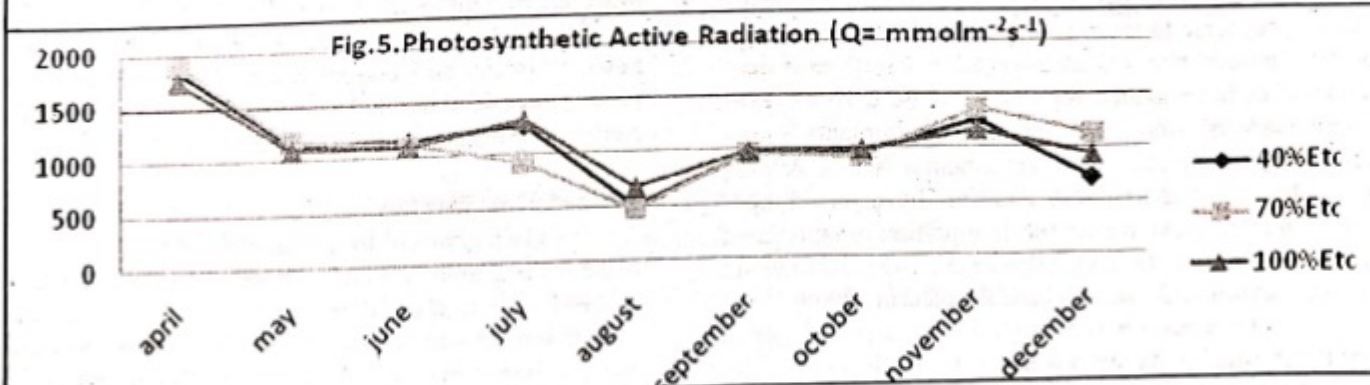
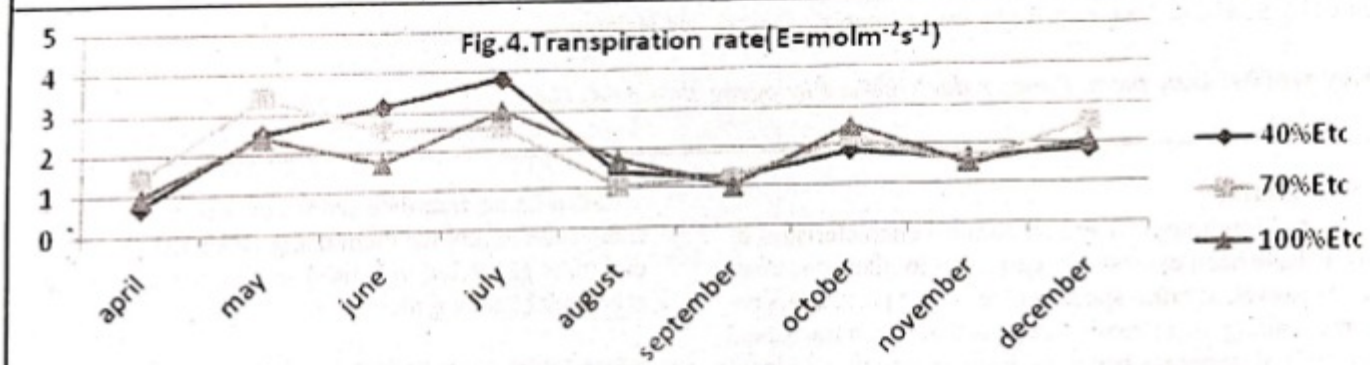
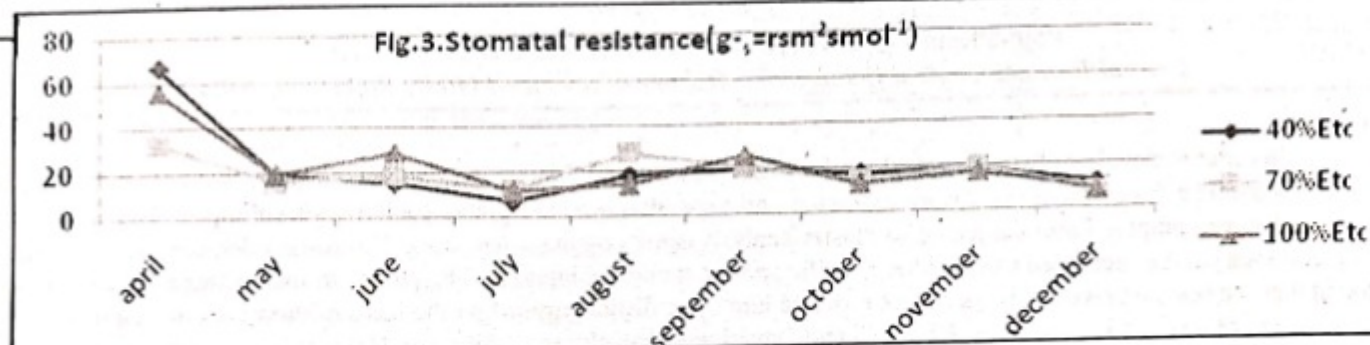
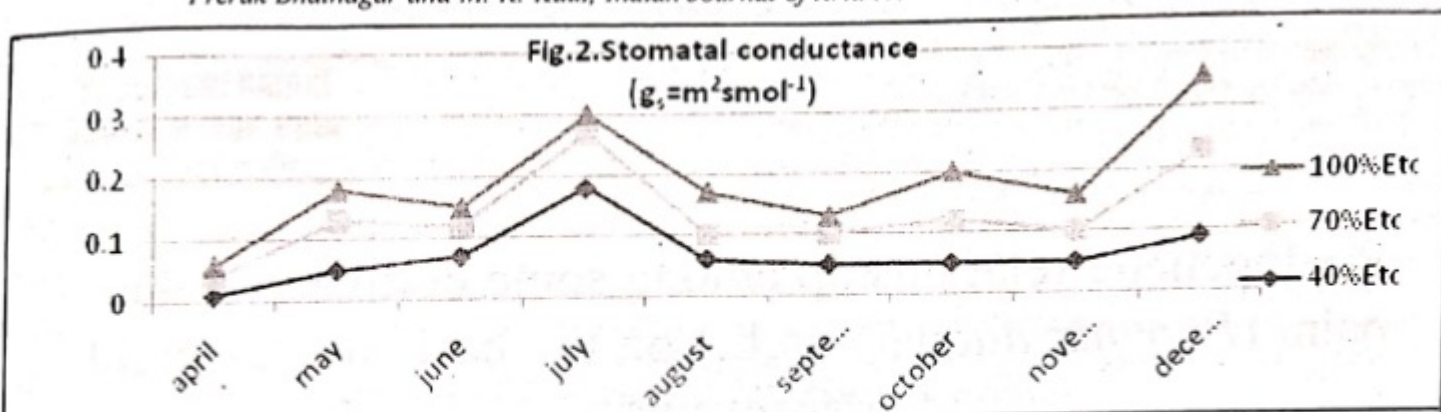
Table-10. Fruit retention per tree under different levels of drip irrigation system

S.No.	Irrigation level	Drip System(2003-04)
1.	40% Etc	30.85
2.	70% Etc	38.13
3.	100% Etc	28.37
	Mean	32.45

References

- Flore, J.A. and Lakso, A.N. 1989. Environmental and physiological regulation of photosynthesis in fruit crops; *Hortic Rev.* 11:111-157.
- Maroco J.P, Pereira J.S and Manuela Chaves M. 1997. Stomatal response to leaf to air vapour pressure deficit in Sahelian species; *Aust J Plant Physiol.* 27:381-387.
- Kriedemann, P.E. and Barrs, H.D. 1981. Citrus orchards. In water Deficits and Plant Growth. Vol.6, ed. T.T. Kozlowski, pp: 325-417.
- Sinclair, T.R. and Allen, L.H. Jr. 1982. Carbon dioxide and water vapour exchange of leaves on field grown citrus trees. *Journal of Experimental Botany.* 33:1166-1175.
- Vu, J.C.V. and Yelenosky, G. (1988). Solar irradiance and drought stress effects on the activity and concentration of ribulose biphosphatase carboxylase in 'Valencia' orange subjected to water deficits. *Environ. Expt. Bot.*, 29:149-154.





Phylogenetic relationship among some cultivars of date palm (*Phoenix dactylifera* L.) on the basis of flavonoid spectrum

Rajesh Kumar Gothwal, R. Bhargava, P. K. Yadav and R. S. Singh

Central Institute for Arid Horticulture, Beechwal, Bikaner-334006, Rajasthan, India

Abstract

In order to develop phyto-chemical markers for delimitation of date palm cultivars, a study was undertaken using five cultivars. The foliar flavonoids were extracted and separated on TLC plates coated with cellulose. The spots thus developed were compared and subjected to cluster analysis using computer software. The results demonstrated that date palm cultivars can be identified using either specific spot or spot combinations. The results of the cluster analysis demonstrated that the selected five cultivars can be grouped into three distinct groups on the basis of their genetic distances. The group A was represented by cultivars Khuneizi and Dayari which has closer affinity with Halawy. The Group B1 was represented by Sewi and the group B2 by cvs. Khuneizi, Dayari and Halawy.

Key words: Date palm, *Phoenix dactylifera*, Phylogeny, flavonoid, TLC

Introduction

Morphological and anatomical characteristics of plants have been extensively exploited in plant systematics. However, at infra-specific level, these parameters become limiting. In a situation such as this, when traditional methods of taxonomy become limiting for cultivar identification, recourse to more sophisticated methods such as phyto-chemical markers are adopted. For this, secondary metabolites have gained reputation to be used as taxonomic markers. Since, their constitution in plants is specific and is not affected by environmental factors. Among these flavonoid spectrum of a cultivar have gained reputation to be an ideal marker for delimitation of taxonomic entity at intra specific level (Das et al., 1977; Koul et al., 1984; Garcia and Oieda, 2004 and Rusak et al., 2005).

Date palm is represented by a large number of cultivars which have been identified/ developed for specific purpose. In these species too, the morphological and anatomical parameters are insufficient to clearly distinguish the cultivars. Moreover, majority of cultivars have come up either due to natural selection or through deliberate breeding. The genetic variability once generated has been fixed on account of vegetative propagation which is commonly practiced in this taxon. Hence, the phylogenetic kinship between the cultivars is not certain which is utmost required under pre-breeding programme.

Accordingly, the present investigation was un-

dertaken using five date palm cultivars to develop phyto-chemical markers for them using foliar flavonoid and the data thus generated was used to assess the phylogenetic relationship among them.

Materials and methods

Five genotypes of date palm viz. Halawy, Khalas, Sewi, Khuneizi and Dayari constituted the material for present investigation. The foliar flavonoid spectrum of these cultivars was studied as described below:

Extraction of foliar flavonoids

Two grams of foliar sample was fixed in 10 ml of methanol containing 1% HCl. The fixed samples were stored at room temperature and before analysis they were macerated in mortar and pestle. The whole content was centrifuged at 10000 rpm for 20 minutes at room temperature. The supernatant was taken and evaporated to dryness in an oven maintained at 60°C. Finally the sample was taken in 1 ml methanol.

Analysis of flavonoids

The flavonoids were separated on TLC plates coated with 0.6mm thick layer of cellulose. An aliquot of 10 µl of sample as prepared above was loaded on one corner of the plate. The plate was first developed with 2% formic acid and later, after rotating at 90°, in solvent containing amyl alcohol: acetic acid and water in the ratio of 10:6:5, the

plates after air drying were viewed for flavonoid spots as under:

1. without any spray
2. after spraying with 1% methanolic $AlCl_3$ under UV
3. after spraying with 1% methanolic NaOH under UV

The spots were marked and pooled chromatogram of each cultivar was prepared. They were then numbered and master chromatogram was prepared for comparison of cultivars. The phylogenetic relationship was ascertained by using computer software.

Results and discussion

Foliar flavonoid patterns have been worked out for five date palm (*Phoenix dactylifera* L.) cultivars. A total of 47 flavonoid spots were observed in these cultivars. The spots have been characterized on the basis of their respective fluorescence properties and position on the composite chromatograms. Fluorescence was checked under UV-light before and after spraying enhancing chemicals.

Perusal of table I revealed that spot number 10, 14 and 25 represent commonly occurring flavonoids, as these spots were common in all the cultivars. The other spots were presented in either one or more cultivars. This is illustrated by the fact that spot number 1, 2, 3, 6, 7, 11, 13, 17, 19, 21, 26, 31, 33, 34, 35, 36, 37, 38, 40, 42 and 43 were present in 20 per cent cultivars, spot numbers 4, 5, 9, 12, 18, 22, 23, 26, 27, 29, 30, 32, 39 and 47 were present in 40 per cent cultivars and spot number 15, 16, 20, 24 and 46 were present in 60 per cent cultivars.

The cultivars can be identified using either typical spots or spot combinations as presented in table 1. Cultivar Halawy can be identified based on typical spot or spot combinations 5, 9, 21, 22, 27, 39 and 47; cultivar Khalas by 1, 2, 3, 4, 5, 11, 13, 17, 18, 19, 28, 29, 33, 43 and 47; cultivar Sewi by 6, 9, 12, 26, 35, 37, 38, 39, 40 and 42; cultivar Khuneizi by 4, 7, 12, 23, 26, 27, 30, 31 and 32 and cultivar Dayari by 18, 23, 29, 30, 32 and 34.

Based on the presence or absence of spots, the cultivars were assessed for their phylogenetic distance. Perusal of data indicates that cultivar Khuneizi and Dayari are most closely related as demonstrated by a similarity index of 42%. This is followed by cultivars Sewi with Khuneizi (34%) and Sewi with Dayari (30%). All other cultivars show poor relationship.

The present results are in line with those reported earlier by Rusak et al. (2005) in *Iris*, Garcia and Oieda (2004) in *Morus alba*, Sanches- Yelano (2004) in *Ericastris* and Brassica, Koul et al. (1984) in *Narcissus* and Das et al. (1977) in *Citrus*.

The data generated in the present study was further subjected to cluster analysis using NTSYS Software. The Jaccard's similarity indices among the cultivars are

presented in Table 2 and the dendrogram developed is depicted in Fig. 1. Perusal of Table 2 and Fig. 1 demonstrates that the five genotypes of date palm under investigation could be grouped into three groups based on their phylogenetic relationships. Group "A" consisted of one cultivars viz. Khalas which shows distant relationships with other cultivars. Similarly the group B is sub-divided into B1 and B2. The group B1 is represented by one cultivar viz. Sewi whereas group B2 consists of 3 cultivars. Among these cvs. Khuneizi and Dayari shows the closer affinity as compared to Halawy.

Table 1. Foliar flavonoid profiles of different date palm cultivars

Spot numbers	Halawy	Khalas	Sewi	Khuneizi	Dayari
1		+			
2		+			
3		+			
4		+		+	
5	+	+			
6			+		
7				+	
8		+	+	+	+
9	+		+		
10	+	+	+	+	+
11		+			
12			+	+	
13		+			
14	+	+	+	+	+
15			+	+	+
16		+	+	+	
17		+			
18		+			+
19		+			
20	+	+			+
21	+				
22	+			+	
23				+	+
24	+		+		+
25	+	+	+	+	+
26			+	+	
27	+			+	
28		+			
29		+			+
30				+	+
31				+	
32				+	+
33		+			
34					+
35			+		
36			+		
37			+		
38			+		
39	+		+		
40			+		
41					
42			+		
43		+			
44		+	+	+	+
45	+		+	+	+
46	+	+		+	
47	+	+			

Table 2 Similarity coefficient based on the flavonoid spots

	Halawy	Khalas	Sewi	Khuneizi	Dayari
Halawy	1.00				
Khalas	0.23	1.00			
Sewi	0.26	0.16	1.00		
Khuneizi	0.27	0.24	0.34	1.00	
Dayari	0.26	0.27	0.30	0.42	1.00

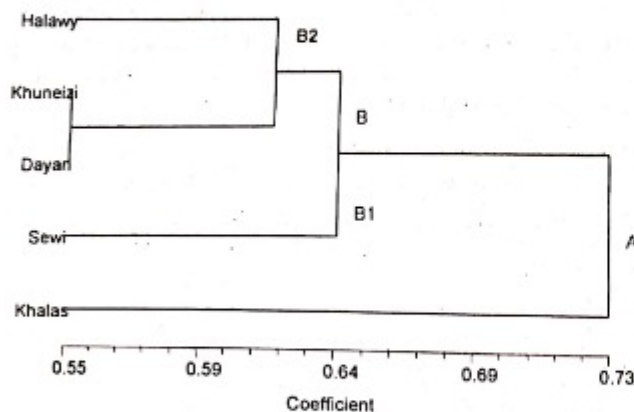


Fig. 1. Dendrogram based on foliar flavonoid spots

Our results further demonstrated that the Jaccard's similarity index between two cultivars is 0.42 showing thereby that the genotypes are phylogenetically similar.

Thus, from the foregoing results it is evident that flavonoid spectrum can be used for cultivar identification as well as for assessing phylogenetic relationship among taxa in date palm.

Reference

- Bhargava, R. (1983). Metabolites as an indicator of polyploidy and hybridity in bulbous angiosperms. Ph. D. Thesis, University of Jammu, Jammu.
- Dass, H. C., Randhawa, G. S. and Prakash, D. (1977). Chemosystematic studies in relation to variability in *Citrus limon*. *Indian Jour. of Experimental Biology*, 15(2): 158-160.
- Frost, S., Holm, G. and Askar, S. (1975). Flavonoids patterns and the phylogeny of barley. *Hereditas* 79: 133-142.
- Garcia, D. E. Ojeda, F. (2004). Evaluation of the main factors that influence the phytochemical composition of *Morus alba* (Linn.). III. Total flavonoids. *Pastos y Forrajes*, 27(3): 267-272.
- Koul, A. K., Sharma, M. C. and Bhargava, R. (1985). Impact of polyploidy on flavonoid constitution in *Narcissus tazetta* L. *Proc. Indian Acad. Sci.*, 95: 1-5.
- Rusak, G., Mitic, B. and Liber, Z. (2005). Leaf flavonoid patterns in the Croatian endemic species *Iris illyrica* Tomm. and *Iris pseudopallida* Trinajstic (Iridaceae). *Periodicum Biologorum*, 107(1): 45-49.
- Sanchez-Yelamo, M. D. (2004). Taxonomic relationships among *Erucastum* and *Brassica* species based on flavonoid compounds. *Cruciferae Newsletter*, 25: 13-14.

Comparative study of quality parameters of date palm fruits under zero energy cool chamber and at ambient storage condition

R.K. Meena, P. K. Yadav and J. Singh,
S.K. Rajasthan Agricultural University, Bikaner - 334 006

Abstract

The present investigation was carried out during summer season of 2004-05. Freshly harvested date palm fruits of doka stage (when fruits turn their colour from green to yellow or red depending upon variety but still remain hard) were placed under zero energy cool chambers as well as at ambient storage conditions. Periodic observations were recorded on TSS, acidity, ascorbic acid and weight loss of date palm fruits. The retention of ascorbic acid (2.36 %) was observed more under zero energy cool chamber. Similarly weight loss (20 %) was less under ZECC than room storage (24 %). Acidity (0.27 %) was also less under ZECC, however TSS was higher under room temperature.

Key words: TSS, acidity, ascorbic acid, weight loss, zero energy cool chamber.

Introduction

Date palm is an important fruit crop of the subtropics grown especially in Rajasthan, Punjab, Haryana and Kutch region of Gujarat. The date palmfruits (*Phoenix spp.*) are used to prepare several value added products such as dry dates, wine, vinegar, arak, jam, chutney, beverages, juice, toffees etc. Its fruits are consumed as hard ripe at doka, soft dates (pind khajoor) and dry dates (Chhuhara). It contains high calorific value (3150 calories/kilogram of fresh fruit) 60 - 65 per cent sugar, fair amount of fibre (2.5%), protein (2.0%), fat (2.0%), minerals upto (2.0%) i.e. iron, potassium, calcium, copper, magnesium, calcium, sulphur, phosphorus etc (Singh, 2007). Research work on improvement of quality of fruit in date palm is less in our country. Fruit being biological entity continues on metabolical activities and undergoes deterioration in qualities. Furthermore, date-palm fruits experiencing ripening during summer are especially very much prone to loss of qualitative parameters owing to prevailing uncongenial atmospheric condition with high and less humidity. In present endeavor, an attempt was made to see the impact of Zero Energy Cool Chamber (ZECC) and ambient storage on qualitative attributes of the date-palm fruits of Medzool variety.

Material and Methods

The present investigation was carried out at the Department of Horticulture, College of Agriculture, RAU, Bikaner during summer season of 2004-05. Freshly harvested datepalm fruits of Medzool variety on doka stage (when fruits turn their colour from green to yellow or red depending upon variety but still remain hard) were placed under zero energy cool chamber as well as at ambient storage conditions in plastic trays. Periodic observations were recorded on TSS, acidity, ascorbic acid and weight loss of date palm fruits. T.S.S. of the fruits was recorded using Hand refracto meter, acidity by titrating fruit juice against N/10 NaOH and ascorbic acid by titrating the juice against 2, 6 Dichlorophenol indophenol dye. The weight loss of the fruits were observed after deducting the retained weight at a particular date of observations from the weight of the fruits kept initially on the first day of observation. As regards to temperature and humidity maintained under zero energy cool chamber (ZECC) and at ambient storage condition, maximum temperature varied from 32.8°C to 38°C and 35.2°C to 40°C respectively. The relative humidity under ZECC varied from 51 - 72 per cent, and at ambient condition, it was 45 - 72 per cent (Table 1).

Table 1. Temperature and humidity conditions at ambient storage and ZECC conditions

Date of observation	Room Temperature			Temperature of ZECC		
	Minimum (°C)	Maximum (°C)	RH (%)	Minimum (°C)	Maximum (°C)	RH (%)
27.07.2005	29.0	40.0	45	27.0	38.0	51
30.07.2005	28.5	39.5	58	26.5	37.0	58
31.07.2005	27.5	36.5	53	25.5	34.5	55
01.08.2005	26.5	38.5	45	24.5	32.8	58
02.08.2005	25.4	35.2	68	24.8	35.2	68
03.08.2005	24.5	36.5	60	25.0	36.0	72
04.08.2005	25.0	36.0	72	26.3	35.2	67

Results and Discussion

Irrespective of storage conditions, TSS increased, acidity and ascorbic acid decreased and weight loss (%) in fruits were recorded (Table 2). However, the fruits stored under ZECC had better retention of TSS, acidity, ascorbic acid and physical weight. Better retention of TSS, acidity and ascorbic acid and weight loss (%) less under zero energy cool chamber owes to the moderating effect of ZECC on temperature and humidity. Under moderate temperature and high humidity conditions reduced rate of degradative process might have been responsible for better retention of qualitative parameters.

TSS increased with the advancement of period irrespective of the storage conditions. However,

comparatively higher TSS was observed under ambient storage condition. This could be attributed to the maximum moisture loss during storage resulting in higher concentration of total soluble solids.

A gradual decline in total acid content of the fruits during storage at room temperature as well as under ZECC was recorded. The reduction in acidity with the advancement of storage period may be due to the fact that organic acid may have been utilized rapidly in respiration during storage. This process ultimately decreased the acidity (Govind and Prasad, 1981). The slower decrease in acidity in ZECC could possibly be due to delay in ripening and slower degradation of organic acid as a result of low temperature and high relative humidity prevalent in ZECC.

Table 2. Physiological changes of date palm fruits under different storage condition.

Date of observation/ storage condition	Changes in physiological parameters			
	TSS (%)	Acidity (%)	Ascorbic acid (mg/100 g)	Weight loss %
A) ZECC Storage				
27.07.2005	41.00	0.34	3.59	0
30.07.2005	43.00	0.29	3.25	4
04.08.2005	46.00	0.27	2.37	5
09.08.2005	50.00	0.27	2.36	20
(B) Room storage				
27.07.2005	41.00	0.34	3.59	0
30.07.2005	44.50	0.34	3.05	6
04.08.2005	50.00	0.32	2.09	10
09.08.2005	52.00	0.31	2.02	24
CD at 5 %	1.54	0.01	0.08	4.5

The finding is in conformity to the observations as recorded by Gupta *et al.*, (1988) in ZECC storage of ber fruits. Regarding ascorbic acid content, it though declined with the advancement of period irrespective of the storage conditions, comparatively lesser retention of ascorbic acid was noted in the fruits stored under ZECC. The ascorbic acid being sensitive to oxidation losses, its content reduced with the exposure of time concurrent to the advancement of storage period. The better retention of ascorbic acid was noted in the fruits stored under ZECC. The prevalence of low temperature and high humidity minimizing oxidation losses may be one of the possible reasons of better retention of ascorbic acid under ZECC. This finding is similar to those as reported by Naik (1985) during storage of mango under ZECC condition. The fruits stored under ZECC experienced less weight loss in percent as compared to those stored under ambient conditions. The low temperature and high humidity prevalent in cool chamber storage might have decreased the rate of respiration and accordingly brought about less weight loss. Singh and Rana (1992) reported similar observations, while working with ZECC storage of sweet orange cultivar Blood Red Malta fruits.

References

- Govind, S. and Prasad, A. 1981, Nitrogen nutrition on the sweet orange. *Prog. Hort.*, 13 (1): 39 - 42.
- Gupta, O.P, Siddique, S. and Chauhan, K.S.: 1988. Evaluation of various calcium compound for increasing the shelf life of ber. *Indian J. Ag. Res.* 21(2): 65 - 70.
- Naik, S .K, 1985. Studies of physico-chemical attributes-in" Alphanso and Ratna mango fruits during growth (development and storage. *M.Sc. (Ag.) Thesis* submitted Konkan Krishi Vidhyapeeth, Dapoli.
- Singh, R.S. 2007. Fruit Production Technology, IBDC, Lucknow.
- Singh, K. and Rana, G.S. 1992. A note on the effect of post harvest treatments on physico-chemical characteristics during storage of sweet orange fruits cv. Blood Red in ZECC. *Harayana J. Hort. Sci.* 21 (3-4): 221 - 223.

SHORT COMMUNICATION

Off season cultivation of summer squash under polythene low tunnels

B.D. Yadav, Yogesh Sharma and M.S. Fageria,

Department of Horticulture, Agricultural Research Station, Durgapura, Jaipur – 302018

Mostly cucurbitaceous vegetables are grown in the main season, which is always less profitable, because of markets are flooded with lot of vegetables at that time. The prices of same vegetables are higher during the off-season. It is difficult to grow cucurbits in winter season because of low temperature and frost injury and thereby adverse effect on growth and fruit setting. Polythene low tunnel technology for production of summer squash, musk melon and water melon is very common in Israel (Singh et al. 2001). This technology is suitable for northern plains where the night temperature during winter season (December-January) goes below 5°C (Singh and Sirohi, 2006). The high temperature inside low tunnels make the crop period short, when it is needed to expedite the crop growth and protect the plants from natural disasters like hails injury, cold winds and advance the crop by 45-60 days then their normal season. This low-cost technology for off-season cultivation of cucurbits is very simple and highly profitable for vegetable growers. For the development and evaluation of the technology a field experiment was conducted at farmer's field in the command area of Chhitoli irrigation project under RWSRP to find out the suitable sowing time of summer squash under polythene low tunnels for off-season cultivation.

The field experiment was carried out at farmer's field of Jai Singh Pura and Bhagatpura Village of Chhitoli project area of Virat Nagar, Jaipur, Rajasthan during 2004-05 & 2006-07. The soil of the experimental plot was loamy sand in texture having P^h 7.7, EC 0.21 d S/m, organic carbon 0.19 percent, available N, P₂O₅ and K₂O was 191.4, 31.2 and 177.0 kg/ha, respectively. The experiment was laid out in randomized block design comprising five treatments of different sowing dates viz. 10th Dec., 20th Dec., 10th Jan. and 20th Jan. with four replications in 3.0 x 2.0 m² plots with a spacing of 1.5 x 0.5 m. After sowing of seeds in prepared beds 6mm galvanized iron arches (hoops) were fixed manually at a distance of 1.5 m to support the polythene of tunnels. The width of hoops was kept 45-60 cm with a height of 45-60 cm above the level of beds for covering polythene and making a low tunnel over the plants. Trans-

parent non-perforated 40 micron UV polythene sheet was used which partly reflected infrared radiation to keep higher temperature of low tunnels than out side. For comparison side by side traditional method was also followed by using saccharum (Sarkanda) on north side of the beds. Summer squash variety Chandrika F₁ hybrid was taken as test crop and sowing was done on different dates. All the improved agricultural practices were followed through out the crop season. In the month of February when atmospheric temperature rose polythene sheets were removed from low tunnels. Growth and yield attributing characters were recorded of five randomly selected plants from each plot. Yield data were recorded for statistical interpretation.

A perusal of three years pooled data (Table – 1, 2) revealed that sowing dates had significant effect on growth, fruit set and yield of summer squash under low tunnels. The maximum vine length (86.75 cm) and fruit set (69.75%) were recorded under 10th December sowing. The minimum fruit drop (30.25%) was observed in 20th December sowing which was statistically at par with 10th December sown crop.

The maximum number of marketable fruits per plant (28.5) and weight per fruit (101.5 g) were also recorded under 10th December sowing which were statistically at par with 20th December sown crop. The incidence of fruit fly (5.8) was found least under 10th December sown crop, while it was highest under last date of sowing i.e. 20th January. Days taken to first harvest reduced with the advancement in sowing dates.

The maximum marketable fruit yield (358.39 q/ha) of summer squash was found when crop was sown on 10th December under polythene low tunnels which was statistically at par with 20th December sown crop. The maximum net return of Rs. 151196.00 and B:C ratio of 1:2.51 was also found with 10th December sown crop under low tunnels. The minimum net return (Rs. 8745.00) and B:C ratio (1:1.07) was observed under farmer's practice. The increase in growth, yield and yield attributing characters might be due to high temperature inside low tunnels make the crop period short, when it is needed to expedite the crop growth by creating an ideal microclimatic condition at the plant

Table 1. Effect of sowing dates on growth, fruit set and yield of summer squash (*Cucurbita pepo* L.)

Sowing dates	Vine length (cm)	Fruit set (%)	Fruit drop (%)	Days to first harvest	No. of marketable fruits/plant	Weight per fruit (g)	Fruit yield (q/ha)	Incidence of fruit fly
10 th Dec.	86.75	69.75	31.50	67.50	28.50	101.5	375.00	5.8
20 th Dec.	80.00	65.25	30.25	68.25	28.50	99.2	366.66	6.0
30 th Dec.	72.25	60.25	36.25	64.25	23.75	88.7	303.33	8.8
10 th Jan.	67.25	54.75	38.75	57.75	19.50	89.0	198.33	13.8
20 th Jan.	63.00	48.25	47.25	57.00	14.75	82.0	161.99	16.3
SEm±	0.55	0.65	0.55	0.97	0.64	0.9	4.54	0.38
CD at 5%	1.71	2.02	1.71	2.99	1.97	2.9	14.01	1.18
CV (%)	1.50	2.20	3.01	3.09	5.57	2.0	3.23	4.23

Table 2. Effect of sowing dates on growth, fruit set and yield of summer squash (*Cucurbita pepo* L.)

Sowing dates	Fruit yield (q/ha)				Gross Income (Rs./ha)	Cost of Production (Rs./ha)	Net return (Rs./ha)	B : C Ratio
	2004-05	2005-06	2006-07	Pooled mean				
10 th Dec.	346.00	354.17	375.00	358.39	250873	99677	151196	1:2.51
20 th Dec.	342.00	350.00	366.66	352.88	247016	99677	147339	1:2.47
30 th Dec.	262.50	287.50	303.33	284.44	199108	99677	99431	1:1.99
10 th Jan.	219.25	212.50	198.33	210.02	147014	99677	47337	1:1.47
20 th Jan.	159.50	154.17	161.66	158.44	110908	99677	11231	1:1.11
SEm±	0.82	9.13	4.54	7.31				
CD at 5%	2.53	28.13	14.01	23.86				
CV (%)	6.62	6.72	3.23	4.64				
Farmer's practice				173.76	121632	112887	8745	1:1.07

Sale price @ Rs. 7/- per kg.

environment. Singh *et al.* (2004) also found an advancement in growing season of summer squash under plastic tunnels. These results are also in conformity with the findings of Singh *et al.* (2005) and Singh (2007).

References

- Singh, Balraj, 2007. Cultivation of summer squash : a success story. *Indian Horticulture*. 52 (4) :28.
- Singh, Balraj; Kumar, Mahesh and Sirohi, N.P.S. 2004. Cultivating off-season summer squash. *Indian Horticulture*. 49 (1) :9-11.
- Singh, Balraj; Sirohi, N. P. S. and Singh, Ajit. 2005. Plastic low tunnel technology for off-season cultivation

of cucurbitaceous vegetables. Natl. Semi. On Cucurbits, 22-23 Sept., 2005, at GBPUAT, Pant Nagar Page No. 57.

Singh, Balraj; Sirohi, N. P. S.; Neubauer, Eitan and Chjin, Abner, 2001. Off-season production of muskmelon under plastic low tunnels. *Indian Horticulture*. 46 (3) : 15-17.

Singh, Balraj and Sirohi, N. P. S. 2006. Protected cultivation of vegetables in India: Problem and future prospects. *ISHS Acta Horticulture* 710 : International symp. on Greenhouse, Environmental controls and In-house mechanization for crop production in the tropics and sub. tropics.

SHORT COMMUNICATION

Nitrogen management in guava (*Psidium guajava* L) cv. Lucknow-49 through fertigation under north Gujarat conditions

N.M.Patel*, D.K.Patel, L.R.Verma and M.M.Patel

Department of Horticulture, C.P.College of Agriculture, S.D.A.U., S. K. Nagar- 385 506, Gujarat

Guava (*Psidium guajava* L.) is an important one of the fruit crop of North Gujarat. Though it is grown in arid and semi-arid conditions, it responds well to nitrogen and farmers apply nitrogen in two splits in the month of June and September. Recently, drip irrigation system gets the prime position for efficient use of water and fertilizer. However, regular irrigation is essential during the reproductive phase (i.e. flowering to ripening of fruits) as irregular moisture conditions causes dropping of flowers and small fruits (Patil *et al.*, 2002). Among different management practices, fertigation plays an important role for enhancing yield and quality of product with saving of water and efficient use of fertilizer. Water is a limiting factor in the arid regions. The fertilizers are becoming costlier day by day. There fore, even under these constraints, it is essential to utilize both these inputs on the scientific basis to get a remunerative crop. Drip system increases the growth and nutritional status of pomegranate under the salt affected soils. (Dwivedi *et al.*, 1996) by leaching out excess salt and maintaining proper concentration through continuous dropping of water. This system also checks seepage and evaporation losses. (Varsney *et al.* 1993). However, there is no information available on the effect of fertigation on this fruit crop under North Gujarat conditions. There fore the present study was undertaken to generate information on the above aspects.

A field trial on guava cv. L-49 was conducted at Fruit Research Station, Dehgam, Di: Gandhinagar during 2001-05. The twelve years old plants grown at 6.0 m x 6.0 m spacing were used for the experiment. Total nine treatments were laid out with four replications in Randomized Block Design. In this study two levels of irrigation i.e. 15 days interval (F_1) and 30 days interval (F_2) during May to June and September to October through drip (0.5 PEF) were applied and four levels of nitrogen viz., 100 % (L_1), 80 % (L_2),

60 % (L_3) and 40 % (L_4) of recommended doze of nitrogen (500 gm / tree) were also applied and studied their interaction effect also. Existing practice i.e. 100 % recommended doze of nitrogen be also tested.

The total number of fruits was found non significant under both levels of irrigation through drip (0.5 PEF) application in all the years of study except 2003-2004. Application of 60 % and 80 % of recommended dose of nitrogen were found significant response during all the years and pooled data except in the year 2005-06.

Interaction effect of $F \times L$ was also found significant during all the years of study. The treatment F_1L_1 produced significantly the highest number of fruits of 687, 532, 525, 640 and 596 during 2001-02, 2003-04, 2004-05, 2005-06 and in pooled results, respectively. However it was at par with F_1L_2 during 2001-2002, 2003-04 and in pooled results. In the year 2005-06 it was at par with all the treatments except F_1L_1 and F_2L_3 during 2004-05, it was at par with F_2L_2 , F_1L_2 and F_2L_4 .

The four years results revealed that fruit yield of guava was affected significantly during 2001-02, 2003-04 and in pooled results in respect of frequency of irrigation. F_1 i.e. 15 days interval of water application gave significantly the highest fruit yield 18.21 t/ha, 18.87 t/ha and 18.45 t/ha during 2001-02, 2003-04 and pooled, respectively. Ram and Rajput (1998) also reported effect of slow release nitrogen fertilizer on higher yield and better quality of guava.

Whereas, application of 60% recommended dose of nitrogen gave significantly the highest fruit yield of guava during 2001-02, 2003-04, 2005-06 and pooled results also. (18.98 t/ha, 19.49 t/ha, 23.68 t/ha and 19.26 t/ha, respectively). In the year 2001-02, 2003-04, 2005-06 and pooled, application of 80 % recommended dose of nitrogen was at par with L_3 (i.e. 60 % recommended dose of nitrogen)

Interaction effect of $F \times L$ was found significant during 2004-05, 2005-06 and in pooled results. Treatment F_1L_1 (i.e. application of irrigation at 15 days interval with 60 % recommended dose of nitrogen) recorded significantly

* Corresponding author's e-mail
patel.narottambhai@yahoo.com

Table 1. Effect of different treatments on number of fruits/tree of guava (2001-02 to 2005-06)

Treatments	Total number of fruits / tree				
	2001-02	2003-04	2004-05	2005-06	pooled
F ₁ L ₁	563	434	298	459	438
F ₁ L ₂	676	504	509	619	577
F ₁ L ₃	687	532	525	640	596
F ₁ L ₄	545	420	374	557	474
F ₂ L ₁	586	385	400	567	485
F ₂ L ₂	611	455	475	587	532
F ₂ L ₃	587	440	382	536	486
F ₂ L ₄	641	434	471	581	532
Control	597	413	464	428	475
C.D. at 5 %	40.83	42.94	71.02	100.05	32.68
C.V.%	4.54	6.48	11.25	12.03	9.02

Table 2. Effect of different treatments on fruit yield (t/ha) of guava (2001-02 to 2005-06)

Treatments	Fruit yield (t/ha)				
	2001-02	2003-04	2004-05	2005-06	pooled
F ₁ L ₁	17.15	17.43	11.72	18.99	16.32
F ₁ L ₂	18.94	20.03	15.67	22.83	19.37
F ₁ L ₃	20.19	21.24	17.65	26.99	21.52
F ₁ L ₄	16.56	16.79	12.47	20.53	16.59
F ₂ L ₁	16.58	14.47	12.55	20.67	16.06
F ₂ L ₂	17.49	18.09	15.60	22.18	18.34
F ₂ L ₃	17.77	17.75	12.18	20.37	17.02
F ₂ L ₄	17.01	17.38	15.30	21.42	17.78
Control	16.72	16.46	15.24	16.98	16.35
C.D. at 5 %	NS	NS	1.36	3.54	1.29
C.V.%	6.14	13.21	6.52	11.06	10.24

Table 3. Economics of Guava cultivation

Treatments	Yield kg/ha	Gross income Rs./ha	Cost of cultivation Rs/ha	Net income Rs./ha	CBR
F ₁ L ₁	16320	65280	22690	42590	2.88
F ₁ L ₂	19370	77480	22557	54923	3.43
F ₁ L ₃	21520	86080	22424	63656	3.84
F ₁ L ₄	16590	66360	22291	44069	2.98
F ₂ L ₁	16060	64240	22640	41600	2.84
F ₂ L ₂	18340	73360	22507	50853	3.26
F ₂ L ₃	17020	68080	22374	45706	3.04
F ₂ L ₄	17780	71120	22241	48879	3.20
Control	16350	65400	22590	42810	2.90

* Selling price of guava = Rs. 4/- per kg

the highest fruit yield of 17.65 t/ha, 26.99 t/ha and 21.52 t/ha during 2004-05, 2005-06 and in pooled results, respectively.

Economics of different treatments revealed that the highest gross realization per hectare of Rs. 86,080 was obtained under treatment F₁L₃ (60 % RDN at 15 days intervals). It was followed by F₁L₂ (80 % RDN at 15 days inter-

vals) (Rs.77,480/ha), giving the highest net realization of Rs.63,656/ha. The second highest with respect to net realization (Rs. 54,923 / ha) was recorded by F₁L₂ (80 % RDN at 15 days intervals). Same treatment F₁L₃ recorded highest cost benefit ratio (3.84).

Various fertigation treatments were applied to study their effect on the growth, yield and economic parameters of guava. The four years pooled data revealed that number of fruits and fruit yield of guava were significantly highest with treatments F₁L₃ (60 % recommended dose of nitrogen at 15 days intervals). However, F₁L₂ (80 % recommended dose of nitrogen at 15 days intervals) was at par with that of F₁L₃. Fertigation with only 60 % recommended dose of nitrogen at 15 days intervals was also found to be most economical and profitable fetching the highest net profit and the highest cost benefit ratio. So that, it can be concluded that farmers of North Gujarat should apply 60 per cent of the recommended dose of nitrogen at an interval of 15 days in the month of May-June and September- October. It gives 32 per cent higher fruit yield and higher net return per hectare alongwith 40 per cent saving of nitrogen.

References

- Dwivedi, S.K., Pathak, R.K., Ali, W. and Kumar, S. 1996. Drip irrigation studies on pomegranate (*Punica granatum* L.) in salt affected soil. *Recent Hort.* 3:36-44
- Patil, A. V., Karale, A. R. and Bose, T. K. 2002 Pomegranate. In: Fruits: Tropical and sub tropical (Eds. Bose, T.K. and Som, M.G.). Naya Prokash, Kolkata, India. pp.225-62
- Ram, R. A. and Rajput, M. S. 1998. Effect of slow release nitrogen fertilizer on yield and fruit quality of guava (*Psidium guajava* L.) cv Sardar. National Seminar on New Horizons in Production and Post Harvest Management of Tropical and Subtropical Fruits., Decembr 8-9, 1998, pp.29
- Varshney, K.G., Arvind, S., Reddy, K. S. and Manohar, K. R. 1993. Evaluation of drip irrigation system in pomegranate. Proc. All India Seminar on sprinkler and drip system held at Institution of Engineers (India), Hyderabad, pp 113-15.

SHORT COMMUNICATION

Development of contamination free culture in bael (*Aegle marmelos* Correa)

Rakesh Bhargava, T. A. More, R. S. Singh, B. D. Sharma, Raj Kumar and Sarita Chauhan
Central Institute for Arid Horticulture, Bikaner 334 006

Bael (*Aegle marmelos* Correa) is one of the important minor fruit crop with high nutritive and medicinal value. It is mainly propagated either by seed or "T" budding or soft wood grafting. True to type plants can be produced in latter two methods but the growth is very slow. Tissue culture technique offers an advantage over conventional methods of propagations in producing large number of true to type plants from healthy elite plant within a short period of time. The surface sterilization is the most important step in micro-propagation and become a critical step in establishment of certain species particularly when the explants are derived from field grown plants. In this perspective studies were undertaken to standardize the protocol for surface sterilization of nodal segment of field grown plant of bael.

The experiment was conducted at Central Institute for Arid Horticulture, Bikaner with a view to assess the efficacy of different surface sterilizing agents. Young, fresh growing branch from mature plant of bael (5-7 years) were harvested and cut in to segments, each segment having at least one bud. These nodal segments were washed under running tap water for two hours. These explants were given quick dip treatment once in Methanol followed by surface sterilization with mercuric chloride (0.1 per cent) for 5, 7, 9 and 11 minute or sodium hypochlorite (0.75 per cent) solution for 6, 8, 10 and 12 minute. Subsequently, the explants were washed thoroughly with autoclaved double distilled water for 3-4 times. These surface sterilized segments were inoculated in 250 ml conical flask containing 30-40 ml of MS medium, Murashige and Skoog (1962), supplemented with 3.0 per cent sucrose and 0.8 per cent agar. All the surface sterilized explants were inoculated under aseptic condition using laminar air flow cabinet. The treatments were replicated ten times and maintained at $27^{\circ}\text{C} \pm 2.0^{\circ}\text{C}$ and 13 hrs photoperiod.

The response of explants to various sterilizing agents in culture medium is presented in Table-1. The efficacy of sterilizing agent mercuric chloride (HgCl_2) and sodium hypochlorite (NaOCl) with different exposure time

was assessed in terms of maximum aseptic explants produced, which responded to sprouting. In case of Mercuric chloride @ 0.1 per cent, the maximum 80 per cent contamination free explants were recorded when exposed to 7 minute. In case of different time exposure of NaOCl (0.75 per cent) the maximum 60 per cent contamination free culture was recorded at 5 and 7 minute. Thus, the present investigation revealed that application of HgCl_2 is better agent for surface sterilization. Syamal *et al.* (2007) had reported that in Kagzi lime the maximum (72.43 per cent) survival of explants was recorded when the explants were treated with mercuric chloride. Similar results have also been reported by Kour *et al.* (2007) in rough lemon and Karwa (2003) in *Citrus reticulata*.

In the present study, the data on number of shoot and length of shoot were also recorded on 30th day after inoculation. The results revealed that among mercuric chloride treatments, the maximum number of shoot (2.80), length of shoot (3.42 cm) was recorded at 5 minute after treatment. Although further increasing the time of exposure reduces number and length of shoot. However, the length of shoot and number of shoots produced at 5 and 7 minute exposures were statistically non significant.

At the end of 30 day maximum number of shoot (2.90) and length of shoot (3.71 cm) were recorded at 6 minute treatment of sodium hypochlorite (0.75 per cent) which declined on increasing the duration of exposure.

The data on time required for bud break reveals that when the explants were treated with HgCl_2 , the minimum time required for bud break (6.20 days) was with 5 minute exposure which increased with increase in duration of exposure but was statistically non-significant. Similarly, in case of explants treated with sodium hypochlorite, the minimum time required for bud break was 6.50 days which increased with increase in duration of exposure.

Thus, based on all the four parameters studied, it was concluded that surface sterilization with Mercuric chloride was better with respect to production of aseptic culture and reducing time to bud break. The further increase in duration of exposure to either of sterilizing agents decreased the number and length of shoot, which may be because of toxic effect of these chemicals.

* Corresponding author's e-mail:
rbciiah@yahoo.com

Table 1. Effect of surface sterilization agents on establishment of axenic culture in Bael

Mercuric chloride (0.1 per cent)					Sodium hypo chlorite (0.75 per cent)				
Time Exposer (min)	Per cent survival explants	Time equied to bud break (days)	No. of shoot	Length of Shoot (cm)	Time Exposer	Per cent survival explants	Time required to bud break (days)	No. of shoot	Length of shoot (cm)
5	70	6.20	2.80	3.42	6	60	6.50	2.90	3.71
7	80	6.40	2.50	2.92	8	60	7	2.60	2.83
9	70	6.50	2.20	1.77	10	50	7.60	2.20	2.13
11	50	7.0	1.50	1.52	12	40	8.60	1.70	1.89
SEm +	0.37	0.30	0.18	0.12		0.27	0.57	0.16	0.06
CD (5%)	1.07	0.89	0.52	0.36		0.76	1.65	0.45	0.18

Acknowledgements

The authors are grateful to National Medicinal Plants Board, New Delhi for financial assistance to undertake present work.

References

- Kour, K., Bakshi, P. and Kher, R. (2007). Studies on micro propagation of rough lemon. *Indian J Hort.* 64(4): 454-455.
- Karwa, A. (2003). In vitro propagation of *Citrus reticulata* Blanco. *Ind. J. Genet.* 63 (2):187-188.
- Murashige, T. L. and Soog, F. (1962) A revised medium for rapid growth and bioassay with tobacco tissue cultures. *Physiol Plant.*, 15:473-97.
- Syamal, M. M., Upadhyay, S., and Biswas, B. (2007). In vitro clonal propagation of Kagzi lime. *Indian J Hort.* 64 (1): 84-86.

SHORT COMMUNICATION

Chlorophyll content in leaves of coriander as influenced by sowing dates, nitrogen and plant growth regulators

S.S. Meena*, R.S. Mehta and O.P. Awasthi**

National Research Centre on Seed Spices, Ajmer-305206 (Rajasthan)

Coriander (*Coriandrum sativum* L.) is one of the important leafy-green vegetable as well as seed spices crop grown in almost all states of India. Rajasthan occupies the first position both in production and acreage of coriander. The production of coriander in Rajasthan is 2.86 lakh tonnes from 2.41 lakh hectare land with the productivity of 1190 kg per hectare (Anonymous, 2004). At present, India is exporting only 5 per cent of the total produce. This is due to inability to withstand international quality standards of the produce. Therefore, there is an urgent need to increase the productivity and to upgrade quality so that it can withstand competition in the international market (Singhal, 1999). The important limiting factors are poor package of practices, untimely sowing, lack of adoption on judicious nutrients and also lack of knowledge on the use of plant growth regulators.

It is, therefore, necessary to identify optimum time of sowing, nitrogen doses, which will ensure a balance between vegetative growth and reproductive phase of coriander so that chlorophyll content in leaves can be enhanced. The use of Naphthalene acetic acid (NAA) and Gibberellic acid (GA_3) have been found to increase the economic yield of several crops, but very little work has been reported for coriander. Keeping in view the present investigation was carried out to study the effect of sowing dates, nitrogen and plant growth regulators on chlorophyll content in leaves of coriander.

The experiment was conducted at Instructional-Cum-Research Farm, Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur, situated at $24^{\circ}.35'$ N latitude and $74^{\circ}.42'$ E longitude at an elevation of 579.5 meter above mean sea level. The climate of this zone is typically semi-arid and subtropical. The average rainfall of this tract ranges from 650–750 mm of which 90 per cent is received during the period of July to September. The soil of experimental site was clay loam in texture, slightly alkaline in reaction and medium in nitrogen and phosphorus and potassium status. The experiment was laid out in Split Plot design with four replications. Three sowing dates (15th Oct, 31st Oct. and 15th Nov.) and two levels of nitrogen (N @ 60 kg ha⁻¹ and N @ 75 kg ha⁻¹) in main plots and five

levels of plant growth regulators (NAA 25 ppm at 30, 75 DAS, GA_3 at 30, 75 DAS and control) treatments were allocated in sub-plots. Before sowing the seeds were split into two halves and seed treatment was given with 2 gm Bavistin per kg of coriander seeds. As per treatment the sowing was done manually on 15th Oct., 30th Oct and 15th Nov. during the year 2003-04 and 2004-05. After sowing, the seeds were covered with soil by partially dismantling the lines. A uniform doses of 45 kg P₂O₅ ha⁻¹ through single super phosphate and 1/3rd nitrogen as per treatment was drilled basally 10 cm deep at the time of sowing. Remaining dose of nitrogen through urea was applied in two equal splits before irrigation at 30 and 75 days after sowing (DAS) during both the years. The plant growth regulator solutions were prepared by dissolving in small quantity of dilute alcohol, then the desired stock solution were prepared by adding 1000 ml distilled water. Few drops of teepole were added to each solution before spray and untreated plots were sprayed with water twice.

The leaf samples from different treatment combinations were collected and analysed for chlorophyll a, b and total chlorophyll content in leaves at 45 and 90 days after sowing. Data analysed statistically as suggested by Panse and Shukhatmae (1995)

Effect of Sowing Dates

A perusal of data in Table 1 reveals that chlorophyll content in leaves of coriander were influenced by date of sowing in both the years. The results exhibited that the maximum chlorophyll a, b and total chlorophyll content in leaves at 45 and 90 days after sowing (10.87, 2.26, 13.13, 11.19, 2.44 and 13.63 mg/g) respectively, were recorded when coriander crop was sown on 15th October. The chlorophyll a, b and total chlorophyll content was reduced in the later date of sowing. This might be due to the fact that reduction in chlorophyll content under delayed sown could be attributed to the reduction in span of reproductive growth phase. The present study is in closing conformity with the findings of Bhati (1991), Jat (1995) and Naghera *et al* (2000).

Effect of nitrogen

The results indicated that increasing leaves of nitrogen fertilization did not show any significant effect on chlorophyll content in leaves.

* Corresponding author's e-mail:

ssmnrcss5@yahoo.com

** Central Institute for Arid Horticulture, Bikaner

Table 1. Effect of sowing dates, nitrogen levels and plant growth regulators on chlorophyll content in leaves of coriander (Pooled data of two years)

Treatments	Chlorophyll 'a' (mg g ⁻¹)		Chlorophyll 'b' (mg g ⁻¹)		Total chlorophyll (mg g ⁻¹)	
	45 DAS	90 DAS	45 DAS	90 DAS	45 DAS	90 DAS
A. Date of sowing						
15 th October	10.87	11.19	2.26	2.44	13.13	13.63
30 th October	10.78	11.06	2.24	2.41	13.02	13.47
15 th November	9.57	9.85	2.00	2.18	11.57	12.03
SEm ±	0.07	0.07	0.02	0.02	0.08	0.08
CD at 5 %	0.20	0.21	0.05	0.05	0.23	0.24
B. Nitrogen levels						
N @ 60 kg/ha	10.36	10.63	2.15	2.32	12.51	12.95
N @ 75 kg/ha	10.45	10.77	2.18	2.36	12.64	13.13
SEm ±	0.05	0.06	0.01	0.01	0.06	0.07
CD at 5 %	NS	NS	NS	NS	NS	NS
C. Plant growth regulators						
Control (Waterspray)	9.47	9.76	1.95	2.13	11.41	11.89
NAA 25 ppm at 30 days after sowing	11.71	12.01	2.41	2.59	14.12	14.58
NAA 25 ppm at 75 days after sowing	9.70	10.03	2.06	2.24	11.76	12.24
GA ₃ 50 ppm at 30 days after sowing	11.54	11.82	2.39	2.56	13.93	14.40
GA ₃ 50 ppm at 75 days after sowing	9.62	9.88	2.03	2.20	11.65	12.11
SEm ±	0.08	0.09	0.02	0.02	0.09	0.10
CD at 5 %	0.23	0.24	0.06	0.06	0.27	0.27

Effect of plant growth regulators

Chlorophyll a,b and total chlorophyll content in leaves of coriander were also found to be influenced significantly as a result of plant growth regulators application (Table 1). The maximum chlorophyll a,b and total chlorophyll content in leaves at 45 and 90 days after sowing (11.71, 2.41, 14.12, 12.01, 2.59 and 14.58 mg/g) respectively with 25 ppm NAA at 30 DAS treatments over control. However, it was found at par with application of 50 ppm GA₃ at 30 DAS. The increase in the peroxidase and catalase activity as a result of application of plant growth regulators might have led to the increased chlorophyll content and its metabolism (Vijayalakshmi and Srinivasan, 1999). The present result on chlorophyll content in leaves are in close agreement with those of Dharmender *et al* (1996) in cabbage, Sumeriya *et al* (2000) in mustard and Medhi (2000) in french bean, who, reported the higher chlorophyll content a result of auxin application which strongly support the present findings.

References

- Anonymous. 2004. Vital Agricultural Statistics, Directorate of Agriculture, Krishi Bhawan, Jaipur, Rajasthan, pp.13.
- Singhal, V. 1999. *Indian Agriculture-1999*, Pub. Indian Economic Data Research Centre, New Delhi. pp. 429-431.
- Panse, V.G. and Sukhatme, P.V. 1995. Statistical Methods for Agricultural Workers. ICAR, New Delhi
- Bhati, D.S. 1991. Effect of sowing date, row spacing and nitrogen on growth, yield and quality of coriander (*Coriandrum sativum* L.). Ph.D. Thesis, Deptt. of Agronomy S.K.N. College of Ag. Jobner.
- Jat, Devlal. 1995. Effect of row spacing and time of sowing on coriander under semi arid conditions. M.Sc. Thesis, Deptt. of Agronomy S.K.N. College of Ag. Jobner (RAU, Bikaner).
- Naghera, R.P., Sukhadia, H. M. and Ramani, B.B. 2000. Effect of sowing dates and varying levels on nitrogen and phosphorus on coriander (*Coriandrum sativum* L.). *Gujarat Agricultural University Research Journal*. 26(1): 52-54.
- Vijayalakshmi, D. and Srinivasan, P.S. 1999. Enzyme activities as influenced by chemicals and growth regulators in mango cv. alphonso. *Madras Agricultural Journal*. 86: 578-580.
- Dharmender Kumar, Gujar, K.D. and Kuldeep Singh. 1996. Effect of GA and NAA on growth, chlorophyll content and maturity of cabbage. *Crop Research*. 12(1): 116-119.
- Sumeriya, H.K., Meena, N.L. and Mali, A.L. 2000. Influence of phosphorus, and growth regulators on granule, growth parameters, quality and economics of mustard [*Brassica juncea* (L.) Czern and Coss]. *Annals of Biology*. 16(1): 51-53.
- Medhi, A.K. 2000. Growth and yield components of french bean plants to foliar application of some plant growth hormones. *Orissa Journal of Horticulture*. 28(2): 29-32.

SHORT COMMUNICATION

Integrated nutrient management in lemon (*Citrus limon* Burm) cv. pant lemon-1

N.K. Mishra*, K.K. Misra and D.S. Rath

Department of Horticulture, GBPUAT, Pantnager-263145 Uttarakhand.

Citrus occupies an important position in fruit industry on account of its great utility. In Tarai, lemon has been found to be the most successful fruit due to its adaptability and availability of fruits throughout the year, among several cultivars grown, Pant Lemaon-1 is the most promising in Tarai condition of Uttarakhand. It is a singal plant selection from "Kagzi kalan Lemon" (Baldevraj, 1990). It bears flowers and fruits in two main flushes and exhausts more nutrients to maintain vegetative growth which can support flowering and fruiting. To meet the requirement of nutrients recommended for different fruit crops, it could be either is supplied through inorganic source, but each one has its limitations. For meeting nutrient requirement, a recent emphasis has been given on the integrated nutrient management (INM). Integrated nutrient management is the combined use of organic and inorganic fertilizers and relies on use of FYM, crop residuse, legumes, biofertilizers, biopestisides. Looking into the importance of nutrient management, the present expriment "Integrated nutrient management in lemon cv. Pant Lemon-1" was planned to study the effect of Integrated nutrient management on yield and quality of lemon.

The study was conducted during 2006-2007 at Horticultural Research Centre, Patharchatta of G.B.P.U.A.&T., Pantnager, U.S. Nager (Uttarakhand) on eight year old uniform plants of lemon (*Citrus limon* Burm) cv. Pant Lemon-1. The planting distance was 5m x5m. All the trees were maintained under uniform cultural treatments during the course of investigation. The experiment was laid out in randomized block design (R.B.D) with fifteen treatment and three replications. The different treatment were as $T_1 = 400g(N) + 250g(P) + 400g(K)$ $T_2 = T_1 + 0.25\%$ $ZnSO_4$ spray, $T_3 = T_1 + 0.5\%$ $ZnSO_4$ spray, $T_4 = T_1 + 1.0\%$ $ZnSO_4$ spray, $T_5 = T_1 + 0.1\%$ $CUSO_4$ spray, $T_6 = T_1 + 0.2\%$ $CUSO_4$ spray, $T_7 = 1/2$ dose $T_1 + 20$ kg FYM, $T_8 = 1/2$ dose $T_1 + 20$ kg vermicompost, $T_9 = 1/2$ dose $T_1 + 20$ kg FYM, $T_{10} = 1/2$ dose $T_1 + 20$ kg FYM + 100 g Trichoderma, $T_{11} = 1/2$ dose $T_1 + 20$ kg FYM + 140 g Trichoderma, $T_{12} = 1/2$ dose $T_1 + 20$ kg vermicompost + 60 g *Pseudomonas*, $T_{13} = 1/2$ dose $T_1 + 20$ kg vermicompost +

100 g *Pseudomonas*, $T_{14} = 1/2$ dose $T_1 + 20$ kg vermicompost + 140 g *Pseudomonas*, $T_{15} =$ Control.

Trichoderma (60, 100 and 140g) was mixed with well rotten FYM (20 kg) two weeks before application in field and *Pseudomonas* (60, 100 and 140g) was mixed in vermicompost (20 kg) five days prior to field application. The treatments were given in the month of April. FYM, Trichoderma, vermicompost and *Pseudomonas*, they were mixed thoroughly and before application a ring was made around the plant (60 ctn. away from the stem). Respective doses of fertilizers were mixed thoroughly into 20 cm top soil. The data on yield, physical parameters and chemical parameters were recorded. The experiment was laid out in Randomized Block Design (RBD) as described by Snedecar and Cochran (1987) and each treatment replicated thrice.

It appear from the data in Table 1 that trees treated with 200 g N + 125 g P + 200 g K + FYM 20 kg (T_7) dose of nutrients significantly improved fruit yield (kg/tree). These results are in accordance with that of Beridze (1990) who found that the highest yield of 6.6 t/ha was obtained from lemon trees receiving 150 kg N + 120 kg P + 80 kg K/ha basal dressing + FYM at 25 t/ha. Increase in yield due to FYM application may be attributed to better uptake of nutrients in addition to better water uptake. Similar results were also reported by Salik *et al.* (2000) who noted highest yields from trees receiving NPK + FYM in case of mandarin trees. The data regarding average fruit weight are presented in Table 1. Fruit weight was significantly influenced by treatments. Among different treatment combinations T_9 ($1/2$ dose $T_1 + 20$ kg FYM + 60g Trichoderma) gave maximum average fruit weight. Our results are in conformity with the study of Patil *et al.* (2004) who reported highest average fruit, weight due to application of 50% recommended dose of fertilizer + 50% FYM. The minimum peel thickness was found in fruits with T_3 (400g N + 250g P + 400g K + 0.5% $ZnSO_4$ spray). Our results are in accordance with findings of Deshraj (1989) who found that peel thickness was reduced by highest level of nitrogen along with highest level of phosphorus.

A perusal data in Table 2 reveal that treatments had significant effect on per cent juice content. Maximum fruit juice content was found with the application of T_4 (400g N + 250g P + 400g K + 1% $ZnSO_4$ spray). These re-

*Corresponding author's e-mail :
nkmishra@yahoo.co.in

sults were also experimentally supported by Sharma *et al.* (2003); Langthasa and Bhattacharya (2004) who reported maximum juice content with 0.5% ZnSO₄ spray. Dixit *et al.* (1977) and Malik *et al.*, (2000) also reported significant improvement by ZnSO₄ application.

The plants which were supplemented by 200g N + 125g P + 200g K + 20 kg FYM (T₁) produced maximum T.S.S. These results are supported by Soorihanathasundrama *et al.*, (2001) who found maximum TSS (26.0%) with 25% FYM and 75% inorganic N as urea as compared to control. The higher TSS might be due to the improvement in the metabolic and enzymatic activity during fruit formation and maturity, which might have triggered the processes related to quality as reported by Khan *et al.*, (2004). The trees receiving T₁₂ (1/2 dose T₁ + 20 kg FYM + 140g *Trichoderma*) dose of nutrients gave maximum acidity. These findings are in agreement with the results obtained by Chaudhary *et al.* (1975) who reported that the application of 45 kg FYM and higher dose of NPK per tree increased acidity as compared to control in guava fruits. Maximum acidity was found from the fruits under highest dose of nitrogen. Similar results have been made by Pomares *et al.* (1983) and Dilipbabu (1984) who reported that nitrogen and potassium gave maximum acidity in all flushes of fruits.

Maximum ascorbic acid (50.27 mg/100g) was found by the application of 200g N + 125g P + 200g K + 20 kg FYM (T₁). These results are supported by Patil *et al.* (2004) who stated that ascorbic acid content (26.76 mg / 100g) was highest with 50% recommended dose of fertilizer + 50% FYM. FYM improves soil structure, infiltration rate,

water holding capacity and available nutrient status of soil. Similar results were obtained by Chaudhary *et al.* (1975) and Ingle *et al.*, (2001). The improvement in quality of fruit may be due to improvement in the soil physical properties, water holding capacity, structure, porosity, bulk density, hardness, chemical properties like nutrient status, soil pH, hormone and biological properties like bacteria, fungi, actinomycetes and earthworm activity in soil (Chattopadhyay, 1994).

References

- Ahmed, F.F., Sayed, M.A. and Maatouk, M.A. 1988. Effect of nitrogen, potassium and phosphorus fertilization on yield and quality of Egyptian Balady lime trees (*Citrus aurantifolia*). *Ann. Agr. Sci.* 33(2): 1249-1268.
- Baldevraj, 1990. Effect of growth regulators on the performance of lemon (*Citrus limon* Burm) cv Pant Lemon-1. M.Sc.Ag. (Horticulture) Thesis. Submitted to, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand.
- Bansal, S.K., Omanwar, P.K. and Bhardwarj, V. 1980. Effect of intensive cropping and fertilization on organic carbon and total and available nitrogen in a soil of Pantnagar. *J. Indian Soc. Soil Sci.* 28: 519-261.
- Beridze, T.R. 1990. The effect of organic fertilizers on lemon tree productivity. *Subtropicheskie Kul'tury*, 3: 83-86.
- Chattopadhyay, T.K. 1994. Nutrition of fruit plants and orchard manuring practices *In: A Textbook on Pomology*. Kalyani Publishers. 153 p.

Table 1. Effect of integrated nutrient management on physical characteristics on lemon cv. Pant Lemon-1.

Treatment	Fruit retention (%)	Avg. number of fruit/tree	Avg. fruit weight (g)	Fruit yield (kg/tree)	peel thickness of fruit (mm)
T ₁ N400 + P250 + K400 g/tree	33.48	59.85	84.33	5.87	2.238
T ₂ T ₁ + 0.25% ZnSO ₄ spray	29.17	70.50	81.22	6.72	2.316
T ₃ T ₁ + 0.5% ZnSO ₄ spray	30.29	66.50	83.83	6.91	2.158
T ₄ T ₁ + 1.0% ZnSO ₄ spray	41.97	78.73	85.56	7.34	2.200
T ₅ T ₁ + 0.1 % CuSO ₄ spray	35.14	61.04	84.66	5.58	2.356
T ₆ T ₁ + 0.2% CuSO ₄ spray	37.32	79.34	86.51	7.00	2.035
T ₇ 1/2 dose T ₁ + 20 kg FYM	39.97	91.16	91.59	9.66	2.155
T ₈ 1/2 dose T ₁ + 20 kg Ver.	39.73	80.05	89.14	7.38	2.140
T ₉ 1/2 dose T ₁ + 20 kg FYM + 60 g Tr.	30.75	83.18	98.10	8.32	2.171
T ₁₀ 1/2 dose T ₁ + 20 kg FYM + 100 g Tr.	37.01	83.58	94.86	9.39	2.238
T ₁₁ 1/2 dose T ₁ + 20 kg FYM + 140 g Tr.	38.88	80.94	91.07	8.71	2.046
T ₁₂ 1/2 dose T ₁ + 20 kg Ver. + 60 g P. f	40.78	86.06	89.53	8.96	2.161
T ₁₃ 1/2 dose T ₁ + 20 kg Ver. + 100 g P. f	41.24	87.39	90.78	6.43	1.995
T ₁₄ 1/2 dose T ₁ + 20 kg Ver. + 140 g P. f	41.94	70.15	89.24	8.07	1.851
T ₁₅ Control	24.32	57.42	78.15	4.86	2.371
CD at 5%	5.05	10.789	9.814	1.0644	0.241

Ver. = Vermicompost, Tr. = *Trichoderma*, P.f. = *Pseudomonas fluorescense*

Table 2. Effect of integrated nutrient management on chemical character of lemon cv. Pant Lemon-1

Treatment	Fruit juice (%)	TSS (Brix)	Acidity (%)	Ascorbic acid (mg/100 ml juice)
T ₁ N400 + P2S0 + K400 g/tree	27.72	5.71	4.86	48.60
T ₂ T ₁ + 0.25% ZnSO ₄ spray	28.40	5.58	4.91	49.55
T ₃ T ₁ + 0.5% ZnSO ₄ spray	28.03	5.54	4.87	49.82
T ₄ T ₁ + 1.0% ZnSO ₄ spray	29.90	5.69	4.68	49.61
T ₅ T ₁ + 0.1 % CUSO ₄ spray	28.03	5.44	4.87	49.73
T ₆ T ₁ + 0.2% CUSO ₄ spray	29.11	5.31	4.89	50.15
T ₇ 1/2 dose T ₁ + 20 kg FYM	27.39	6.19	4.93	50.27
T ₈ 1/2 dose T ₁ + 20 kg Ver.	28.72	5.55	5.09	50.02
T ₉ 1/2 dose T ₁ + 20 kg FYM + 60 g Tr.	29.86	5.55	5.09	49.73
T ₁₀ 1/2 dose T ₁ + 20 kg FYM + 100 g Tr.	28.09	5.33	5.05	50.02
T ₁₁ 1/2 dose T ₁ + 20 kg FYM + 140 g Tr.	29.14	5.25	5.10	49.90
T ₁₂ 1/2 dose T ₁ + 20 kg Ver. + 60 g P.f.	29.60	5.38	5.49	50.15
T ₁₃ 1/2 dose T ₁ + 20 kg Ver. + 100 g P.f.	29.38	5.38	5.20	50.05
T ₁₄ 1/2 dose T ₁ + 20 kg Ver. + 140 g P.f.	29.29	5.44	5.17	50.41
T ₁₅ Control	26.98	6.15	4.95	47.85
CD at 5%	0.940	0.4174	0.306	NS

Ver. = Vermicompost, Tr. = *Trichoderma*, P.f. = *Pseudomonas fluorescense*

- Chaudhary, D.N., Shayamal, N.R. and Maurya, K.R. 1975. Influence of inorganic and organic manures alone and in combination on growth, yield and chemical qualities of guava (*Psidium guajava* Linn.). *Indian Food Packer*, 24-26.
- Deshraj, 1989. Effect of various levels of N, P and K on growth, yield and quality of sweet lime (*Citrus limettioides* Tanaka). M. Sc. Agriculture (Horticulture) Thesis. Submitted to, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand.
- Dilipbabu, 1984. Effect of different doses of N, P and K on growth, yield and quality of Pant lemon-1. M. Sc. Agriculture (Horticulture) Thesis. Submitted to, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand.
- Dixit, C.K., Yamdagni, R. and Jindal, P.C. 1977. A note on the effect of micronutrients spray on quality of Kinnow 'a mandarin' hybrid. *Haryana J. Hort. Sci.*, 6(3-4): 153-154.
- Ingle, H.V., Athawale, R.B., Ghawde, S.M. and Shivankar, S.K. 2001. Integrated nutrient management in acid lime. *South Indian Hort.*, 49: 126-129.
- Khan, M.A., Hameedunnisa-Begum and Swarajyalakshmi, G. 2004. Influence of component of integrated nutrient management on fruit yield and quality of acid lime in red calcareous soil. *Ann. Agr. Res.*, 25 (1): 124-128.
- Langthasa, S. and Bhattacharya, R.K. 1991. Foliar application of zinc on fruit quality of 'Assam Lemon' (*Citrus limon* Burm). *South Indian Hort.*, 39(3): 153-155.
- Malik, R.P., Ahlawat, V.P. and Nain, A.S. 2000. Effect of foliar spray of urea and zinc sulphate on yield and fruit quality of Kinnow 'a mandarin hybrid'. *Haryana J. Hort. Sci.*, 29 (1/2): 37-38.
- Patil, M.B., Mohammed, R.G. and Ghadge, P.M. 2004. Effect of organic and inorganic fertilizers on growth, yield and quality of tomato. *J. Maharashtra Agric. Univ.*, 29(2): 124-128.
- Pomares, F., Cruz, G., Tarazona, F., Estela, M., Martin, B. And Faus, R. 1983. Phosphorus and potassium fertilization of Washington Navel trees. *Primer Congreso Nacional*, 11,669-680.
- Salik, M.R., Muhammad, F. and Shakir, M.A. 2000. Effect of time of fertilizer application on productivity of Kinnow (*Citrus reticulata* Blanco). *Pakistan J. Biol. Sci.*, 3(9): 1375-1376.
- Snedecor, G.W. and Cochran, G.W. 1987. Statistical Methods. 6th Edn. Oxford and IBH, New Delhi.
- Soorianthasundram, K.; Kumar, N. and Shanthi, A. 2001. Influence of organic nutrition on the productivity of banana cv. Nendran (French Plantain-AAB). *South Indian Hort.*, 49: 109-113.

SHORT COMMUNICATION

Response of nutrient application on growth, herbage and oil yield of mint (*Mentha arvensis* L.) in western Uttar Pradesh

P. L. Saroj and Anant Kumar

Sardar Vallabh Bhai Patel University of Agriculture and Technology, Meerut (UP)-250 110

Introduction

Among aromatic crops, mint (*Mentha arvensis* L.) is more popular in the country, as it is very economical crop and can be grown on variety of soils and climatic conditions, though it prefers well drained soils and humid conditions. At present, India is major producer of mint oil and menthol in the world. In Uttar Pradesh, mint is grown commercially in the Indogangatic plains of Rampur, Moradabad, Badaun, Bareilly and Barabanki districts. The menthol is major constituents of mint oil and has various uses in pharmaceuticals, cosmetics, flavours and confectionery industries. As a herbal drug, it is considered stimulant, stomachic and carminative.

However, not much work has been done on varietal improvement, screening of germplasm for various purpose including oil content, mint based crop diversification etc. Sporadic information are available on nutrient management with special reference to increase in oil yield (Chandra *et al.*, 1983; Singh *et al.*, 1973; Bhardwaj *et al.*, 1983). Some workers tried agronomical aspects coupled with application of NPK fertilizers for improvement of growth and yield of mint. However, no information is available about nutrient application in mint crop under western Uttar Pradesh conditions, where it is gaining popularity in recent years. Besides above, the role of sulphur deficiency causes reduction in dry matter production and zinc has been found to increase menthol content in mint. In general, these nutrients are applied individually to improve growth and oil yield of mint. Therefore, the present study was planned to find out the response of basic nutrients (NPK) either alone or in combination with sulphur and zinc on growth, herbage and oil yield of mint under western Uttar Pradesh conditions.

The field experiment was conducted at Horticulture Research Centre, Sardar Vallabh Bhai Patel University of Agriculture and Technology, Meerut (UP) during summer 2005 and 2006 on well drained sandy soils. The soil fertility status was medium having 7.8 pH. The agroclimatic region is broadly categorized as subtropical with 780 mm

annual rainfall. The average temperature during summer ranges between 26-34 °C while in winter 15-20 °C. Occasional frost is also experienced.

The treatment comprised of three levels of NPK (i) 120+40+25 Kg N, P, K; (ii) 160+60+40 Kg N, P, K and (iii) 200+80+55 Kg N, P, K as well as 20 Kg sulphur and 5 Kg zinc either alone or in combination were applied. Thus total 13 treatments were made including control plot (unfertilized). The experiment was laid out in randomized block design having three replications in a plot size of 2 x 2 m. The cuttings of mint cultivar Kosi were spaced at 30 cm row to row. The complete dose of phosphorus, potash, sulphur, zinc and 1/3rd of nitrogen were applied as basal dose during field preparation while remaining two doses of nitrogen were top dressed after 50 and 80 days of transplanting. All the plots under different treatment were managed uniformly with respect to irrigation, weed management, plant protection measures etc. The crop was harvested 110 days after transplanting for recording observations on plant height, plant spread, number of branches, leaf area index, number of leaves/ 25 cm² area, herbage yield and oil content. The distillation for oil content was done in the laboratory after conditioning the herbage under various treatments. The pooled data of two harvests were analyzed statistically for interpretation of results.

Growth and herbage yield

The data presented in table 1 indicate that all the growth parameters including plant height, plant spread, number of branches per plant, number of leaves per 25 cm² and leaf area index were significantly higher in T₁₂ (200+80+55+20+5 Kg N, P, K, S, Zn) and minimum under T₁₃-control plot. This is also apparent that with the increasing N, P, K either alone or in combination with sulphur and zinc the growth parameters of mint were increased correspondingly. The observations of this investigation indicated that application of nutrients are essentially required for better vegetative growth of mint crop. Almost similar observations were made by Bhardwaj and Awasthi (1989); Singh *et al.* (1992) and Zheljaskov *et al.* (1996) under different agroclimatic situations.

Based on pooled data analysis of two harvests, all the treatments show significant difference with respect

Corresponding author's E-mail:

plsaroj@yahoo.co.in

Table 1. Effect of nitrogen, phosphorus, potash, sulphur and zinc on growth and herbage yield of mint.

Treatment	Growth parameters					Herbage yield (q ha-1)*
	Plant height (cm)	Plant spread (cm)	Number of branches plant-1	Number of leaves/ 25 cm ²	Leaf Area Index	
T ₁ (120+40+25 Kg N,P,K)	65.54	40.44	35.52	447.83	4.025	427.82
T ₂ (T ₁ +20 Kg S)	68.35	42.42	37.26	456.83	4.803	478.55
T ₃ (T ₁ +5 Kg Zn)	68.04	41.60	36.43	450.46	4.829	472.24
T ₄ (T ₁ +20+5 Kg S, Zn)	70.17	44.04	40.45	505.20	5.017	502.56
T ₅ (160+60+40 Kg N,P,K)	72.80	45.08	42.45	573.86	5.300	507.29
T ₆ (T ₅ +20 Kg S)	76.76	46.62	43.94	584.80	5.503	524.88
T ₇ (T ₅ +5 Kg Zn)	75.19	46.17	43.16	579.80	5.545	518.46
T ₈ (T ₅ +20+5 Kg S, Zn)	81.44	48.37	45.21	598.66	5.720	542.63
T ₉ (200+80+55 Kg N,P,K)	81.25	48.19	45.66	596.26	5.702	530.53
T ₁₀ (T ₉ +20 Kg S)	81.34	51.18	46.61	613.06	5.890	538.41
T ₁₁ (T ₉ +5 Kg Zn)	81.28	50.43	46.50	604.86	5.810	543.90
T ₁₂ (T ₉ +20+5 Kg S, Zn)	83.31	52.46	48.28	619.60	6.106	554.70
T ₁₃ (Control)	49.82	35.60	25.53	385.53	2.271	321.72
SEm±	1.02	0.66	0.80	2.26	0.042	1.05
CD (p=0.05)	2.99	1.95	2.36	6.64	0.123	3.07

* Based on two consecutive harvests

to herbage yield. The herbage yield which is ultimately attributed by different growth parameters was also highest (554.70 q ha-1) in the same treatment (T₁₂) followed by T₁₁ (543.90 q ha-1), T₁₀ (538.41 q ha-1) and minimum in T₁₃-control (321.72 q ha-1).

Oil yield

The oil content of a particular variety is genetic character but the synthesis in plant system may largely be influenced by the growing conditions, stage of harvesting, exogenous application of desired nutrients, conditioning of herbage and distillation system etc. Therefore, variations between the treatments with respect to per cent oil content was meager, though all the treatments varied significantly if compared with control. It is also obvious that the application of N, P, K in combination with sulphur and

zinc have added advantage in oil content of mint than N, P, K alone. However, the higher dose of N, P, K (T₉, T₁₀, T₁₁, T₁₂) either alone or in combination with sulphur and zinc did not beneficial in improving oil content. Similar results were made by Samra *et al.* (1978).

Among various treatments, highest oil yield was recorded in T₈ (431.63 l ha-1) followed by T₁₂ (425.30 l ha-1) and minimum in T₁₃-control (196.18 l ha-1), though the herbage yield was maximum in T₁₂. This indicated that luxuriant vegetative growth was detrimental for oil yield of mint. The results are in close proximity with Singh *et al.* (1979), Sharma *et al.* (1980) and Chandra *et al.* (1983). Thus, for better oil yield of mint, application of 160+60+40+20+5 Kg N, P, K S, Zn is recommended under western Uttar Pradesh conditions. By the said dose of nutrients, the oil yield of mint can be doubled in comparison to control.

Table 2. Effect of nitrogen, phosphorus, potash, sulphur and zinc on oil yield of mint.

Treatment	Oil content (%)	Essential oil yield (l ha-1)
T ₁ (120+40+25 Kg N,P,K)	0.779	329.95
T ₂ (T ₁ +20 Kg S)	0.816	364.92
T ₃ (T ₁ +5 Kg Zn)	0.818	372.00
T ₄ (T ₁ +20+5 Kg S, Zn)	0.820	384.24
T ₅ (160+60+40 Kg N,P,K)	0.822	371.70
T ₆ (T ₅ +20 Kg S)	0.825	411.23
T ₇ (T ₅ +5 Kg Zn)	0.825	422.96
T ₈ (T ₅ +20+5 Kg S, Zn)	0.836	431.63
T ₉ (200+80+55 Kg N,P,K)	0.781	374.12
T ₁₀ (T ₉ +20 Kg S)	0.782	401.08
T ₁₁ (T ₉ +5 Kg Zn)	0.790	416.89
T ₁₂ (T ₉ +20+5 Kg S, Zn)	0.784	425.30
T ₁₃ (Control)	0.609	196.18
SEm±	0.001	0.44
CD (p=0.05)	0.003	1.29

* Based on two consecutive harvests

References

- Bhardwaj, S.D., Srivastava, L. I. and Kaushal, A. N. 1983. Studies of rate and split application of N on herbage and oil yield of *Mentha citrata* Ehrh. *Indian Perfumer*. 27(2): 98-103.
- Bhardwaj, S.D. and Awasthi, O. P. 1989. Nitrogen management in peppermint (*Mentha piperita* L.) under different harvesting schedule. *Indian Perfumer*. 33(2): 87-93.
- Chandra, M., Singh, J. N. and Kewlanand. 1983. Effect of nitrogen levels and harvesting times on growth and yield of Japanese mint (*Mentha arvensis* L.). *Indian Perfumer*. 35(2): 104-107.
- Randhawa, G. S., Sidhu, B.S., Maney, R. K. and Saini, S.S. 1984. Herb and oil yield of *Mentha spicata* under different row spacing and nitrogen levels in Punjab. *Indian Perfumer*. 28(2): 105-107.
- Samra, J. S., Singh, S.S. and Bains, D. S. 1978. Time of nitrogen application to *Mentha arvensis* L.. *Indian Perfumer*. 22(1): 23-25.
- Sharma, S.N., Singh, A. and Tripathi, R.S. 1980. Effect of NPK and micronutrient on herb and menthol yield of Japanese mint. *Indian Journal of Agronomy*. 25(2): 278-281.
- Singh, K. P., Sadhu, A. S. and Husain, A. 1973. Effect of N,P& K fertilization on the yield of green herb, oil and oil content of *Mentha piperita* L. *Indian Journal of Agronomy*. 18(1): 47-50.
- Singh, V. P., Chatterjee, B. N. and Singh, D.V. 1992. Effect of varying levels of N application on the growth and development of mint species. *Indian Perfumer*. 10(1): 45-51.
- Singh, V.P., Duhan, S. P. S. and Bist, H. S. 1979. Response of Japanese mint to NPK under Tarai conditions of Nainital. *Pantnagar Journal of Research*. 4(1): 24-26.
- Zhelijazkov, V., Craker, L. E., Nolan, L. and Shetty, K. 1996. Effect of increasing doses of fertilizer application on quantitative and qualitative characters of mint. *Acta Horticulture*. 426: 579-592.

SHORT COMMUNICATION

Yield, quality and nutrient uptake of fenugreek (*Trigonella foenum-graecum*) as influenced by irrigation levels and weed management practices

R. S. Mehta*, B. S. Patel, S. S. Meena and L. R. Meena
National Research Center on Seed Spices, Ajmer, Rajasthan 305 206

Fenugreek is an important seed spice crop mainly grown during *rabi* in Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Haryana, Punjab, Bihar and Andhra Pradesh. The seeds of fenugreek are used as a condiment and seasoning agent for garnishing and flavouring dishes. In India, water is increasingly becoming scarce and costly due to continuous lowering of water table on account of burgeoning population. In India 80 per cent of available water is used for agriculture. There is a water crisis today but crisis is not about having too little water to satisfy our needs, it is a crisis of managing water badly resulting in lower water use efficiency. Moreover, water is an indispensable for every metabolic activity of plant. Simultaneous emergence and rapid growth of weed leads to severe weed competition with fenugreek for light, moisture, space and nutrients. Weeds are responsible for causing significant losses in crop productivity and quality of product. Therefore, precise information on water and weed management in fenugreek is essential for realising higher yield of fenugreek.

A field experiment was conducted at S.D. Agricul-

tural University, Sardarkrushinagar, a Gujarat during *rabi* 2006-07 and 2007-08. The soil of the experimental field was loamy sand in texture having water holding capacity of 7.09 and 7.14 %, pH 7.75 and 7.73 and electrical conductivity 0.12 and 0.11 dS/m, respectively during 2006-07 and 2007-08. The soil of the experimental field of both the sites were low in organic carbon (0.17 and 0.22) available nitrogen (152.8 and 165.3 kg/ha), medium in available P (18.0 and 21.0 kg/ha) and good in respect to available K (216.9 and 220.6 kg/ha). The experiment was laid out in split plot design with four replications, keeping three levels of irrigation (0.6, 0.8 and 1.0 IW/CPE ratios) in main plot and six weed control treatments (weedy check, weed free, hand weeding at 20 and 40 DAS, HW at 20 + IC at 40 DAS, pre emergence (PE) application of Pendimethalin @ 0.75 kg/ha and application of Pendimethalin @ 0.75 kg/ha + IC at 40 DAS) in sub plots. The fenugreek (GF-2) was sown in second week of November during both the years at 30 cm rows apart using a seed rate of 20 kg/ha. Irrigation water was measured by parshall flume installed in the field channel and total 7, 8 and 10 irrigations of 50 mm depth with

Table 1. Yield, harvest index and protein content in seed and straw of fenugreek as influenced by irrigation levels and weed management practices (Pooled of 2006-07 and 2007-08)

management practices (Pooled of 2006-07 and 2007-08)						
Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	biological yield (kg/ha)	Harvest Index (%)	Protein content (%)	
					Seed	Straw
<i>Irrigation levels (IW/CPE ratio)</i>						
0.6	1072	2200	3272	32.7	20.04	7.34
0.8	1346	2684	4030	33.4	20.78	7.60
1.0	1474	2835	4309	34.1	21.16	7.69
CD (P=0.05)	63.0	123.1	185.2	NS	0.68	0.23
<i>Weed management practices</i>						
Weedy check	1479	2904	4383	32.69	20.44	7.44
Weed free	1434	2835	4269	33.65	20.97	7.67
HW at 20 and 40 DAS	1287	2552	3839	33.51	20.70	7.56
HW at 20 DAS and IC at 40 DAS	1199	2380	3580	33.42	20.58	7.51
Pendimethalin @ 0.75 kg ha ⁻¹ PE)	1447	2840	4287	33.42	20.45	7.47
Pend.@ 0.75 kg/ha + IC at 40 DAS (PE)	54.2	114.8	166.4	33.65	20.83	7.61
CD (P=0.05)	54.2	114.8	166.4	NS	NS	NS

*Corresponding authors e-mail:
rsmagron@yahoo.co.in

Table 2. Seed, straw and biological yields (kg ha⁻¹) as influenced by interaction effect between irrigation levels and weed management Practices (Pooled of year 2006-07 and 2007-08)

Weed management practices / Irrigation levels	Seed yield (kg/ ha)			Straw yield (kg/ ha)			Biological yield (kg /ha)		
	0.6 IW/CPE	0.8 IW/CPE	1.0 IW/CPE	0.6 IW/CPE	0.8 IW/CPE	1.0 IW/CPE	0.6 IW/CPE	0.8 IW/CPE	1.0 IW/CPE
W ₁ : Weedy check	861	929	1017	1874	1900	2007	2736	2829	3024
W ₂ : Weed free	1189	1551	1698	2402	3059	3249	3592	4610	4947
W ₃ : HW at 20 and 40 DAS	1164	1494	1645	2363	2979	3164	3526	4473	4809
W ₄ : HW at 20 DAS and IC at AS	1041	1316	1503	2138	2624	2892	3180	3941	4395
W ₅ : <u>Pend@ 0.75 kg ha⁻¹</u> (PE)	996	1284	1318	2046	2560	2534	3042	3844	3852
W ₆ : <u>Pend.@ 0.75 kg ha⁻¹</u> + IC at 40 DAS (PE)	1177	1502	1663	2376	2979	3164	3553	4481	4827
CD (P=0.05)	106.3*	93.9**		219.1*	198.8**		321.5*	288.2**	

* CD for irrigation levels means at same level of weed management practices

** CD for weed management practices means at same level of irrigation mean

Table 3. Nitrogen, phosphorus and potassium uptake in fenugreek as influenced by irrigation levels and weed management practices (Pooled of 2006-07 and 2007-08)

Treatments	Nitrogen uptake (kg/ha)			Phosphorus uptake (kg/ha)			Potassium uptake (kg/ha)		
	Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total
Irrigation levels (IW/CPE ratio)									
0.6	34.41	25.88	60.29	4.54	3.03	7.57	12.34	25.87	38.21
0.8	44.89	32.72	77.61	5.82	3.74	9.57	15.78	30.99	46.77
1.0	49.94	34.94	84.88	6.49	4.03	10.51	17.57	32.17	49.75
CD (P=0.05)	2.51	1.91	4.33	0.34	0.21	0.54	0.90	1.79	2.63
Weed management practices									
Weedy check	30.73	22.97	53.69	3.99	2.65	6.64	10.86	22.04	32.89
Weed free	49.73	35.74	85.47	6.51	4.12	10.63	17.57	34.01	51.59
HW at 20 and 40 DAS	47.69	34.39	82.08	6.21	3.97	10.18	16.84	32.81	49.65
HW at 20 DAS and IC at 40 DAS	42.54	30.76	73.31	5.53	3.55	9.09	15.02	29.35	44.37
Pendimethalin @ 0.75 kg ha ⁻¹ (PE)	39.37	28.51	67.88	5.13	3.30	8.43	13.91	27.22	41.14
Pend.@ 0.75 kg / ha + IC at 40 DAS (PE)	48.42	34.72	83.14	6.31	3.99	10.29	17.09	33.06	50.16
CD (P=0.05)	2.36	1.79	3.84	0.32	0.20	0.48	0.89	1.70	2.40

0.6, 0.8 and 1.0 IW/CPE ratio, respectively were provided during both the seasons. Application of Pendimethalin @ 0.75 kg/ ha (PE) was done on second day after irrigation which was applied immediately after sowing with the help of a knapsack sprayer fitted with flat fan nozzle with a spray volume of 600 litres / ha. In manual weed control treatments, weeds were uprooted and removed at 20 and 40 DAS and inter-culturing was done as per treatments at 40 DAS. The concentration of N in seed and straw was determined by procedure suggested by Snell and Snell (1949) and of P and K content by methods suggested by Jackson (1973). The nutrient uptake was determined by multiplying the concentration with their respective dry matter accumulation.

Effect of irrigation levels

The highest, seed, straw and biological yields as well as nitrogen, phosphorus and potassium uptake and protein content in seed and straw was obtained with irrigation at 1.0 IW/CPE ratio followed by with 0.8 IW/CPE ratio but harvest index was not affected (Table 1 & 2). Application of irrigation at 1.0 IW/CPE ratio resulted 10 and 38 % higher seed and 7 and 29 per cent straw yield over 0.8 and 0.6 IW/

CPE ratio respectively. Significantly higher N, P and K uptake by seed, straw and total was recorded with 1.0 IW/CPE ratio followed by with 0.8 IW/CPE ratio. The lowest seed, straw and biological yields as well as N, P and K uptake was obtained with irrigation at 0.6 IW/CPE ratio. The increase in seed, straw and biological yield with 1.0 IW/CPE ratio could be explained by the fact that frequent irrigations under this treatment facilitated maintenance of optimum moisture level in soil as well as in plant during entire growth period which resulted better translocation of photosynthates from source to sink resulting in higher yield attributes and yield of fenugreek. Similarly, maximum uptake of N, P and K in seed, straw and crop might be due to cumulative effect of N content in seed and straw as well as higher yield and dry matter production under 1.0 IW/CPE ratio. These findings are in close agreement with those reported by, Dutta *et al.* (2006).

Effect of weed management practices

Pendimethalin with IC at 40 DAS and HW at 20 and 40 DAS were found as effective as weed free treatments in respect to seed, straw and biological yields as well as NPK uptake by seed, straw and crop but protein

content in seed and straw as well as harvest index was not affected with weed management practices. The higher yield and uptake of N,P and K by seed, straw and crop of fenugreek seems to be due to better weed control which resulted congenial competition free growing condition for higher yield which enhance higher uptake of nutrients with application of Pendimethalin + IC at 40 DAS and HW at 20 and 40 DAS. Tiwari *et al.*, (2006) and Patel *et al.* (2007) also reported similar results in fenugreek.

Interaction effect of irrigation and weed management practices

The higher seed, straw and biological yield was obtained with application of irrigation at 1.0 IW/CPE ratio with weed free treatment which was at par with irrigation at 1.0 IW/CPE ratio and Pendimethalin with IC at 40 DAS and significantly higher over rest of the treatment combinations (Table 2). Effective weed control with application of Pendimethalin + IC at 40 DAS and HW at 20 and 40 DAS along with adequate availability of moisture at 1.0 IW/CPE ratio gave higher growth and yield attributes which in turn resulted higher seed and straw yields. These results corroborate with those of Dungarwal *et al.* (2002).

Thus it can be inferred that application of irrigation at 1.0 IW/CPE ratio with weed control by pre emergence application of Pendimethalin @ 0.75 kg/ha is most effective for realising higher yield and better water use efficiency.

References

- Dungarwal, H.S., Chaplot, P.C. and Nagda, B.L. 2002. Herbicidal weed management in fenugreek (*Trigonella foenum-graecum* L.), *Indian Journal of Weed Science* 34: 247-250.
- Dutta, S. and Chatarjee, R. 2006. Effect of irrigation regimes on moisture extraction pattern, evap and yield of fenugreek (*Trigonella foenum-graecum* L.). *Journal of Spices and Aromatic Crops*, 15 (2):125-129.
- Jackson, M.L. 1973. Soil chemical analysis. *Prentice Hall Inc. Engle Cliffs, New Jersey*.
- Kulshrestha, G. and Parmar, B.S. 1992. Resources management for sustainable crop production souvenir, Indian Society of Agronomy, pp. 399-431.
- Singh S.J, Prasad S M and Sinha K K. 2001, Response of french bean (*Phaseolus vulgaris* L.) to irrigation and weed management in North Bihar. *Indian Journal of Agronomy*, 46 (2):282.
- Snell, F.B. and Snell, C.T. 1949. Colorimetric method of analysis. *IIAD Vannostr and Co. Inc., New York*.
- Tiwari, R.C., Bairwa, R.C., Sharma, P.K. 2006. Effect of phosphorus and weed control on fenugreek (*Trigonella foenum graecum* L.) *Legume Research*, 29 (4):304-307.

SHORT COMMUNICATION

Association analysis for quality attributes in ber (*Ziziphus mauritiana* L.)

S. Pareek* and R.S. Dhaka

Department of Horticulture, S.K.N. College of Agriculture, (RAU), Jobner 303329

Yield being a complex character, is composed of several components, some of which affect the yield directly while, others contribute towards it indirectly. Correlation studies provide an opportunity to study the magnitude and direction of association of yield with direct and indirect quality parameters and also among these parameters. To accumulate optimum combination of quality characters in a single genotype, it is essential to know the implication of the inter-relationship of various characters. Linear correlations between yield and various quality characters, because of the interrelationship among the components themselves can present a confusing picture. For this reason standard partial correlation or regression (path coefficient) can give a more realistic interpretation of characters involved. Considering these points in view, the present study was conducted to understand inter-relationship of the quality traits in ber.

Ten year old plants of eleven genotypes of ber comprising eight commercial cultivars of *Ziziphus mauritiana* and three local selections of *Ziziphus rotundifolia* were used for this study. They were studied in randomized block design at Horticultural Research Farm, S.K.N. College of Agriculture, Jobner, during fruiting season of 1999-2000. Recommended agronomical practices were adopted under rainfed conditions. Observations were recorded on nine quality traits, viz., pulp : stone ratio, TSS, acidity, ascorbic acid, total sugar, reducing sugars, non-reducing sugars, T.S.S. : acid ratio and yield per plant. Physico-chemical characteristics were recorded from twenty randomly selected mature fruits from each replication. The T.S.S. was estimated using a hand refractometer. Acidity and ascorbic acid were determined by titration methods (A.O.A.C., 1990). Total sugar content was determined by using anthrone reagent method (Dubois *et al.*, 1951). Reducing sugars was measured by following Nelson's modification of Somogyi's method (Somogyi, 1952). Mean data were used for correlation and path coefficient analysis as per method of Dewey and Lu (1959).

Estimates of correlation coefficients at genotypic

and phenotypic levels are presented in Table 1. The genotypic correlation coefficients were generally higher for all the combinations than their respective phenotypic correlation coefficients, thereby suggesting strong inherent association between various characters at genetic level. The phenotypic correlation decreased due to environmental effects. At the genotypic level correlation coefficients revealed that fruit yield had significantly positive correlation with pulp : stone ratio (0.644), T.S.S. (0.570), acidity (0.598), ascorbic acid (0.674), total sugar (0.461) and reducing sugars (0.905) which indicated that selection for these traits, would lead to an improvement in yield, while it was significantly and negatively associated with T.S.S. : acid ratio (-0.630). Positive association of total sugar content (Bisla and Daulta, 1986) and pulp : stone ratio (Prajapati *et al.*, 1996) with fruit yield in ber have been reported earlier and these results are in agreement with the present study. Pulp : stone ratio was significantly and positively associated with ascorbic acid, total sugar and reducing sugars. T.S.S. had significant positive correlation with T.S.S. : acid ratio, however, association with ascorbic acid and reducing sugars was found to be significant and negative. Acidity had high significant negative association with T.S.S. : acid ratio. Ascorbic acid showed significant positive inter-relationship with total sugar and reducing sugars. Total sugar was significantly and positively associated with reducing and non-reducing sugars. These findings are in conformity with those of Gupta and Mehta (2000). Pant (1996) reported positive correlation of T.S.S. with total sugar in pomegranate. Estimates of phenotypic correlation coefficient revealed positive and highly significant correlation of fruit yield with T.S.S., acidity, ascorbic acid, total sugar and reducing sugars. Thus, we find consistency in the correlation both at genotypic as well as phenotypic levels.

Considering the fruit yield as the effect and eight quantitative traits as the causes, the path coefficient analysis was done to find out the direct and indirect contribution of these characters towards fruit yield in ber genotypes. The genotypic residual value was fairly low. The analysis of genotypic and phenotypic correlations into direct and indirect effects are presented in Table 2. T.S.S., reducing sugars and total sugar made appreciable direct

*Corresponding author's email:
sunil_ciah@yahoo.co.in

positive contribution to fruit yield. It is interesting to note that reducing sugars which had highest correlation also exhibited highest direct path (1.378) towards fruit yield. T.S.S. contributed indirectly mostly through acidity and ascorbic acid. Reducing sugars exerted its influence mainly through pulp : stone ratio, total sugar and T.S.S. : acid ratio. Total sugar exhibited indirect effect via reducing sugars, T.S.S. : acid ratio and pulp : stone ratio. Low non-significant correlation and negative direct path non-reducing sugar with fruit yield indicated that much reliance cannot be placed on the selection of genotypes in enhancing the fruit yield, which confirmed the conclusion drawn from correlation. Ascorbic acid which had next to highest genotypic correlation exhibited negative direct path on fruit yield. Contrary to this acidity, which had significant positive correlation, exhibited high negative direct path towards fruit yield. The positive genotypic correlation of acidity was counter balanced by high negative direct path and nega-

tive indirect effect via T.S.S. and ascorbic acid. Non-reducing sugars and T.S.S. : acid ratio made negative direct contribution.

The results of phenotypic path coefficient analysis in the form of direct and indirect effects on fruit yield are presented in Table 2. The value of residual path after deducting the direct and indirect effects was not very high. Break-up of phenotypic correlations of fruit yield into its components showed that acidity, reducing sugars and non-reducing sugars directly contributed maximum towards fruit yield. T.S.S., ascorbic acid, total sugar and T.S.S. : acid ratio, made negative direct contributions. Similar conclusions were earlier reported by Bisla and Daulta (1986; 1987) and Prajapati *et al.* (1996).

From the study it could be inferred that the parameters reducing sugars, T.S.S. and total sugar can be used as selection criteria for improvement of ber crop.

Table 1. Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficients between quality attributes and fruit yield in ber

Character	Pulp: stone ratio	T.S.S.	Acidity	Ascorbic acid	Total sugar	Reducing sugar	Non-Reducing sugar	T.S.S.: acid ratio	Fruit yield
Pulp: stone ratio	-	-0.307	0.032	0.479*	0.486*	0.663**	0.250	-0.036	0.595**
T.S.S.	-0.313	-	-0.345	-0.701**	0.649**	0.484*	0.273	0.522*	0.555**
Acidity	0.003	-0.381	-	0.226	0.027	0.409	-0.154	-0.942**	0.541**
Ascorbic acid	0.495*	-	0.231	-	0.455*	0.717**	0.191	-0.377	0.657**
Total sugar	0.504*	0.705**	0.034	0.456*	-	0.474*	0.918**	-0.062	0.451*
Reducing sugar	0.697**	-0.489*	0.437*	0.721**	0.477*	-	0.085	-0.382	0.891**
Non-Reducing sugar	0.258	0.275	-0.158	0.193	0.919**	0.091	-	0.102	0.108
T.S.S.: acid ratio	-0.003	0.575**	-0.954**	-0.396	0.073	-0.418	0.105	-	-
Fruit yield	0.644**	0.570**	0.598**	0.674**	0.461*	0.905**	0.116	-0.630**	0.542**

* Significant at $p=0.05$ and ** Significant at $p=0.01$

Table 2. Estimates of direct and indirect effects at phenotypic (p) and genotypic (g) levels for quality attributes

Character		Pulp: stone ratio	T.S.S.	Acidity	Ascorbic acid	Total sugar	Reducing sugar	Non-Reducing sugar	T.S.S.: acid ratio	Correlation with fruit yield
Pulp: stone ratio	P	0.040	0.086	0.005	-0.096	0.419	0.744	0.235	0.002	0.595**
	G	0.408	-0.383	-0.012	-0.358	0.256	0.961	-0.241	0.014	0.644**
T.S.S.	P	-0.073	-0.278	-0.054	0.140	0.042	0.543	0.257	-0.022	0.555**
	G	-0.128	1.224	1.704	0.511	0.025	0.674	-0.258	-3.082	0.570**
Acidity	P	0.001	0.096	0.158	-0.045	-0.023	0.459	-0.145	0.040	0.541**
	G	0.001	-0.466	4.473	-0.168	0.017	0.602	0.148	4.937	0.598**
Ascorbic acid	P	0.019	0.195	0.036	-0.200	-0.392	0.804	0.179	0.016	0.657**
	G	0.202	-0.863	-1.035	0.724	0.232	0.993	-0.181	2.052	0.674**
Total sugar	P	0.019	-0.014	0.004	-0.091	-0.863	0.532	0.861	0.003	0.451*
	G	0.206	0.060	-0.154	-0.330	0.507	0.657	-0.861	0.376	0.461*
Reducing sugar	P	0.026	0.135	0.064	-0.143	-0.409	1.122	0.080	0.016	0.891**
	G	0.284	-0.598	-1.956	-0.522	0.242	1.378	0.085	2.162	0.905**
Non-Reducing sugar	P	0.010	-0.076	-0.024	-0.038	-0.792	0.095	0.938	-0.004	0.108
	G	0.105	0.337	0.705	-0.140	0.466	0.125	-0.937	-0.545	0.116
T.S.S.: acid ratio	P	-0.001	-0.145	-0.149	0.075	0.053	-0.429	0.096	-0.043	-0.542**
	G	-0.001	0.704	4.267	0.287	-0.037	-0.576	-0.099	-5.175	-0.630**

Diagonal values represent direct effects. * Significant at $p=0.05$ and ** Significant at $p=0.01$

Residual effects : Phenotypic = 0.1327, Genotypic = -0.0327.

References

- A.O.A.C. 1990. Official methods of analysis. Association of Official Analytical Chemists, Washington, D.C.
- Bisla, S.S. and Daulta, B.S.: 1986. Studies on variability, heritability, and genetic advance for quality traits in ber. *Haryana Journal of Horticultural Science*, 15: 175-178.
- Bisla, S.S. and Daulta, B.S. 1987. Correlation and path analysis studies on fruit and seed characters in ber. *Agricultural Science Digest*, 7: 170-172.
- Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agronomy Journal*, 51: 515-518.
- Dubois, M., Gilles, K., Hamiton, J.K., Robers, P.A. and Smith, F. 1951. A colorimetric method for determination of sugar. *Nature*, 16: 167.
- Gupta, N.K. and Mehta, A.K. 2000. Genetic variability and association of component characters for fruit yield in ber (*Zizyphus mauritiana* Lamk.). *Advances in Plant Sciences*, 13: 75-78.
- Pant, K.S. 1996. Variation studies and provenance evaluation of wild pomegranate (*Punica granatum* L.). *Thesis Abstract*, CCSHAU, Hisar. 22: 43.
- Prajapati, B.H., Goswami, D.G. and Prajapati, M.R. 1996. Cause and effect analysis for fruit yield in ber. *Gujarat Agricultural University Research Journal*, 21: 76-79.
- Somogyi, M. 1952. Biochemcial Methods for Agricultural Sciences. Willey Eastern Limited, New Delhi. pp. 5-6.