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Intervarietal morphological variability in bael (*Aegle marmelos*) under rainfed semi-arid hot ecosystem of western India

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ABSTRACT

A total of 12 varieties of bael (*Aegle marmelos* Correa.) were established through *in-situ* patch budding under field conditions in July 2003, and stem growth pattern and leaf morphology were studied during 2011 and 2012. The results revealed that all varieties showed considerable morphological variations in qualitative and quantitative morphological characters under rainfed condition in western India. Central, right and left lateral leaflets showed notable variations in leaf length, leaf width, petiole length and petiolule length. The intermodal distance were compared among varieties. Similarly, qualitative morphological characters in terms of leaf shape, leaf base, leaf apex and leaf margin exhibited notable variability. The characterization in a variety based on stem growth and morphological characters of leaf and bark, most of the varieties can easily be identified even in absence of fruits.

KEY WORDS: Bael, Qualitative characters, Quantitative characters, Variety, Morphological variability, Rainfed, Semi-arid, Ecosystem

Bael (*Aegle marmelos* Correa.), an indigenous medicinal fruit tree, is a member of family Rutaceae (Zeven and de Wet, 1982). It is found growing throughout south-east Asia. In India, it grows in Indo-gangetic plains and sub-Himalayan tracts, north-east India and in dry and deciduous forests of central and southern India. Besides, occurring as natural wild plant in forest, it is commonly grown in the homestead gardens, backyards, religious places and at farmers' fields. The demand for bael fruits is increasing owing to nutraceutical, therapeutical and post-harvest values, and its usages in various *Ayurvedic* system of medicines. The fruit has higher content of riboflavin (Mukharjee and Ahmed, 1957). It has great potential to become a new export commodity as a supplementary food because each part of the tree such as root, bark, leaf flower and fruit has important ingredients for

indigenous traditional formulations (Pandey *et al.*, 2013).

Bael is known to have extensive phenotypic variation arising owing to cross-pollination and effect of varied agroclimatic conditions on morphological characters in different parts of the country (Rai and Dwivedi, 1992). Farmers are experiencing the challenge of identifying cultivars but they are unfamiliar with the characteristics of many different varieties of bael. In order to identify distinct characters of various bael cultivars, the morphological characterization is essential without considering the fruit characters. This has necessitated the development of bael descriptors that can be used to recognize varieties with the help of morphological variability excluding fruit characters. Different aspects of leaf morphological features have been extensively utilized for taxa delimitation (Metcalf and Chalk, 1979; Stace 1965). Therefore, present study was undertaken to determine diversity in established bael varieties under rainfed, semi-arid region in western India. This will be helpful and effective in utilization of bael genetic resources, especially in further improvement.

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MATERIALS AND METHODS

The study was undertaken at the Central Horticultural Experiment Station, Vejalpur, Godhra. The area is characterized by semi-arid hot climate and potential evapotranspiration of the area is 1500-1600 mm, whereas actual mean usual precipitation is about 831 mm. The mean monthly maximum and minimum temperature ranges between 26 and 41°C and monthly 10°C to 26°C, respectively. The experimental soil type is clay to clay loam in texture having calcareous zone below 60-70 cm from soil surface. Twelve varieties, CISHB1, CISHB2, Pant Aparna, Pant Sujata, Pant Shivani, Pant Urvashi, NB5, NB7, NB9, NB16, NB17 and Goma Yashi, were replicated four times in a randomized block design and each variety was considered as treatment.

Different qualitative growth characters were observed visually in the field as illustrated by Wilde *et al.* (1972) and Simpson (2006). In September, 40 leaves were randomly collected from trees of each variety from all the directions and subjected to morphological measurement. The leaves were compound trifoliate type, the full length of leaf, right, left and central leaflet's length, width, leaf thickness, petiole and petiolule length, width and internodal length were measured with the help of scale and Vernier calliper. The data were statistically analyzed for measurable characters as per the method of Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Qualitative Morphological Characters

The varieties, CISHB 1 and NB 16, had upright

habit; CISHB2, Pant Sujata, NB5, NB7 and Goma Yashi had semi-spreading habit; Pant Urvashi, NB17 and NB9 had spreading habit, whereas Pant Aparna and Pant Shivani had drooping type tree growth habit. Based on density of foliage, dense foliage was observed in Pant Aparna, Pant Sujata, Pant Shivani, NB5, NB7 and Goma Yashi, sparse in CISHB1, CISHB2, NB16 and NB17, and the same was compact in Pant Urvashi and NB9. Bark colour was recognized yellowish- grey in CISHB 1, Pant Shivani, NB5 and NB17, grayish-yellow in Pant Sujata, Pant Urvashi and Goma Yashi, blackish-grey in NB9 and NB16, yellowish in Pant Aparna and CISHB2, whereas it was observed grey in NB7.

All the varieties showed more or less similar splitting pattern of bark which was irregular intersecting striations having either small rectangular or square triangle blocks (Fig. 1). Similar kind of variations has also been reported by Singh and Singh (2005) in growth habit among 20 genotypes of mahua under rainfed condition.

The data reveals that varieties, NB5 and NB9, central and lateral leaflets both had variation in their shape. The leaflet shape of Pant Aparna, Pant Shivani and Pant Urvashi was ovate, oval to lanceolate in CISHB1, elliptical to ovate in CISHB2, broadly ovate to cordate in Pant Sujata, elliptical to lanceolate in NB9 and ovate to lanceolate in NB16. In NB5 central leaflet was ovate to elliptic and lateral leaflet elliptical and in NB17, the central leaflet was elliptical and lateral leaflet was ovate (Table 1).

According to Nicotra *et al.* (2011), different leaf shapes can be found in association with variation in

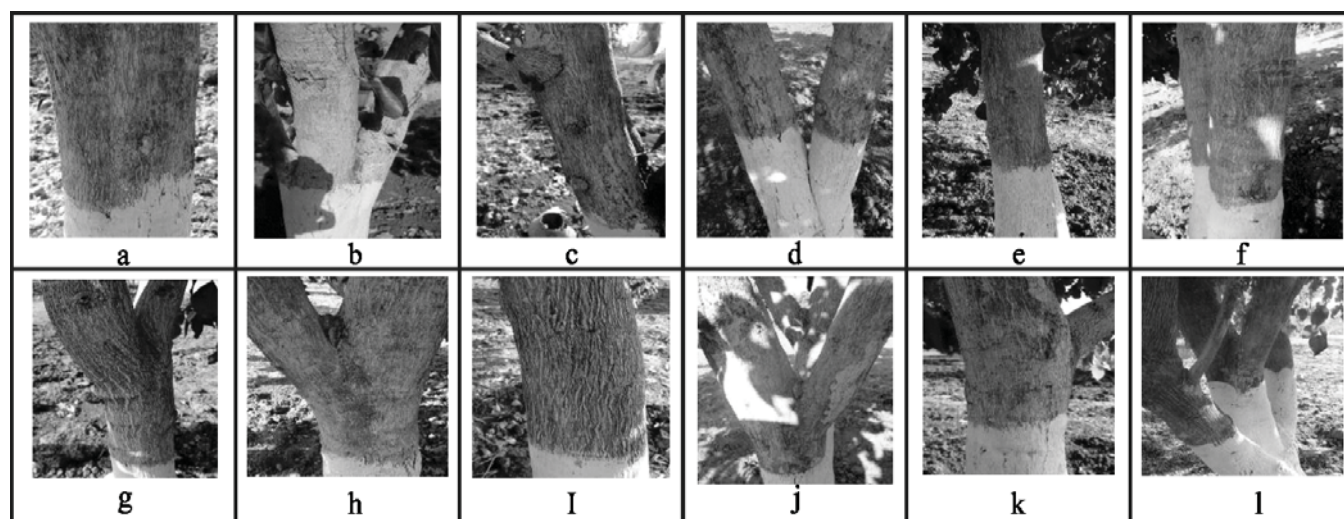


Fig. 1. Bark of bael varieties: a, NB 17; b, CISHB 2; c, NB 16; d, Pant Aparna; e, NB 5; f, Pant Urvashi; g, Goma Yashi; h, Pant Shivani; I, NB 9; j, Pant Sujata; k, CISHB1; l, Pant Urvashi.

Table.1 Qualitative morphological leaf characters of Bael varieties

Variety	Central leaf shape	Lateral leaf-let shape	Leaf apex	Leaf base	Leaf margin	Leaf surface	Leaf colour
CISHB-1	Broadly lanceolate to ovate	Ovate	Acuminate	Narrowly cuneate tapering but oblique at one side	Superficially crenulate	Dull rough	Dark green at both side
CISHB-2	Broadly ovate	Ovate	Central leaflet had acuminate and lateral leaflet had Acute	Round	Prominent Crenate, bicrenate	Dull papery rough	Dorsal side dark green and light green at ventral side
Pant Aparna	Ovate	Ovate	Acute ,sub acute cuneate in laterals	Broadly cuneate in central oblique slightly depressed	prominent crenate but leaf margin at one side	shiny, smooth	Dorsal side dark green and ventral side light green
Pant Sujata	Broadly ovate	Ovate to cordate	Acute	Narrowly cuneate	Prominent crenulate	Shiny smooth	Dark green at both side
Pant Urvashi	Ovate	Ovate	Central leaflet had acuminate and lateral leaflet had Acute	Rounded	Superficially crenulate	Shiny smooth	Light green at both side
Pant Shivani	Ovate	Ovate	Acute	Broadly cuneate and rounded in laterals	Superficially crenate	Dull rough	Light green at both side
NB 5	Ovate to elliptic small	Elliptical	Acuminate	Narrowly cuneate but lateral leaflet has round	Superficially crenate	Dull rough	Dorsal side dark green and ventral side light green
NB 7	Broadly ovate	Broadly ovate	Acuminate	Narrowly cuneate tapering at the central leaflet and slightly attenuate in the lateral leaflet	Crenate prominent	Shiny smooth	Dorsal side dark green and ventral side light green
NB 9	Elliptical to lanceolate	To ovate	Central had acuminate, laterals had acute	Narrowly cuneate tapering, laterals had rounded	Crenate superficially	Shiny smooth	Dark green at both side
NB 16	Ovate to lanceolate	-	Acute	Narrowly cuneate	Crenulate deeply, prominent	Shiny smooth	Dark green at both side
NB 17	Ovate	Ovate	Acuminate	Narrowly cuneate	Crenate deeply prominent	Papery dull rough	Dorsal side green and pale green at ventral side
Groma Yashi	Elliptical to lanceolate	Elliptical to lanceolate	Slightly aristate to acuminate	Narrowly cuneate but lateral leaflet has rounded	Crenulate, superficially	Dull smooth	Dorsal side dark green and light green ventral side

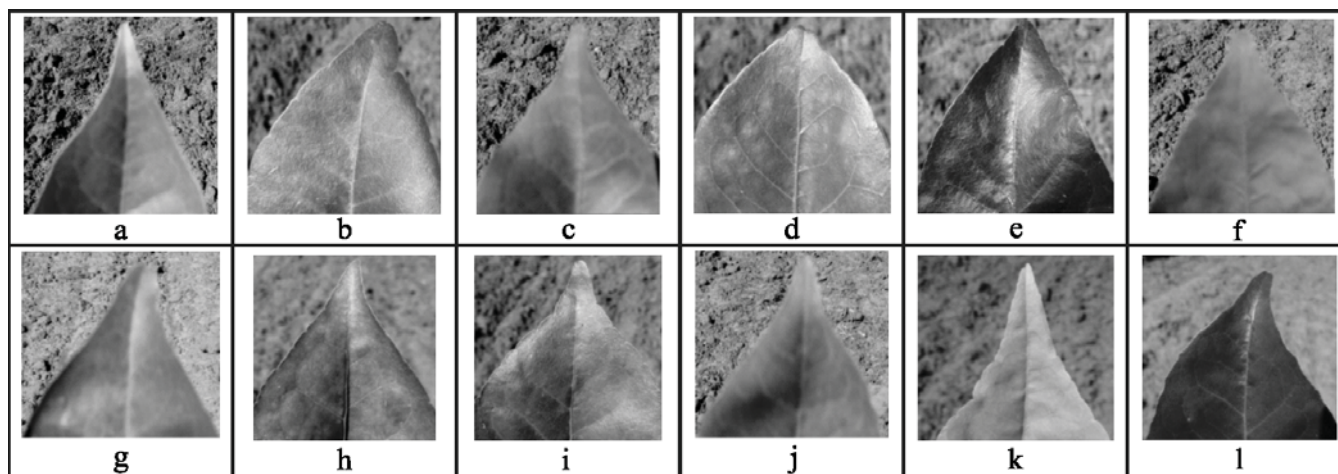


Fig.2. Leaf apex of different bael varieties: a, CISHB 1: acuminate; b, CISHB 2: acute, c, Goma Yashi: aristate; d, Pant Aparna: sub acute; e, Pant Sujata: acute; f, Pant Shivani : acute; g, Pant Urvashi: acuminate; h, NB 7: acuminate; I, NB 16: acute; j, NB 5: acuminate; k, NB 17: acuminate; l, NB 9: acuminate.

other leaf traits due to different climatic factors. Based on visual observation of leaf apex, varieties showed four types of leaf apex, viz. acute, subacute, acuminate and aristate type (Fig. 2). Varieties, CISHB1, NB7, NB5 and NB17 had acuminate apex, Pant Aparna (sub acute), Pant Sujata, Pant Urvashi, Pant Shivani and NB16 had acute type. However, CISHB2 and NB9 which had central leaflet acuminate and laterals acute apex, Goma Yashi had slightly aristate to acuminate in central leaflet and acuminate in lateral leaflet (Fig. 2). Leaflet in most of the varieties showed cuneate type of leaf base but degree of angle varied, i.e. broadly cuneate and narrowly cuneate, tapering (Table 1).

The broadly cuneate leaf base was observed in Pant Aparna and Pant Shivani, narrowly cuneate in CISHB1 (tapering), NB9 and NB16, but CISHB2 and Pant Urvashi had rounded type of leaf base (Fig. 3). However, CISHB1 had narrowly cuneate leaf base but oblique from one side, while in NB7 central leaflet was narrowly cuneate and laterals had slightly attenuate leaf base while NB17 had narrowly cuneate and Pant Shivani had broadly cuneate type central leaflet leaf base, but lateral leaflet had rounded leaf base. Similar finding has also been reported in *M. tomentosa* by Singh *et al.* (2013) in leaf morphology. The morphological characters showed considerable variability among 31 genotypes of *Morinda tomentosa*.

Leaf margin in CISHB1, Goma Yashi and Pant Urvashi had crenulate superficially; prominent crenulate in NB16, NB17 and Pant Sujata, bicrenate prominent in CISHB2, NB7 and prominent crenate in Pant Aparna. Whereas it was superficially crenate observed in NB9, NB5, and Pant Shivani (Fig. 3). However, Kawamura *et al.* (2010) has reported in *Arabidopsis* that the quantity production and

transportation of auxin in leaf margin influence different shapes and margin.

In leaf colour and leaf texture, there were significant differentiation in dorsal and ventral colour of leaflet and texture. Varieties, CISHB1, Pant Sujata, NB9 and NB16 had dark green colour at both the sides and shiny smooth excluding CISHB1 which had dull and rough surface. The leaf colour in CISHB2, Pant Aparna, NB7 and Goma Yashi was dark green at dorsal surface and light green at ventral surface; texture dull papery in CISHB2, rough in Pant Aparna, shiny smooth in NB7 and dull smooth Goma Yashi. Pant Urvashi and Pant Shivani had light green at both the side and texture was shiny smooth and dull rough, respectively.

Quantitative Morphological Character

Variety NB7 (26.06 cm) had longest leaf, compared to other varieties (Table 2). The shortest leaf was measured in NB9 (15.35 cm), followed by CISHB1 (15.54 cm). The length of central leaflet lamina was maximum in NB7 (20.05 cm) and minimum in NB9 (9.71 cm). The width of central leaflet lamina ranged between 9.19 and 10.72 cm maximum being in CISHB1 (10.72 cm) and minimum (5.39 cm) in NB9. The length of right lateral leaflet lamina was maximum in NB7 (15.00 cm), whereas it was recorded minimum (7.03 cm) in NB16, followed by Pant Urvashi (7.34cm). The width of right lateral leaflet lamina ranged between (3.50 and 8.27 cm), which was maximum (8.27 cm) in NB7 and the same was minimum in NB16 (3.50 cm). The length of left lateral leaflet lamina was found the maximum in NB-7 (14.52 cm) and the same was minimum in NB16 (7.32 cm), followed by Goma Yashi (7.57 cm) and Pant Urvashi (8.06cm). The width of left leaflet lamina was maximum (8.56 cm) in NB7 and minimum (3.30 cm), in

Table 2. Quantitative morphological leaf characters of bael varieties

Variety	Leaf length (cm)	Central leaflet lamina length (cm)	Central leaflet lamina width (cm)	Right lateral leaflet lamina length (cm)	Right lateral leaflet lamina width (cm)	Left lateral leaflet lamina length (cm)	Left lateral leaflet lamina width (cm)	Leaflets thickness (cm)	Central Petiolule length (cm)	Central Petiolule width (cm)	Petiole length (cm)	Petiole width (cm)	Internodal distance (cm)	Phyllotaxy
CISHB 1	15.54	13.01	10.72	9.0	4.56	9.00	4.51	0.05	2.54	0.17	2.97	0.13	4.04	Pentastichous
CISHB 2	18.83	14.86	8.34	9.0	5.89	9.87	6.03	0.05	3.96	0.28	4.04	0.29	4.24	Tristichous
Pant Aparna	17.54	14.42	8.18	8.5	5.57	9.25	6.53	0.06	1.75	0.30	3.86	0.16	4.51	Pentastichous
Pant Sujata	17.02	14.12	8.34	8.5	6.80	8.58	6.86	0.03	2.03	0.16	4.32	0.13	3.53	Tristichous,
Pant Urvaashi	16.50	13.94	7.37	7.3	4.20	8.06	5.53	0.06	2.76	0.80	3.97	0.13	3.51	Pentastichous
Pant Shivani	16.50	14.11	6.73	9.0	6.09	8.32	5.84	0.03	1.88	0.12	3.12	0.13	3.82	Pentastichous
NB 5	15.54	12.25	6.18	8.5	5.06	9.00	6.04	0.06	1.57	0.38	2.56	0.13	3.00	Tristichous
NB 7	26.06	20.05	9.19	15.0	8.27	14.52	8.56	0.04	2.56	0.14	5.73	0.13	4.56	Pentastichous
NB 9	15.35	9.87	5.39	9.0	4.81	10.53	4.81	0.05	3.06	0.11	3.56	0.11	4.53	Tristichous
NB 16	17.01	13.35	5.99	7.0	3.50	7.32	3.30	0.04	2.85	0.15	3.50	0.15	3.20	Tristichous
NB 17	18.56	12.70	7.16	8.36	4.84	8.34	4.50	0.04	2.18	0.13	4.25	0.18	3.50	Pentastichous
Goma Yashi	16.50	10.50	7.20	8.0	5.57	7.57	6.06	0.06	1.50	0.11	4.50	0.10	3.50	Tristichous
C.D (5%)	3.51	2.71	1.51	1.74	1.09	1.83	1.14	0.12	0.47	0.04	0.75	0.02	0.76	-----

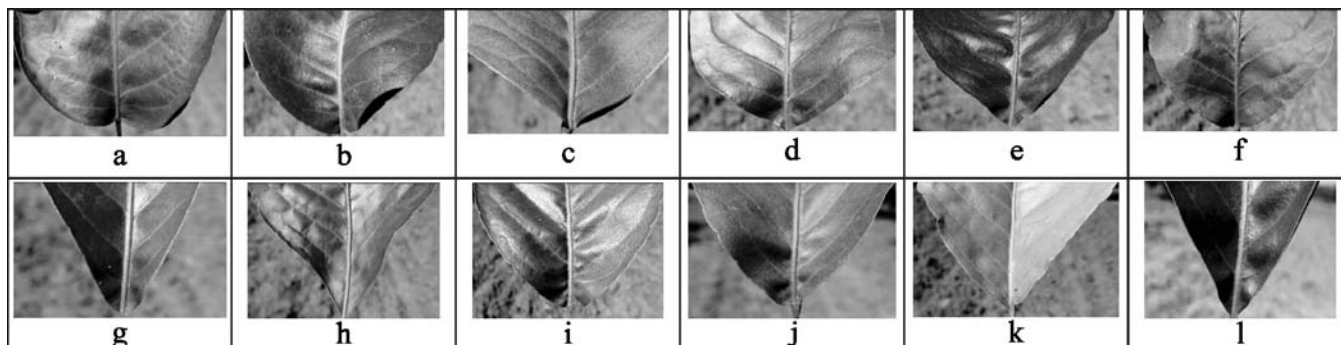


Fig. 3. Leaf base of different varieties of bael: a, Pant Urvashi: round; oblique from one side; b, CISHB 2: round; c, Goma Yashi: narrowly cuneate; d, Pant Aparna: broadly cuneate; e, Pant Sujata: narrowly cuneate; f, Pant Shivani: round; g, CISHB 1: narrowly cuneate (tapering); h, NB 7: attenuate; i, NB 16: narrowly cuneate; j, NB 5: narrowly cuneate oblique from one side; k, NB 17: narrowly cuneate; l, NB 9: narrowly cuneate (tapering).

NB-16 followed by CISHB1 (4.51 cm) and NB17 (4.50 cm).

The thickness of leaf ranged between 0.03 and 0.06 cm. The maximum value for leaf thickness (0.06 cm) was in Pant Aparna, NB5 and Goma Yashi, but it was minimum (0.03 cm) in Pant Sujata and Pant Shivani. The mean leaf thickness was observed 0.04 cm in NB7, NB16 and NB17 under rainfed condition.

The central petiolule length was maximum (3.96 cm) in CISHB2, followed by NB9 (3.06cm) and it was minimum (1.50 cm) in Goma Yashi. The central petiolule width was highest in NB5 (0.38 cm), followed by CISHB2 (0.28 cm) and it was lowest (0.8 cm) in Pant Urvashi, followed by NB9 (0.11 cm) and Goma Yashi (0.12 cm) and NB17 (0.13 cm). The lateral petiolule of both the leaflets had more or less insignificantly small stalk which ranged between 0.3 and 0.7cm which could be designated as sessile in all varieties. The maximum petiole length in NB7 (5.73 cm), whereas it was minimum in CISHB1 (2.97 cm). Petiole thickness was highest in CISHB2 (0.29 cm), followed by NB16 (0.15 cm) and it was minimum (0.10 cm) in Goma Yashi,

followed by NB9 (0.11 cm). The distance between two internodes ranged between 3.00 and 4.56 cm being maximum in NB7 (4.56 cm) and the minimum in NB5 (3.0 cm), followed by NB-16 (3.20 cm). Variability in leaf biometrics of bael varieties are in agreement to the finding as reported by Verma *et al.* (2003) in *Rubus* species.

Phyllotaxy

The tristichous (1/3 phyllotaxy) was commonly noted in CHESB 2, Pant Urvashi, Pant Sujata, NB 5, NB 16, NB 17 and Goma Yashi, whereas pentastichous (2/5 phyllotaxy) was observed in CHESB 1, Pant Aparna, Pant Shivani, NB 7 and NB 9 type. However, phyllotaxy was more or less found specific to each variety.

There was difference in tree habit, leaf size, petiole size, phyllotaxy and leaf margin. The major variations in tree habit, *i.e.* upright in CISHB 1 and CISHB 16; semi-spreading in CISHB 2, NB 5, Goma Yashi and NB 7, whereas Pant Sujata, Pant Aparna and Pant Shivani had drooping growth habit. The leaf shape (lanceolate to broad ovate, ovate) and phyllotaxy

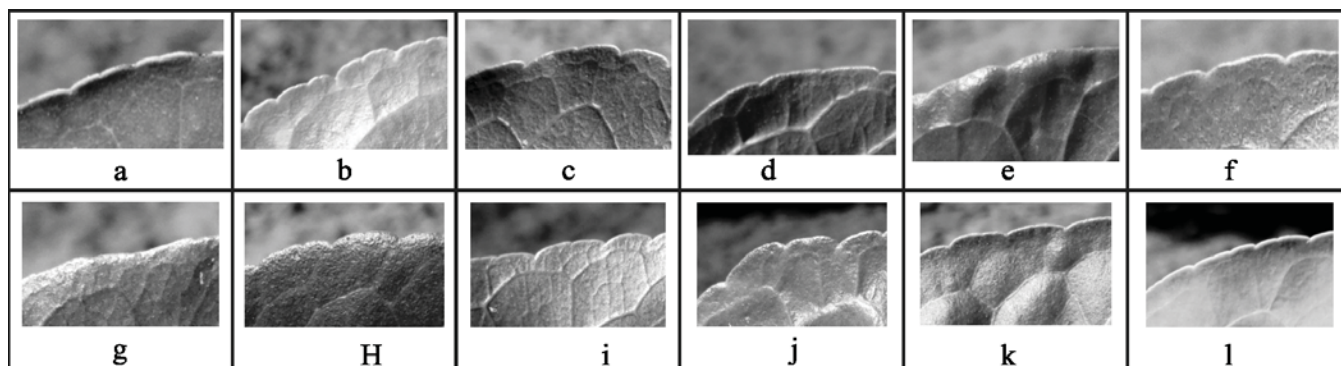


Fig. 4. Leaf margin of different bael varieties: a, CISHB 1: superficially crenulate; b, CISHB 2: prominent bicrenate; c, GomaYashi: superficially crenulate; d, NB 5: superficially crenate; e, NB 7: prominent crenate; f, Pant Urvashi: superficially crenulate; g, NB 9: superficially crenate; h, NB 16: prominent crenulate; i, NB 17: crenate prominent; j, Pant Aparna: prominent crenate; k, Pant Shivani: superficially crenate; l, Pant Sujata: prominent crenulate.

(tristichous and pentastichous) were observed. Variability specifically to leaf margin (prominent crenate in CISHB 2, NB 7 and NB 17; crenate, superficially crenulate in Goma Yashi) and leaf apex (aristate in GomaYashi) were observed as distinct characters. The leaves were large broad in NB 7, compared to other varieties. Then, it may be concluded that bael varieties can easily be differentiated on the basis of qualitative and quantitative morpho-logical traits.

REFERENCES

- Gomez K A and Gomez A A. 1984. *Statistical Procedure for Agricultural Research*, 2nd edn., John Wiley and Sons Inc., New York.
- Kawamura E, Horiguchi G and Tsukaya H. 2010. Mechanisms of leaf tooth formation in Arabidopsis. *The Plant Journal* **62** : 429–41.
- Metcalf C R and Chalk L. 1979. *Anatomy of the Dicotyledons*, 2nd edn., Oxford, Clarendon Press.
- Misra K K, Singh R and Jaiswal H R. 1999. Studies on leaf characters, development pattern and shoot growth in bael genotypes. *Prog. Hort.* **31**(3-4) : 144-50.
- Mukharjee B and Ahmed K. 1957. Riboflavin. *Pakistan J. Biol. Agric. Sci.* **1** : 47-51.
- Nicotra A B, Leigh A, Boyce C K, Jones C S, Niklas K J, Royer D L and Tsukaya H. 2011. The evolution and functional significance of leaf shape in the angiosperms. *Functional Plant Biology* **38** : 535–52.
- Pandey D, Tandan D K, Hudedamani U and Tripathi M. 2013. Variability in bael (*Aegle marmelos* Corr.) genotypes from eastern Uttar Pradesh. *Indian Journal of Horticulture*, **70**(2) : 170-78.
- Rai M and Dwivedi R. 1992. Bael (*Aegle marmelos* Correa) diversity in India. In : *Underutilized Fruits of Medicinal Value*, IBPGR Newsletter **10** : 13-14.
- Simpson M G. 2006. *Plant Systematic*. Elsevier Academic Press, Netherlands.
- Singh A K, Singh Sanjay and Joshi H K. 2013. Assessment of *Morinda tomentosa* genotypes for morphological and qualitative characters under rain fed semi-arid conditions of western India. *Proceeding of Noni Search National Symposium on Noni for Sustainable Wellness*, held at GKVK, Bengaluru, 29-30 October 2013.
- Singh Sanjay and Singh A K. 2005. Genetic diversity in mahua (*Bassia latifolia*) under semi-arid ecosystem of Gujarat. *Indian Journal of Agricultural Science* **75**(8) : 519-23.
- Stace C A. 1980. The taxonomic importance of the leaf surface. *Current Concepts of Plant Taxonomy*. London Academic press.
- Verma S K, Arya R R, Singh H and Bhardwaj P N. 2003. Vegetative and Fruit characteristics of some *Rubus* Species grown in Uttaranchal. *Progressive Horticulture* **35**(2) : 183-88.
- Wilde S A, Voigt G K and Iyer J G. 1972. *Soil and Plant Analysis for Tree Culture*. New Delhi, Bombay & Calcutta. Oxford & IBH Pub. Co.
- Zeven A C and De Wet J M J. 1982. *Dictionary of Cultivated Plants and their Regions of Diversity: Excluding Most Ornamentals, Forest trees and Lower Plants*. Centre for Agricultural Publishing and Documentation (Pudoc), Wageningen.

Effect of varieties and minimal processing on glucosinolates content in cauliflower (*Brassica oleracea* var. *botrytis*)

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ABSTRACT

An experiment was conducted to find out the effect of varieties and minimal processing on glucosinolates content in cauliflower (*Brassica oleracea* L. var. *botrytis*) at Indian Agricultural Research Institute, New Delhi, during 2004-2006. Among cauliflower cultivars, Pusa Sharad had higher amount of glucosinolates (149.27 $\mu\text{mol}/100$ g), followed by Pusa Himjyoti (85.44 $\mu\text{mol}/100$ g). Cauliflower Sweta cut into florets, pre-treated with 150 ppm sodium hypochlorite for 2 minutes and 1 % citric acid for 5 minutes, packed in HDPE (500-L gauge), LDPE (100 -L gauge) and PP (100-L gauge) and stored at 5° C for 20 days. Afterwords, glucosinolates content was higher in cauliflower packed in HDPE films (55.78 $\mu\text{mol}/100$ g), followed by LDPE (43.74 $\mu\text{mol}/100$ g) and PP packaging (48.89 $\mu\text{mol}/100$ g).

KEY WORDS: Cauliflower, Glucosinolates, Mminimal processing, Phytochemicals, Varieties, Organic soil, Phenolic compounds.

Cauliflower (*Brassica oleracea* L. var. *botrytis*) is the power house of health- promoting phytochemicals such as glucosinolates, vitamin C and phenolic compounds. Glucosinolates are unique class of sulphur containing glycosides responsible for characteristic flavour. These glucosinolates are known to have cancer chemo-protective activity (Fahey *et al.*, 2001; Kaur and Kapoor, 2001). The risk of cancer can significantly be reduced by an intake of as little as 10 g of cruciferous vegetable per day (Price *et al.*, 1998).

The products of glucosinolates breakdown have been shown to act as anti-carcinogens by inhibition of the phase I enzymes and induction of the phase II enzymes that affect the xenobiotic transformations (Anil Kumar *et al.*, 2006). The variation in glucosinolate content is an effect of genetic factors, environment and their interaction. Quantitative differences of

glucosinolate content were reported in cultivars of brussels, sprouts, cauliflower and broccoli (Vallejo *et al.*, 2003). Within the cultivars, stage of maturity also had an effect on glucosinolate content. Seasonal effects on glucosinolate content were reported by Rosa and Gomes (2001). Winter or autumn seasons induce lower glucosinolate level due to short day, wet condition, cool temperature and less radiation. Broccoli grown in late season (December sowing) had more glucosinolate than early (March sowing) season (Vallejo *et al.*, 2003).

Organic soil has been suggested to increase the levels of glucosinolates. Brassicaceous crops require considerably more sulphur due to its role in the synthesis of glucosinolases. Sulphur deficiency in soil reduced the synthesis of gluconisolases (Zhao *et al.*, 1994 and Ciskca *et al.*, 2000). Although nitrogen is a constituent of glucosinolate, study by Mc Donald *et al.* (1981) showed that higher application of nitrogen tend to give less glucosinolate level. Higher levels of nitrogen fertilization resulted in more extensive use of products of the tricarboxylic acid cycle for production of protein instead of glucose for production of glucosinolates. Boron regulates the synthesis of glucosinolate yielding

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precursors (Shelp *et al.*, 1992). Apart from fertilization, water stress also tends to increase the synthesis of glucosinolates.

Minimal processing includes operations like cutting, shredding, washing *etc.*, to prepare “ready-to-use” vegetables. Cell rupture and membrane damage due to minimal processing would have paved the way to myrosinase to come into contact with glucosinolates to degrade them (Hansen *et al.*, 1995). In addition to this, comparatively higher concentration of O₂ in LDPE would have been the responsible factor for degradation of glucosinolates (Rangkadilok *et al.* 2002). Hence an experiment was conducted to find out the effect of different varieties and minimal processing on glucosinolate content in cauliflower.

MATERIALS AND METHODS

Freshly harvested curds of uniform size and maturity of three cauliflower varieties, *viz.* Pusa Sharad, Pusa Hybrid 2 and Pusa Himjyoti were obtained from the Unit of Vegetable Research and Demonstration, Indian Agricultural Research Institute, New Delhi. Immediately after harvesting, they were transported to Division of Post-Harvest Technology, New Delhi. Outer leaves were removed and the curds were washed with tap water. Each variety was considered as one treatment. In each variety, six replications with 5 curds each were taken for the analysis of glucosinolate.

Freshly harvested cauliflower curd of var. Sweta were obtained from commercial growers, Najafgarh, New Delhi. They were transported to Post-Harvest Technology laboratory, Indian Agricultural Research Institute, New Delhi within 4-5 hours of harvesting. They were washed with tap water and cut into florets (5.5 cm × 3 cm) using a sharp serrated knife. The florets were then washed again and air dried. Florets were treated with 150 ppm sodium hypochlorite for 2 minutes and 1% citric acid for 5 minutes, packed in 500-gauge high density polyethylene (HDPE), 100-gauge low density polyethylene (LDPE) and 100-gauge polypropylene (PP) and stored at 5°C for 20 days. The experiment was laid as a completely randomised design. Glucosinolates was estimated at the end of storage.

Glucosinolates were analyzed as per the method described by Vallego *et al.* (2002). Florets were ground into a fine powder. Powder (1 g) was extracted with 3.5 ml of 70% methanol. The extracts were heated at 70°C in a water bath for 10 min, then centrifuged (500 g, 10 min., 4°C) to remove particulate matter. The supernatants were decanted. The remaining pellets were re-extracted with 3.5 ml of 70% methanol to ensure complete extraction and the extracts were again

centrifuged (500 g, 10 min., 4°C). The two supernatants were combined and made up to a final volume of 5 ml with 70% methanol.

Desulphation and initial separation of desulphoglucosinolates were performed using columns. Columns were prepared by sephadex A35 and 2 M acetic acid (1:1 w/v). These columns were washed with 2 ml of 6 M imidazole formate followed by 2 × 2 ml water (HPLC grade). One ml methanol extract was loaded onto a column and washed with 2 × 1 ml of 0.1 M sodium acetate (pH 4.0). Sulphatase (100 µl) was loaded onto column and desulphation was done overnight (12 h) at room temperature. The desulphoglucosinolates were eluted with 3 × 500 µl of water. Sinigrin (2-propenyl glucosinolate) of 3 mM concentration (in 70% methanol) was used as a standard.

Each sample (20 µl) was analysed on a HPLC system (Thermo Separation Product Model Spectra System P 2000) consisting of UV detector set at 227 nm and a RP-18 column (5 µm particle size). The flow rate was 1.5 ml/min. The mobile phase was a mixture of water and acetonitrile (4:1). The amount of glucosinolates was expressed as µmol/100g of sinigrin.

RESULTS AND DISCUSSION

Significantly higher levels of glucosinolates (149.27 µmol/100 g) were estimated in Pusa Sharad compared to Pusa Himyoti (85.44 µmol/100 g) and Pusa Hybrid-2 (63.74 µmol/100 g).

The variation in glucosinolate content may be due to genetic variability among the cultivars. The biosynthesis of glucosinolates depends on various factors such as genetic factors, stage of maturity, season and fertigation in various cole crops (Fig. 2). Winter or autumn seasons slow down glucosinolates biosynthesis due to short day, wet condition and cool temperature. Since the cauliflower cultivars were harvested in different seasons having variability in temperature, the variation in glucosinolate could possibly be due to the season.

Minimally processed vegetables are living tissues that are undergoing catabolic activities. Packaging of minimally processed cauliflower in permeable polymeric film can reduce O₂ concentration and increase CO₂ concentration in the package atmospheres, thereby affecting quality attributes.

There was effect of modified atmosphere packaging on the retention of glucosinolate (Sinigrin) content of minimally processed cauliflower on 20th of day of storage (Fig. 2). The glucosinolates content was found to be the higher in cauliflower packed in HDPE films (55.78 µmol/100 g), followed by LDPE (48.89 µmol/100 g) and PP packaging (43.74 µmol/100 g). The lower

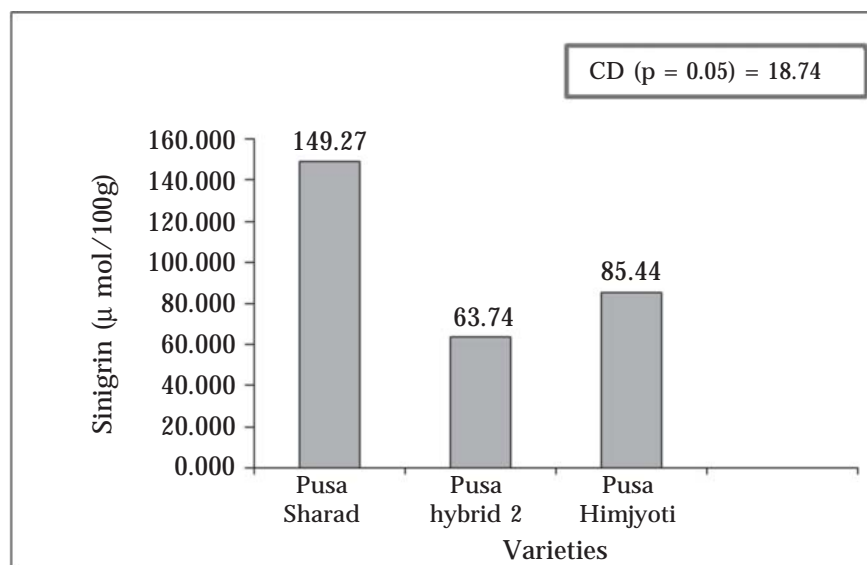


Fig. 1. Varietal influence of glucosinolates in cauliflower

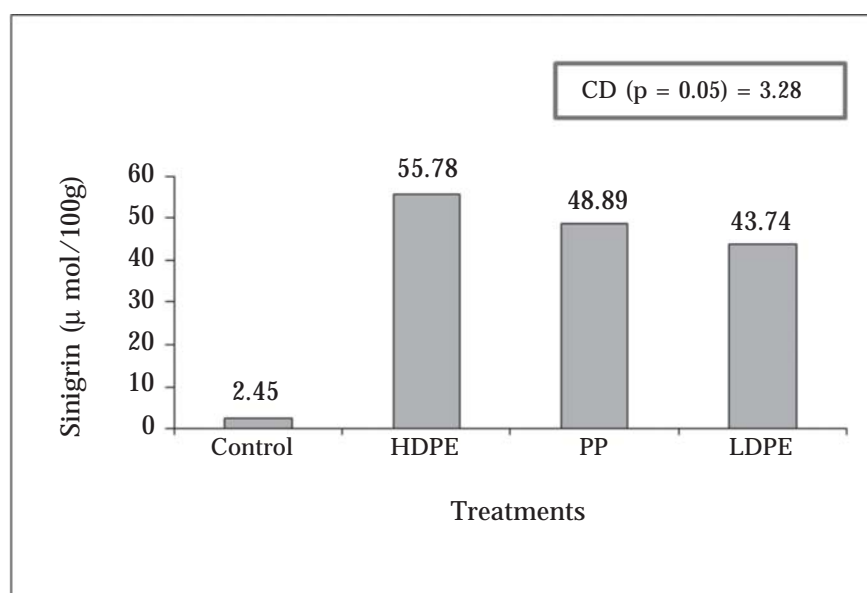


Fig. 2. Effect of packaging material on glucosinolates in minimally processed cauliflower

content of glucosinolates in florets packed in LDPE might be due to cell rupture and membrane damage would have paved the way to myrosinase to come into contact with glucosinolates.

The amount of glucosinolates is influenced by season. Higher amount of glucosinolates was estimated in early variety of cauliflower than late variety. The glucosinolates content was found to be the higher in minimally processed cauliflower packed in HDPE films followed by LDPE and PP packaging.

REFERENCES

- Anil Kumar K R, Khanum F and Bawa A S. 2006. Dietary role of glucosinolate derivatives; A review. *J. Food Sci. Technol.* **43**(1) : 8-17.
- Ciskca E., Przybyszewska M. and Kozłowska H. 2000. Content of glucosinolates in cruciferous vegetables grown at the same site for two years under different climatic conditions. *J. Agric. Food Chem.* **48** : 2862-2867.
- Fahey J W, Zalemann A T and Talalay P. 2001. The chemical diversity and distribution of glucosinolates and

- isothiocyanates among plants. *Phytochemistry* **56** : 5-51.
- Hansen M, Moller P and Sorensen H. 1995. Glucosinolates in Broccoli stored under controlled atmosphere. *J. Amer. Soc. Hort. Sci.* **120**(6) : 1069-1074.
- Kaur C and Kapoor H C. 2001. Antioxidant activity and quality of minimally processed Indian Cabbage (*Brassica oleracea* var. *Capitata*). *Journal of Food Processing and Preservation.* **25**(5) : 367-380.
- Mc Donald R C, Manley T R, Barry T N, Forss B A and Sinclair A G. 1981. Nutritional evaluation of kale (*Brassica oleracea*) diets 3 : changes in plant composition induced by soil fertility practices, with special reference to SMCO and glucosinolate concentration. *J. Agri. Sci. Camb.* **97** : 13-23.
- Price K R, Casascelli F, Colquhoun I J and Rhodes M J C. 1998. Composition and content of flavonol glycosides in broccoli florets. (*Brassica oleracea*) and their fate cooking. *J. Sci. Food Agri.* **77** : 468-472.
- Rangkadilok N, Tomkins B, Nicolas M E, Premier R R, Bennett R N, Eagling D R and Taylor, P W. 2002. The effect of post harvest and packaging treatments on glucoraphanin concentration in Broccoli (*Brassica oleracea* var. *italica*) *J. Agric. Food Chem.* **50** : 7386-7391.
- Rosa E and Gomes M H. 2001. Relationship between free amino acids and glucosinolates in primary and secondary inflorescences of 11 broccoli (*Brassica oleracea* L. var. *italica*) cultivars grown in early and late seasons. *J. Sci. Food Agric.* **82** : 61-64.
- Shelp B J, Shattuck V I, McLellan D and Liu, L. 1992. Boron nutrition and the composition of glucosinolates and soluble nitrogen compounds in two broccoli (*Brassica oleracea* var. *italica*) cultivars. *Can. J. Plant Sci.* **72** : 889-899.
- Vallejo F, Barberan FAT, Bena vente Garcia A G and Garcia Viguera C. 2003. Total and individual glucosinolate contents in inflorescences of eight broccoli cultivars grown under various climatic and fertilization conditions. *J. Sci. Food Agric.* **83** : 307-313.
- Zhao F, Evans E J, Bilsborrow P E, Syers J K. 1994. Influence of nitrogen and sulphur on the glucosinolate profile of rapeseed. (*Brassica napus* L.) *J. Sci. Food Agric.* **64** : 295-304.

Effect of different chemicals on spike length and quality of cut carnation (*Dianthus caryophyllus*) flowers cv. Red Domingo

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ABSTRACT

The experiment was conducted to find out the effect of different chemicals on spike length and quality of cut flowers of carnation (*Dianthus caryophyllus* L.) during 2009 at ASPEE Collage of Horticulture and Forestry, Navsari. The chemicals like sucrose, 8HQC, aluminum sulphate and citric acid were used. There were 15 treatments comprising three spike length and five chemicals along with their all possible combinations. Three spike length were: L₁-30 cm, L₂-45 cm and L₃-60 cm, with five chemicals were: C₁ - sucrose 4%, C₂ - sucrose (4%) + 8-HQC (200 mg/litre), C₃ - sucrose (4%) + Al₂(SO₄)₃ (100 mg/litre), C₄ - sucrose (4%) + citric acid (200 mg/litre) and C₅ - control (distilled water) in a completely randomized design with factorial concept. The treatments were repeated thrice. Different spike length and chemicals, 60 cm spike length and sucrose 4% + 8-HQC 200 mg/litre were found to be the most beneficial for improving vase-life. Similar trend was observed on quality parameters such as fresh weight, solution uptake and flower diameter. In combination of 60 cm spike length and sucrose 4% + 8-HQC 200 mg/litre all quality parameters found significant on 12th day. While, colour and freshness were excellent in the same combination throughout the period of investigation.

KEY WORDS: Carnation, Spike length, 8-HQC, Sucrose, Aluminum sulphate and Citric acid

Carnation (*Dianthus caryophyllus* L.) is essentially a florist's crop, widely cultivated on a commercial scale in different parts of the world. In recent years, carnation is gaining popularity with its increased area and production. The development of standard type of carnation revolutionized its trade. In Gujarat, area under carnation crop is about 7 ha producing 147 lakh cut carnations. But still nearly, 40-50% losses of cut flowers occur due to improper post-harvest handling during entire market chain.

MATERIALS AND METHODS

The fresh cut flowers of carnation cv. Red Domingo were collected and pulsed in water immediately after harvesting. In total, 15 treatments

were tried comprising three spike length and five chemicals along with their all possible combinations. Three spike length were : L₁-30 cm, L₂-45 cm and L₃-60 cm and five chemicals were C₁ - sucrose 4%, C₂ - sucrose (4%) + 8-HQC (200 mg/litre), C₃ - sucrose (4%) + Al₂(SO₄)₃ (100 mg/litre), C₄ - sucrose (4%) + citric acid (200 mg/litre) and C₅ - control (distilled water). The treatment were tried in completely randomized design with factorial concept during December 2009 and repeated thrice. The research work was carried out at P. G. Laboratory, Department of Horticulture, N. M. College of Agriculture, Navsari Agricultural University, Navsari. The observations were recorded according to the standard methodology for flower weight, water uptake and flower diameter at 3, 6, 9 and 12 days intervals.

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RESULTS AND DISCUSSION

Fresh weight

The fresh weight was significantly influenced by different spike length of carnation flower (Table 1) and maximum fresh weight (%) of flowers at 3, 6, 9 and 12 days (106.52, 100.44, 90.57 and 69.72 %, respectively) were found in 60 cm (L_3) spike length, which was at par with 30 cm L_2 treatment at 3, 6 and 9 days. The minimum fresh weight (%) of flowers on 3, 6 and 9 days (104.97, 97.41 and 86.34 %, respectively) were recorded in 30 cm spike length treatment. Maximum fresh weight at 3, 6, 9 and 12 days (109.48, 105.06, 97.61 and 49.20 %, respectively) were recorded when they were kept in sucrose 4 % + 8 HQC 200 mg/litre. The minimum fresh weight (%) was noted in the control (distilled water). The interaction effect of spike length and chemicals were found non-significant except at 12 days of storage (Table 2).

The higher fresh weight (%) during vase-life as compared to the rest of the treatments might be due to sucrose acts as a carbon source, maintains mitochondrial structure, function and improves water balance in cut flowers (Halevy and Mayak, 1981) and help in increasing the level of moisture retention in cut flowers, thus increasing their fresh weight as a consequence of improved water balance. It also reduces the transpiration loss due to increased osmotic potential of cytoplasm. Further, it is also known to act as an oxidisable respiratory substrate and as an antidesiccant, which helps in maintaining fresh weight of cut flowers (Marousky, 1969). While, 8-HQC is known to reduce transpirational loss of water and increase the fresh weight by partially closing the stomata's (Marousky, 1969). The 8-HQ served as a good surfactant solution with its strong antimicrobial properties and also by elimination of physiological stem blockage in sterile tissue encouraged free flow of the water uptake (Marousky, 1972). The significant increase in fresh weight of cut spikes could be attributed to strong antimicrobial activities of 8-HQ (Rogers, 1973) that restricted the growth of microorganisms in the solution.

Water uptake

The effect of different spike length had significant effect on solution uptake during the vase-life (Table 1) and maximum solution uptake at 3, 6, 9 and 12 days (46.80, 43.27, 37.53 and 20.00 ml, respectively) was observed in flowers having 60 cm spike length. While flowers having 30 cm spike length (L_1) suffered minimum solution uptake at 3, 6 and 9 days (44.53, 41.13 and 35.20 ml, respectively). Maximum volume of solution uptake was noted in solution containing

sucrose 4% + 8 HQC 200 mg/litre (C_2) at 3, 6, 9 and 12 days (51.56, 47.56, 43.89 and 18.33 ml, respectively). While, minimum uptake of solution was recorded in the control (distilled water) on all days. The interaction between spike length and chemicals failed to show any significant effect on solution uptake up to 9 day but on 12 days (Table 2). Significantly maximum (28.33 ml) solution uptake was recorded in 60 cm spike length with sucrose 4% + 8 HQC 200 mg/litre (L_3C_2).

The maximum solution uptake might be due to sucrose having source of carbohydrate and HQC reduced stem blockage. Water uptake in cut flowers takes place mainly because of the need to maintain the water balance in the cut flowers against transpiration loss of water. The addition of sucrose to vase solution decreases the water potential in tissues thereby improving the water uptake by the cut stem (Kofranek and Halvey, 1976). Increase in water uptake due to various chemicals in the vase solutions was mainly attributed to reduction in the vascular blockage of the stem by preventing bacterial and fungal growth (Gowda, 1986; Marousky, 1969, 1972; Doorn and Parek, 1990).

Flower diameter

Maximum flower diameter at 3, 6, 9 and 12 days (5.97, 5.69, 4.51 and 3.65 cm, respectively) were recorded in those flowers having 60 cm spike length which was at par with 45 cm (L_2) treatment at 3 and 6 days (5.90 and 5.62 cm, respectively) (Table 1). However, cut flowers having 30 cm spike length were recorded significantly minimum flower diameter at 3, 6 and 9 days (5.83, 5.44 and 4.23 cm, respectively). In vase effect, maximum flower diameter at 3, 6, 9 and 12 days (6.25, 6.09, 5.04 and 3.11 cm, respectively) were observed in cut flowers in sucrose 4 % + 8 HQC 200 mg/litre (C_2). Whereas, minimum flower diameter at 3, 6, 9 and 12 days (5.43, 5.02, 3.56 and 1.91 cm, respectively) were noted in the control (C_5). The interaction effect again found significant at 12 days (Table 2).

The maximum flower diameter effect might be due to when exogenous sugars in the form of sucrose were supplied to the vase solutions, flowers diameter reported to be increased significantly up to the senescence day. The sucrose provides energy and HQC protects against bacteria resulting in healthy condition of cut flowers which exhibits bigger size flowers. Addition of other chemicals with sucrose in vase solution can be seen to increase the flower diameter significantly over the treatments containing only the sucrose. These chemicals are known to have bactericidal and fungicidal properties and therefore, stem blockage due to bacterial growth is prevented

Table 1. Effect of different spike length and chemicals on change in weight (%), solution uptake (ml) flower diameter (cm) and vase-life (days) in cut carnation flower cv. Red Domingo.

Treatments	Change in fresh weight (%)				Solution uptake (ml)				Flower diameter (cm)				Vase life (days)
	3 rd day	6 th day	9 th day	12 th day	3 rd day	6 th day	9 th day	12 th day	3 rd day	6 th day	9 th day	12 th day	
Spike length (L)													
L ₁	104.97	97.41	86.34	0.00	44.53	41.13	35.20	0.00	5.83	5.44	4.23	0.00	10.97
L ₂	105.70	99.05	88.85	68.60	45.67	42.06	36.27	18.00	5.90	5.62	4.36	3.56	13.05
L ₃	106.52	100.44	90.57	69.72	46.80	43.27	37.53	20.00	5.97	5.69	4.51	3.65	15.00
SEm. ±	0.42	0.49	0.65	0.34	0.18	0.11	0.12	0.15	0.04	0.04	0.04	0.02	0.07
CD (5 %)	1.22	1.42	1.89	0.98	0.52	0.33	0.34	0.44	0.11	0.11	0.11	0.05	0.21
Chemicals (C)													
C ₁	104.41	96.37	85.52	44.48	42.67	39.56	32.56	9.44	5.79	5.42	4.05	2.10	12.55
C ₂	109.48	105.06	97.61	49.20	51.56	47.56	43.89	18.33	6.25	6.09	5.04	3.11	13.88
C ₃	105.09	99.94	89.27	45.71	45.44	42.33	35.89	12.78	5.96	5.58	4.42	2.31	13.00
C ₄	106.68	102.05	92.04	47.45	48.67	44.78	39.78	16.11	6.08	5.81	4.75	2.62	13.33
C ₅	102.99	91.44	78.50	43.70	40.00	36.56	29.56	7.22	5.43	5.02	3.56	1.91	12.22
SEm. ±	0.54	0.63	0.84	0.44	0.23	0.15	0.15	0.19	0.05	0.05	0.05	0.02	0.09
CD (5 %)	1.57	1.83	2.43	1.27	0.67	0.43	0.44	0.57	0.14	0.15	0.14	0.07	0.27
Interaction (L × C)													
SEm ±	0.94	1.10	1.45	0.76	0.40	0.25	0.26	0.34	0.09	0.09	0.08	0.04	0.16
CD (5 %)	NS	NS	NS	2.20	NS	NS	NS	0.99	NS	NS	NS	0.12	NS
CV (%)	1.54	1.93	2.85	2.86	1.53	1.05	1.24	4.66	2.53	2.72	3.29	3.05	2.19

Table 2. Interaction effect between different spike length and chemicals on change in fresh weight (%), solution uptake (ml) and flower diameter (cm) of cut carnation flower cv. Red Domingo on 12th day

Treatment	Change in fresh weight (%)	Solution uptake (ml)	Flower diameter (cm)
L ₁ C ₁	00.00	00.00	00.00
L ₁ C ₂	00.00	00.00	00.00
L ₁ C ₃	00.00	00.00	00.00
L ₁ C ₄	00.00	00.00	00.00
L ₁ C ₅	00.00	00.00	00.00
L ₂ C ₁	66.37	13.33	3.15
L ₂ C ₂	72.90	26.67	4.64
L ₂ C ₃	67.83	18.33	3.45
L ₂ C ₄	70.84	23.33	3.75
L ₂ C ₅	65.08	8.33	2.83
L ₃ C ₁	67.08	15.00	3.16
L ₃ C ₂	74.70	28.33	4.65
L ₃ C ₃	69.29	20.00	3.48
L ₃ C ₄	71.52	25.00	4.10
L ₃ C ₅	66.02	13.33	2.85
SEm ±	0.76	0.34	0.04
CD (5 %)	2.20	0.99	0.12
CV (%)	2.86	4.66	3.05

and thereby maintains the water flow to the flower stem (Marousky, 1969, 1972; Doorn and Parik, 1990). Sucrose inhibits the senescence process and maintained water balance (Bhattacharjee, 1993). Since quinoline esters are acidic in vase solution, 8-HQC inhibits stem plugging by reducing pH of solution, thereby increasing conductivity of stems and hence increased flower diameter (Marousky, 1972). The 8-HQC also improves the diameter and opening of flowers due to its germicidal activity and antiethylene effect (Halevy and Mayak, 1981).

Vase-life

The vase-life of cut flowers increased with an increase in length of spikes (Table 1). The maximum vase-life was recorded in spikes having longest length 60 cm (L₃). This might be attributed due to variations in their reserved food materials and higher activity of progressive increase in spike length and due to successive improvement of transpirational pool. The Maximum vase-life was noted when cut flowers were kept in solution having sucrose (4 %) + 8-HQC (200 mg/litre). Sucrose is the main source of energy and good respiratory substrate for the maintenance of osmotic potential in flowers. Sugar had improved the water balance in cut flowers (Marousky, 1971). The 8-HQC is most effective fungicide and has a strong inhibition effect against bacteria, yeast and fungi and xylem blocking. The effect of 8-HQC component in enhancing vase-life of cut flowers might be due to fact that 8-HQC reduced physiological stem blockage in sterile tissues. It was suggested that this effect was related to the chelating

properties of quinoline esters, which may chelate metal ions of enzyme activity in creating stem blockage (Marousky, 1972).

REFERENCES

- Bhattacharjee S K. 1993. Studies on post-harvest life of cut roses. *Indian J. Hort.* **50**(2) : 174-79.
- Doorn WG and Perik R.J. 1990. 8-HQC and low pH prevent vascular blockage in stems of cut rose flowers by reducing the number of bacteria. *J. American Soc. Hort. Sci.* **115**(6) : 979-81.
- Gowda J N V. 1986. Post harvest life of China aster as influenced by chemical preservatives. *Curr. Res.* **15**(12) : 138-39.
- Halevy A H and Mayak S. 1981. Senescence and post harvest physiology of cut flowers. Part II. *Hort. Rev.* **3** : 59-143.
- Kofranek A M and Halevy A H. 1976. Sucrose pulsing of gladiolus stems before storage to increase spike quality. *Hort. Sci.* **11** : 572-73.
- Marousky F J. 1969. Vascular blockage, water absorption, stomatal opening and respiration of cut 'Better Times' roses treated with 8-Hydroxyquinoline citrate and sucrose. *J. American Soc. Hort. Sci.* **94** : 223-26.
- Marousky F J. 1971. Inhibition of vascular blockage and increased moisture retention in cut roses induced by pH, 8-Hydroxyquinoline and sucrose. *J. American Soc. Hort. Sci.* **96** : 38-41.
- Marousky F J. 1972. Water relations, effects of floral preservatives on bud opening and keeping quality of cut flowers. *Hort. Sci.* **7** : 114-16.
- Rogers M N. 1973. A historical and critical review of postharvest physiology research on cut flowers. *Hort. Sci.* **8** : 189-94.

Studies on post-harvest attributes of tuberose (*Polianthes tuberosa*) cultivars as influenced by tinting with edible colours

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ABSTRACT

Tuberose (*Polianthes tuberosa*) is a popular cut flower having white coloured fragrant blooms. In order to increase the value and appeal of flower along with fragrance, the spikes of tuberose can be tinted with artificial colours. Therefore, three cultivars viz. Shringar, Calcutta Double and Prajwal were selected to carry out tinting and post harvest studies. The freshly harvested cut flower spikes were treated with five edible dyes (Raspberry Red, Orange Red, Green, Yellow and Chocolate brown) alone or in combination with 8-HQC to observe the effect of edible dyes on quality and vase life of tuberose. The cut ends of tuberose spikes were immersed in dye solution for six hours and after that they were transferred to distilled water. Minimum weight loss (6.09 g) and percent weight loss (17.71%) was observed in cut spikes of cultivar prajwal, however, maximum weight loss (12.85 g) and percent weight loss (25.04 %) was recorded in cv. Calcutta Double. Maximum volume of dye uptake (6.89 ml) was recorded with 0.2 % green dye; among cultivars the spikes of cv. Calcutta Double showed maximum dye uptake (5.29 ml). Maximum water uptake (32.80 ml) was recorded in flowers treated with 0.2 % yellow dye + 200 ppm 8HQC (T₉). Among three cultivars maximum water uptake (31.46 ml) was recorded in cv. Shringar. Minimum floret drying (26.26%) throughout the studies was observed in flowers treated with 0.2% raspberry red dye+200ppm 8HQC. Among cultivars, Prajwal showed minimum floret wilting (24.63%). The maximum vase life (12.58 days) was observed with 0.2% raspberry red dye while minimum vase life (9.15 days) was observed with orange red dye. The cultivar Calcutta Double flowers exhibited maximum vase life (12.60 days) while cv. Prajwal flowers showed minimum vase life (8.81 days).

KEY WORDS: Colour retention, Food dyes, Tuberose, Tinting, Vase- life.

Tuberose (*Polianthes tuberosa*) is a perennial plant belongs to the family Agavaceae and is native of Mexico. Tuberose is also an important cut flower stands fifth in the international trade after rose, carnation, chrysanthemum and gladiolus. Because of its magnificent inflorescence, shape, size and keeping quality, it occupies prime position both in domestic and international market. It is used in flower arrangements and due to its excellent fragrance it is also used as loose flower and in perfume industry. The elongated spikes produces cluster of fragrant waxy white flowers that bloom from bottom towards top of the spikes unlike other cut flowers. The tuberose flowers

are found only in white colour with an intensity of creaminess. Value addition in floriculture increase the economic value and consumer appeal of any floral commodity. The value addition techniques like colouring of white flowers, flower dehydration, flower processing, advances in flower arrangement etc. can add value up to 5 to 10 times (Mekala *et al.*, 2012). Tinting is one of the important value addition techniques in flower crops where colour pigments are absent or light or dull. It enhances the aesthetic beauty of fresh and dry flowers. For decorative purpose where a particular color is desired, tinting of white flower could be the only way of obtaining the colour of interest. Artificial colouring of spikes can fetch a premium price in the market. Such type of artificial colouring is done by using food colours. Certified synthetic food colours are less expensive and lead to minimum health hazards by imparting an intense and uniform colour. Vase life

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of tinted flowers is also an important consideration, which varies with the dyes used, its concentration and also with the stage of harvest. Some chemicals prolong the vase life and some chemicals retards the vase life of flowers. As food dyes are also of chemicals in nature and their role in vase life alteration is unknown. Therefore, present study was conducted to find out the effect of edible food colours on improving the appearance as well as vase life of tinted spikes of tuberose cultivars.

MATERIALS AND METHODS

The present investigation was carried out in the laboratory of Division of Floriculture and Landscaping, IARI, PUSA, New Delhi during the year 2012-14. All the dyes used in the experimentation were of food grade, purchased from Standard Indian food dye companies. The experiment was carried out in completely randomized design with factorial concept and was replicated thrice. The flowers of tuberose cvs, Shringar, Calcutta Double and Prajwal were tinted with five edible dyes viz. green, orange, yellow, red and chocolate brown alone or in combination with 200 ppm 8-HQC and were compared with control (Distilled water). The flowers were harvested (when 2 basal florets were open) in the morning hours by cutting the spikes with sharp secateurs having the stalk length of above 65 cm. The 0.2 per cent solution of each dye was prepared by dissolving 200 mg of food dye in 100 ml of distilled water. The spikes were cut down to a height of 60 cm from base of the neck and at the base of the spikes a slant cut of 45° was given in order to make maximum dye solution absorption and then the spikes were left immersed in the dye solution for six hours. The observations were recorded for following parameters like physiological weight loss, percentage weight loss, volume of dye uptake, volume of water uptake, percentage floret dried and vase life.

The colour obtained and the colour retention by the spikes was recorded by using RHS colour chart. The wilting of fifty per cent of florets in the spikes was taken as an index of end of vase life of the flower spikes. The loss of water from the flower spikes due to transpiration was measured by observing the difference between consecutive measurements of container with solution and spikes recorded at beginning and at the end of vase life within the particular duration of period (Venkatarayappa *et al.*, 1981). The diameter of the fifth pair of floret in the spikes from the base was recorded with digital vernier calipers for five randomly selected spikes and the average value is taken as floret size in cm. Result of the experiments were analyzed using analysis of variance (ANOVA) and factorial CRD.

RESULTS AND DISCUSSION

It is clear from the data presented in Table 1 that the effect of dyes and preservative solution was found to be non significant w.r.t. physiological weight loss. Comparison of different cultivars shows that minimum physiological weight loss (6.09 g) was observed in cv. Prajwal and it was statistically at par with cv. Shringar. However, maximum physiological weight loss (12.85g) was recorded in cv. Calcutta Double. The interaction data (VXT) shows statistically significant difference w.r.t. physiological weight loss (PLW). Minimum physiological weight loss of spikes (3.90 gm) was found in cv. Prajwal treated with 0.2% Raspberry Red dye + 200 ppm 8 HQC (T₃) and it was statistically at par with cv. Shringar treated with T₃, T₅, T₈, T₁₀, T₁₁, T₁₂ treatments and in cv. Calcutta Double with 0.2% Orange Red dye+200 ppm 8-HQC (T₇) and in cv. Prajwal with all treatments except T₂. However, maximum PLW of spikes (16.70 gm) was found in cv. Shringar treated with Orange dye 0.2% + 200 ppm 8 HQC (T₇) and it was statistically at par with in cv. Shringar with treatments T₆ and in cv. Calcutta Double with treatments T₁, T₂, T₃, T₄, T₅, T₆, T₉, T₁₀ and T₁₂.

It is clear from table 1 that there was significant difference w.r.t. of the per cent weight loss among the cultivars, however, effect of treatments and cultivar × treatment interaction was found to be non significant. The minimum weight loss (17.71%) was recorded in cultivar Prajwal which was significantly superior over other cultivars while maximum weight loss (28.04 %) was recorded in cv. Calcutta Double. The difference in weight loss of different varieties might be due to the difference in their genetic makeup. The results are in close agreement with those of Chikhasubanna and Yogitha (2002), Singh *et al.* (2003), Dixit and Shukla (2005) and Khan *et al.* (2007).

Data presented in Table 2 shows that the maximum volume of dye uptake (6.89 ml) was recorded in spikes treated with 0.2% Green dye (T₂) and it was statistically at par with T₄, while minimum volume of dye uptake (3.94 ml) was observed in spikes treated with 0.2% Yellow dye + 200 ppm 8 HQC (T₉) and it was statistically at par with T₁, T₃, T₅, T₆, T₇, T₈ and T₁₀. Among cultivars maximum volume of dye uptake (5.29 ml) was observed in cv. Calcutta Double and it was statistically superior among all the cultivars. In cultivar and treatment interaction (VXT) data was found statistically significant and maximum volume of dye uptake (11.11 ml) was found in cv Calcutta Double treated with 0.2% Green dye (T₂V₂) which was significantly superior over all other treatment combinations.

Freshly harvested spikes of all the cultivars when

Table 1. Effect of tinting treatments on physiological weight loss (gm) and per cent weight loss in tuberose cultivars.

Treatments	Cultivars									
	Physiological weight loss (gm)					Weight loss (%)				
	Shringar (V ₁)	Calcutta Double (V ₂)	Prajwal (V ₃)	Mean	Shringar (V ₁)	Calcutta Double (V ₂)	Prajwal (V ₃)	Mean		
0.2% + Green dye +200 ppm 8 HQC (T ₁)	9.21	13.71	5.56	9.49	28.76(5.43)	29.34(5.51)	15.27(4.01)	24.46(4.98)		
0.2% Green dye (T ₂)	11.22	11.96	10.40	11.19	32.63(5.68)	27.40(5.30)	23.66(4.90)	27.90(5.29)		
0.2% Raspberry Red dye +200 ppm 8 HQC (T ₃)	6.71	12.89	3.90	7.83	17.47(4.25)	27.35(5.31)	12.88(3.42)	19.23(4.33)		
0.2% Raspberry Red dye (T ₄)	9.09	14.60	6.09	9.93	23.20(4.76)	31.77(5.72)	18.19(4.37)	24.39(4.95)		
0.2% Chocolate brown +200 ppm 8 HQC (T ₅)	7.79	16.65	4.96	9.80	18.76(4.40)	31.77(5.71)	16.15(4.14)	22.22(4.75)		
0.2% Chocolate brown (T ₆)	13.47	13.97	5.24	10.89	31.30(5.56)	25.32(5.10)	17.83(4.32)	24.81(4.99)		
0.2% Orange Red +200 ppm 8 HQC (T ₇)	16.70	8.33	7.88	10.97	37.07(6.09)	19.03(4.47)	23.68(4.96)	26.59(5.17)		
0.2% Orange Red (T ₈)	6.37	9.64	8.07	8.03	20.07(4.35)	21.07(4.65)	23.07(4.90)	21.41(4.63)		
0.2% Yellow dye +200 ppm 8 HQC (T ₉)	9.00	14.06	5.12	9.39	27.51(5.22)	33.09(5.84)	15.32(3.92)	25.30(4.99)		
0.2% Yellow dye (T ₁₀)	8.15	12.15	5.49	8.60	24.35(5.03)	30.23(5.59)	17.63(4.27)	24.07(4.96)		
Distilled water (T ₁₁)	5.98	10.59	5.51	7.36	17.03(4.24)	25.68(5.15)	15.40(4.05)	19.37(4.48)		
200 ppm 8-HQC (T ₁₂)	5.19	15.61	4.88	8.56	14.17(3.88)	34.43(5.95)	13.49(3.81)	20.70(4.54)		
Mean	9.07	12.85	6.09		24.36(4.91)	28.04(5.36)	17.71(4.26)			
C.D (P=0.5%)						3.80 (0.39)				
Cultivar		1.41								
Treatments		NS						NS		
Cultivar × Treatments		4.88						NS		

Table 2. Effect of tinting treatments on volume of dye and volume of water uptake in tuberose cultivars.

Treatments	Cultivars									
	Volume of dye uptake (ml)					Volume of water uptake (ml)				
	Shringar (V ₁)	Calcutta Double (V ₂)	Prajwal (V ₃)	Mean	Shringar (V ₁)	Calcutta Double (V ₂)	Prajwal (V ₃)	Mean		
0.2% + Green dye +200 ppm 8 HQC (T ₁)	4.11	6.28	4.28	4.89	32.45	34.22	29.37	32.01		
0.2% Green dye (T ₂)	2.55	11.11	7.00	6.89	30.89	34.86	26.83	30.86		
0.2% Raspberry Red dye +200 ppm 8 HQC (T ₃)	2.55	6.22	4.00	4.26	27.11	35.00	28.94	30.35		
0.2% Raspberry Red dye (T ₄)	2.45	8.67	6.06	5.72	25.33	Treatments	23.56	27.30		
0.2% Chocolate brown +200 ppm 8 HQC (T ₅)	2.44	5.83	4.00	4.09	26.67	35.33	29.22	30.41		
0.2% Chocolate brown (T ₆)	5.33	5.44	5.00	5.26	37.00	36.78	21.33	31.70		
0.2% Orange Red +200 ppm 8 HQC (T ₇)	3.44	7.17	3.58	4.73	32.45	34.11	24.14	30.23		
0.2% Orange Red (T ₈)	3.22	6.28	5.56	5.02	35.17	26.89	24.72	28.93		
0.2% Yellow dye +200 ppm 8 HQC (T ₉)	4.17	2.99	4.67	3.94	34.72	33.06	30.61	32.80		
0.2% Yellow dye (T ₁₀)	5.50	3.44	6.56	5.17	34.33	24.61	27.07	28.67		
Distilled water (T ₁₁)	0.00	0.00	0.00	0.00	24.00	17.22	23.86	21.69		
200 ppm 8-HQC (T ₁₂)	0.00	0.00	0.00	0.00	37.67	9.17	32.55	26.46		
Mean	2.98	5.29	4.23		31.48	29.52	26.85			
C.D (P=0.5%)				0.80				2.50		
Cultivar				1.61				5.01		
Treatments				2.79				8.67		
VXT										

Table 3. Effect of tinting treatments on per cent floret dried (%) and vase life (days) in different tuberose cultivars.

Treatments	Cultivars							
	Floret dried (%)			Vase-life (days)				
	Shringar (V ₁)	Calcutta Double (V ₂)	Prajwal (V ₃)	Mean	Shringar (V ₁)	Calcutta Double (V ₂)	Prajwal (V ₃)	Mean
0.2% + Green dye +200 ppm 8 HQC (T ₁)	55.71(7.52)	31.01(5.66)	13.70(3.82)	33.47(5.66)	9.75	13.21	9.52	10.83
0.2% Green dye (T ₂)	37.18(6.11)	23.63(4.77)	18.55(4.41)	26.45(5.10)	13.70	12.04	9.82	11.85
0.2% Raspberry Red dye +200 ppm 8 HQC (T ₃)	43.24(6.64)	12.99(3.60)	22.54(4.83)	26.26(5.02)	10.72	12.55	9.53	10.94
0.2% Raspberry Red dye (T ₄)	50.07(7.12)	15.56(4.00)	23.46(4.91)	29.70(5.35)	14.78	12.89	10.07	12.58
0.2% Chocolate brown +200 ppm 8 HQC (T ₅)	45.94(6.85)	29.99(5.56)	23.20(4.81)	33.04(5.74)	14.57	10.74	9.04	11.45
0.2% Chocolate brown (T ₆)	46.51(6.89)	17.10(4.25)	21.39(4.73)	28.33(5.29)	10.60	12.74	8.58	10.64
0.2% Orange Red +200 ppm 8 HQC (T ₇)	49.83(7.12)	43.92(6.67)	20.56(4.64)	38.10(6.14)	10.57	16.08	9.75	12.13
0.2% Orange Red (T ₈)	49.46(7.08)	56.87(7.52)	17.63(4.30)	41.32(6.30)	8.35	10.70	8.48	9.18
0.2% Yellow dye +200 ppm 8 HQC (T ₉)	55.06(7.46)	53.78(7.40)	22.44(4.84)	43.76(6.57)	9.07	11.27	7.80	9.38
0.2% Yellow dye (T ₁₀)	54.07(7.42)	50.68(7.17)	18.92(4.45)	41.22(6.35)	10.20	13.53	9.74	11.16
Distilled water (T ₁₁)	54.94(7.48)	71.48(8.51)	48.30(7.02)	58.24(7.67)	10.20	12.18	6.47	9.62
200ppm 8-HQC (T ₁₂)	51.31(7.23)	69.14(8.37)	44.91(6.77)	55.12(7.46)	10.72	13.22	6.95	10.29
Mean	49.44(7.08)	39.68(6.12)	24.63(4.96)		11.10	12.60	8.81	
C.D (P=0.5%)								
Cultivar	3.76(0.32)	1.18						
Treatments	7.52(0.63)	NS						
VXT	13.03(1.10)	NS						

tinted with, the food dyes of green, orange, yellow, red and chocolate brown and placed in vases for vase life studies exhibited different shades of respective colours as per RHS colour chart. After 4-5 days onwards gradually all the spikes started losing the intensity of colour. All the spikes of tinted flowers lost their colour gradually and by the end of vase life and turned light color still when they are in vases. The pattern of loss in color is such that gradually the intensity is lost later on turning towards lighter shade in the respective colour. These findings were similar to Sambandhamurthy and Appavu (1980) in tuberose, Sudha Patil and Dhaduk (2008) in lady's lace cut flowers.

The data presented in Table 2 depicts that the maximum volume of water uptake (32.80 ml) was recorded in spikes treated with 0.2% Yellow dye + 200 ppm 8 HQC (T_9) and it was statistically at par with T_1 , T_2 , T_3 , T_5 , T_6 , T_7 , T_8 and T_{10} , while minimum volume of water uptake (21.69 ml) was recorded in spikes treated with distilled water (T_{11}) and it was statistically at par with T_{12} . Among cultivars maximum volume of water uptake (31.48 ml) was observed in cv. Shringar and which was statistically at par with cv. Calcutta Double (29.52 ml). The cultivar and treatment interaction (VXT) also showed significant difference and maximum volume of water uptake (37.0 ml) was recorded in spikes of cv. Shringar treated with Chocolate brown dye (T_6) and it was statistically at par with V_1T_1 , V_1T_2 , V_1T_7 , V_1T_8 , V_1T_9 , V_1T_{10} , V_1T_{12} , V_2T_1 , V_2T_2 , V_2T_3 , V_2T_4 , V_2T_5 , V_2T_6 , V_2T_7 , V_2T_9 , V_3T_1 , V_3T_3 , V_3T_5 , V_3T_9 and V_3T_{12} . However, minimum volume of water uptake (9.17 ml) was recorded in spikes of cv. Calcutta Double treated with 200 ppm 8-HQC (V_2T_{12}) and it was statistically at par with V_2T_{11} . The highest water absorption by the spikes may be due to the fact that the spikes may have greater area of xylem which helped in higher water absorption. These results are in accordance with Varun and Barad (2010) in tuberose.

It is clear from the data presented in Table 3 shows that the minimum percentage floret dried (26.26%) when spikes were treated with 0.2% Raspberry Red dye + 200 ppm 8 HQC (T_3) and it was statistically at par with T_2 , T_4 and T_6 , whereas maximum percentage floret drying (58.24%) was observed in spikes held in distilled water (T_{11}) and it was statistically at par with T_{12} . Among cultivars minimum percentage floret dried (24.63%) was observed in cv. Prajwal while maximum in Shringar (49.44%) In cultivar and treatment interaction (VXT) data was found statistically significant and minimum percentage dried floret (12.99 %) were recorded in cv. Calcutta Double treated with 0.2% Raspberry Red dye + 200 ppm 8 HQC and it was statistically at par with V_2T_4 , V_2T_6 , V_3T_1 , V_3T_2 , V_3T_7 , V_3T_8 and V_3T_{10} while maximum percentage floret

dried (71.48%) was found in cv. Calcutta Double treated with distilled water (V_2T_{11}) and it was statistically at par with V_1T_1 , V_1T_9 , V_1T_{10} , V_1T_{11} , V_2T_8 , V_2T_{11} and V_2T_{12} .

Data presented in Table 3 shows that the effect of edible dyes was found to be non significant, however, maximum vase life (12.58 days) was recorded in spikes treated with 0.2% Raspberry Red dye (T_4) and minimum vase life (9.18 days) was observed in spikes treated with 0.2% Orange dye (T_8). Among the cultivars maximum vase life (12.60 days) was observed in spikes cv. Calcutta Double and it was statistically superior among all the cultivars, while minimum vase life (8.81 days) was recorded in cv. Prajwal. In cultivar and treatment interaction (VXT) data was found to be statistically non-significant and maximum vase life (16.08 days) was found in cv. Calcutta Double treated with 0.2% Orange dye + 200ppm 8 HQC (V_2T_7) and minimum vase life (6.47 days) was found in cv. Prajwal treated with distilled water (V_3T_{11}). This difference in vase life of different cultivars might be attributed to their genetic make up. As per Hegazi and El-Kot Gan., (2009) 2-3 basal floret open stage have optimum reserve of food material which are utilized for long time and extended the vase life. Sudha Patil and Dhaduk (2008) reported that there was no adverse significant effect of dye concentration, time of immersion and combination of both factors on the vase life and quality of lady's lace cut flowers by. The obtained results may also be due to a fact that higher water absorption maintained better water balance and flower freshness, saved from early wilting and enhanced vase life. These results were in accordance with Varun and Barad (2010). So it is concluded from the present studies that the postharvest life of tuberose remain unaffected by tinting the flower spikes with edible dyes and the difference was observed only among the cultivars which may be attributed to different in genetic makeup of the cultivars. It mean food colours can be used safely to enjoy the beauty of tinted flowers.

REFERENCE

- Chikhasubanna V and Yogitha N. 2002. Effect of chemical preservatives on post harvest longevity of cut roses cvs. *Cream Prophyta and Sacha Crop Research*, **24**(1) : 49-52.
- Dixit A K and Shukla P K. 2005. Effect of chemicals on vase life of gladiolus and annual chrysanthemum. *Orissa Journal of Horticulture*, **33**(1) : 106-107.
- Hegazi M and El-Kot Gan. 2009. Influences of Some Essential Oils on Vase-Life of Gladiolus hybrida, L. Spikes. *International Journal for Agro Veterinary and Medical Sciences*, **3**(1) : 19-24.
- Khan F U, Khan F A, Hayat N and Bhat S A. 2007. Influence of certain chemicals on vase life of cut tulip. *Indian Journal of Plant Physiology*, **12**(2): 127-132.

- Mekala P, Ganga M and Jawaharlal M. 2012. Artificial colouring of tuberose flowers for value addition. *South Indian Horticulture*, **60** : 216-223.
- Sambandhamurthy S and Appavu K. 1980. Effect of the chemical on colouring of tuberose (*Polianthes tuberosa* L.) *Proc. of National Seminar on Production Technology for Commercial Flower Crops*, TNAU, Coimbatore, Tamil Nadu, India, pp 73-75.
- Singh K P, Kumar V and Suchitra. 2003. Vase life of quality of China aster (*Callistephus chinensis*) cut flowers as influenced by holding solutions. *Journal of Horticultural Science*, **6(4)** : 362-366.
- Sudha Patil and Dhaduk B K. 2008. Value addition of Lady's Lace (*Pimpinella monoica*) cut flowers by colouring with edible dyes. *Journal of Ornamental Horticulture*, **11(1)** : 32-36.
- Varun D K and Barad A V. 2010. Effect of stem length and stage of harvest on vase-life of cut flowers in tuberose (*Polianthes tuberosa* L.) cv. Double. *Journal of Horticultural Sciences*, **5(1)** : 42-47.
- Venkatarayappa T, Murr D P and Tsujita M. 1981. Effect of Co₂+ and sucrose on the physiology of cut 'Samantha' roses. *Journal of Horticultural Science*, **56** : 21-25.

Effect of plant spacing on yield and quality of strawberry cv. Festival in West Garo Hills, Meghalaya

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ABSTRACT

An experiment was conducted to find out the effect of plant spacing on growth, flowering, fruiting, yield and quality of strawberry (*Fragaria ananassa*) cv. Festival in West Garo Hills of Meghalaya during 2014-2015. The study area is situated approximately between the longitudes 90° 30' and 89° 40'E, and the latitudes of 26° and 25° 20' N. The runners of strawberry were planted under nine different spacings, viz. T₁-15 × 25 × 100 cm, T₂-15 × 30 × 100 cm, T₃-15 × 35 × 100 cm, T₄-20 × 25 × 100 cm, T₅-20 × 30 × 100 cm, T₆-20 × 35 × 100 cm, T₇-25 × 25 × 100 cm, T₈-25 × 30 × 100 cm, T₉-25 × 35 × 100 cm (plant to plant, row to row and trench to trench). The highest plant height and spread in North-South and East-West direction were recorded with a spacing of 15 cm × 25 cm × 100 cm (T₁). The highest TSS : acid ratio of fruits (36.80) was observed in T₇ (25 cm × 25 cm × 100 cm). Plants spaced at 15 cm × 30 cm × 100 cm (T₂) produced highest number of flowers and fruits, fruit setting, larger fruits of higher fruit weight, highest yield/plant and highest productivity per hectare and also highest vitamin C content in fruits.

KEY WORDS: Strawberry, Yield, Quality, West Garo Hills, Plant spacing.

Strawberry (*Fragaria ananassa*) is one of the most popular soft fruit cultivated in plains as well as in hills up to an elevation of 3000 m in humid or dry region. Among the fruits, strawberry gives quickest returns in the shortest possible time.

Its cultivation in India was confined initially to temperate hilly regions, but with the introduction of day neutral cultivars, it has spread to the subtropical and tropical regions also. West Garo hills being a subtropical region is favourable for the cultivation of day neutral varieties of strawberry. However, negligible research has been done on strawberry in this region.

The spacing adopted during planting and cultural practices followed during cultivation like manuring, irrigation, mulching, weeding *etc.* influence the vegetative growth, flowering, fruiting and production of any fruit crop. Various studies report the effect of planting density on vegetative growth, reproductive development and performance in different strawberry cultivars, suggesting that manipulation of planting density could allow an increase in productivity (Tamiru, 1996; Perez *et al.* 2004). However, the response will depend upon factors like cultivar used, prevailing

weather conditions and cultural practices followed during cultivation. (Perez *et al.* 2005). According to Wilson and Dixon (1988) and Hancock (1999) the optimum spacing will depend on the force of the material and the climate. Considering the importance of these aspects, an experiment was conducted with nine spacing trials of strawberry cv. Festival, to evaluate the growth, yield and fruit quality in West Garo Hills of Meghalaya.

MATERIALS AND METHODS

The research study was conducted in the farm of Dept. of Rural Development and Agricultural Production, NEHU, Tura Campus situated in Duragre, Rongram block, West Garo Hills district. West Garo Hills district is situated approximately between the longitudes 90° 30' and 89° 40' E, and the latitudes of 26° and 25° 20' N. Runners of strawberry cultivar Festival were planted in double row system with nine spacing treatments and three replications per treatment with 50 plants per replication during 2014-2015. The planting was done on 16 September. The treatments were as follows: T₁: 15 cm × 25 cm × 100 cm ; T₂: 15 cm × 30 cm

× 100 cm; T₃: 15 cm × 35 cm × 100 cm; T₄: 20 cm × 25 cm × 100 cm; T₅: 20 cm × 30 cm × 100 cm; T₆: 20 cm × 35 cm × 100 cm; T₇: 25 cm × 25 cm × 100 cm; T₈: 25 cm × 30 cm × 100 cm; T₉: 25 cm × 35 cm × 100 cm (plant to plant, row to row and trench to trench spacing).

The growth parameters of the plant were recorded in terms of height, spread, and number of crowns. Flowering and fruiting behavior were studied with respect to date of first flowering, date of first harvest, duration from first flowering to first harvest, number of flowers per plant, number of fruits per plant and percentage of fruit set. Yield attributing characters like fruit weight, number of fruits per plant, yield per plant (g) and productivity/ha (q) were recorded. Chemical composition of fruits were estimated in terms of total soluble solids (TSS), acidity, total sugar, vitamin C and TSS/Acid ratio. The TSS was determined with the help of a Hand Refractometer and expressed in °Brix. Acidity was estimated by titrating the juice against N/10 NaOH and expressed as percent citric acid. Total sugar (%) and vitamin C content(mg/100g pulp) were estimated by the standard procedure of AOAC (2012). The data were statistically analysed by the method of analysis of variance using RBD as described by Panse and Sukhatme (1990).

RESULTS AND DISCUSSION

Study of growth parameters of strawberry cv. Festival under different plant spacing revealed that highest plant height of 21.10 cm and highest plant spread in East-West (28.43 cm) and North-South (32.47 cm) direction were observed in T₁ (15 × 25 × 100 cm). The highest number of crowns (4.61) was recorded in plants of 25 × 35 × 100 cm spacing (T₉). The duration from first flowering to first harvest was lowest (29.36 days) in T₆ (20 × 35 × 100 cm) and highest (43.66 days) in T₈ (25 × 30 × 100 cm) (Table 1). Fruits of T₈ (25 × 30 × 100 cm) recorded the highest fruit weight (15.26 g) and fruit diameter (29.73 mm). Highest fruit length of 36.57 mm was observed in T₅ (20 × 30 × 100 cm) followed by 36.36 mm in T₂ (15 × 30 × 100 cm) and 36.33 mm in T₈ (25 × 30 × 100 cm) (Table 2). Al-Ramamneh *et al.* (2013) also observed higher fruit weight and size under wider spacing.

Highest number of flowers (30.2) was observed in T₁ (15 × 25 × 100 cm). Highest number of fruits (22.67) and highest fruit set percentage (75.40 %) were observed in T₂ (15 × 30 × 100 cm) (Table 1). The highest yield per plant (342.77 g) was recorded in T₂ (15 × 30 × 100 cm) (Table 2). Mesbah Uddin *et al.* (2010) also observed

Table 1. Growth, flowering and fruiting behaviour of strawberry cv. Festival under different plant spacing

Treatment	Plant Height (cm)	Spread E-W (cm)	Spread N-S (cm)	Number of crowns	Date of first flowering	Date of first harvest	Duration from first flowering to first harvest	first flowering flowers per plant	Number of fruits per plant	% fruit set
T ₁	21.10	28.43	32.47	3.00	19 Oct-15 Dec	14 Nov-20 Feb	37.02	30.20	18.50	61.25
T ₂	18.43	26.07	28.10	2.77	21 Oct-4 Jan	18 Nov-17 Jan	31.57	30.06	22.67	75.40
T ₃	16.80	25.80	27.23	3.60	20 Oct-17 Jan	14 Nov-7 Feb	34.67	19.40	13.07	67.35
T ₄	15.40	21.90	26.90	3.13	25 Oct-19 Jan	24 Nov-20 Feb	42.27	23.27	14.48	63.14
T ₅	16.03	23.67	26.73	3.60	22 Oct-14 Jan	18 Nov-14 Feb	35.17	25.51	18.37	72.02
T ₆	13.63	17.83	22.13	3.77	18 Oct-19 Jan	17 Nov-18 Feb	29.36	27.29	16.74	60.87
T ₇	14.07	20.53	20.57	3.00	20 Oct-15 Jan	14 Nov-25 Feb	34.80	27.26	19.13	70.20
T ₈	13.10	18.17	18.83	3.45	17 Oct-2 Dec	14 Nov-7 Feb	43.66	27.33	17.78	63.43
T ₉	12.70	16.97	9.62	4.61	16 Oct-10 Jan	18 Nov-4 Feb	30.17	23.16	16.31	69.86
SEm±	1.22	2.15	2.32	0.29	-	-	2.56	1.42	1.03	2.5
CV (%)	9.5	11.91	12.05	10.27	-	-	8.36	6.73	7.24	4.57
CD at 5%	2.58	4.57	4.93	0.61	-	-	5.42	3.02	2.19	5.31

T₁-15×25×100 cm, T₂-15×30×100 cm, T₃-15×35×100 cm, T₄-20×25×100 cm, T₅-20×30×100 cm, T₆-20×35×100 cm, T₇-25×25×100 cm, T₈-25×30×100 cm, T₉-25×35×100 cm (plant to plant, row to row and trench to trench spacing).

Table 2. Fruit weight, length, diameter and yield of strawberry cv. Festival under different plant spacing.

Treatment	Fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)	Yield/plant (g)	Yield/ha (q)
T ₁	14.86	35.69	28.62	273.06	291.26
T ₂	15.19	36.36	29.17	342.77	351.56
T ₃	14.32	35.99	28.46	189.33	186.99
T ₄	13.70	35.43	28.89	200.80	160.64
T ₅	14.94	36.57	29.32	281.14	216.26
T ₆	14.78	35.36	29.47	248.44	184.02
T ₇	14.65	34.19	28.52	276.43	176.92
T ₈	15.26	36.33	29.73	273.88	168.54
T ₉	13.92	36.15	29.24	227.11	134.58
SEm±	0.46	NS	NS	25.49	19.01
CV (%)	0.82	2.57	3.84	12.14	11.20
CD at 5%	0.97	NS	NS	54.04	40.14

NS= Non- Significant

T₁-15×25×100 cm, T₂-15×30×100 cm, T₃-15×35×100 cm, T₄-20×25×100cm, T₅-20×30×100 cm, T₆-20×35×100 cm, T₇-25×25×100 cm, T₈-25×30×100 cm, T₉-25×35×100 cm (plant to plant, row to row and trench to trench spacing).

highest number of fruits and yield/plant under early planting and closer spacing. The highest productivity of 351.55 q/ha was observed in T₂ (15 × 30 × 100 cm) followed by 291.26 q/ha in T₁ (15 × 25 × 100 cm) which were the closest of spacings followed in the present experiment. The lowest productivity of 134.58 q/ha was noted in T₉ (25 × 35 × 100 cm) which was the widest spacing followed in the experiment (Table 2). Albrechts (1971), Freeman (1981), Nestby (1994), Perez *et al.* (2004), Perez *et al.* (2005), Paranjpe *et al.* (2008) and Laugale *et al.* (2012) also observed that increasing the plant density increased yield per unit area and lower plant densities exhibited lower productivity.

However, the highest TSS and total sugar were observed in T₅ (20 × 30 × 100 cm) with 8.50 °Brix and 5.16% respectively. The highest TSS/acid ratio of 36.80 was recorded in T₇ (25 × 25 × 100 cm) which also showed lowest acidity of 0.21% while highest vitamin C content of 99.08 mg/100 g was noted in T₂ (15 × 30 × 100 cm). Better quality fruits from plants spaced at wider distances maybe due to lesser competition for sunlight, water and nutrition.

The growth parameters like plant height and spread were higher in treatments with higher plant densities (T₁, T₂ and T₃). Fruit weight was also higher in T₁ and T₂. Yield per plant and yield/ha were highest in T₂

Table 3. Fruit quality parameters of strawberry cv. Festival under different plant spacing.

Treatment	TSS (°Brix)	Acidity (%)	TSS/acid ratio	Sugar (%)	Vitamin C (mg/100g)
T ₁	7.67	0.26	29.48	4.23	73.07
T ₂	7.33	0.24	31.74	4.30	99.08
T ₃	8.17	0.28	29.36	3.97	76.92
T ₄	7.83	0.28	28.20	2.77	64.42
T ₅	8.50	0.30	28.72	5.16	68.03
T ₆	8.00	0.30	26.80	4.39	75.07
T ₇	7.67	0.21	36.80	4.45	89.45
T ₈	7.67	0.24	33.03	4.14	56.06
T ₉	7.83	0.26	30.12	4.55	78.73
SEm±	NS	0.02	1.39	0.26	3.45
CV (%)	5.89	8.39	5.61	7.62	5.58
CD at 5%	NS	0.04	2.95	0.55	7.3

NS= Non- significant

T₁-15×25×100 cm, T₂-15×30×100 cm, T₃-15×35×100 cm, T₄-20×25×100 cm, T₅-20×30×100 cm, T₆-20×35×100 cm, T₇-25×25×100 cm, T₈-25×30×100 cm, T₉-25×35×100 cm (plant to plant, row to row and trench to trench spacing).

(higher density). This implies that the spacing adopted in treatments T₁, T₂ and T₃ in the present study provide ample amount of nutrients, water and light necessary for proper growth and production. There is further scope for research trials with reduced spacing than considered in the present experiment in order to accommodate more number of plants in a unit area, thereby improving the chances of further increase in productivity.

CONCLUSION

The spacing trial of strawberry *cv.* Festival in West Garo Hills revealed that plants spaced at 15 cm × 30 cm × 100 cm showed the best performance in terms of number of flowers and fruits, fruit set%, larger fruits of higher fruit weight, highest yield/plant, highest productivity and highest vitamin C content in fruits.

REFERENCES

- Albregts E E. 1971. Influence of plant density on strawberry fruit production. *Florida Agricultural Experiment Stations Journal Series No. 4146*. <http://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az114336.pdf> Accessed on 1.09.14.
- Al-Ramamneh E, Al-Rawashdeh Z, Karajeh M and Abu-Romman S. 2013. Plant Response of Strawberry to Intra-row Spacing and Growing Conditions in South of Jordan. *Asian Journal of Plant Sciences* **12** : 201-07.
- AOAC. 2012. *Official Methods of Analysis*. Association of Official Analytical Chemists, AOAC, Washington DC.
- Freeman B. 1981. Response of strawberry fruit yields to plant population density. *Australian Journal of Experimental Agriculture and Animal Husbandry* **21**(110) : 349-53.
- Hancock JF. 1999. Strawberries. *CABI International*. Wallingford, UK.
- Laugale V, Lepse L, Strautina S, Krasnova I and Seglina D. 2012. Effect of planting density and plastic soil mulch on strawberry plant development, yield and fruit quality. *Acta Horticulturae* **926** : 517-23.
- Mesbah Uddin ASM, Ahmad MR and Rahman MM. 2011. Effect of planting time and spacing on the growth and yield of strawberry. Research Report on Horticultural Crops 2010-11. Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur.
- Nestby R. 1994. Effects of bed height, plant spacing and cultivar on strawberry yield and fruit classification. *Norwegian Journal of Agricultural Sciences* **8** : 127-33.
- Panase, V.G. and Sukhatme, P.V. 1990. *Statistical Methods for Agricultural Workers*. I.C.A.R. New Delhi.
- Paranjpe AV, Cantliffe DJ, Stoffella PJ, Lamb EM and Powell CA. 2008. Relationship of plant density to fruit yield of 'Sweet Charlie' strawberry grown in a pine bark soilless medium in a high-roof passively ventilated greenhouse. *Scientia Horticulturae* **115**(2) : 117-23.
- Perez De Camacaro, M, Carew J and Battey N. 2005. Effect of planting density on vegetative and reproductive growth of strawberry *cv.* Elsanta. *Bioagro [online]* **17**(1) : 11-15.
- Perez De Camacaro, ME, Camacaro GJ, Hadley P, Dennett MD, Battey NH and Carew JG. 2004. Effect of plant density and initial crown size on growth, development and yield in strawberry cultivars Elsanta and Bolero J. *Hort. Sci & Biotech* **79**(5) : 739-46.
- Tamiru M. 1996. The effect of density and initial plant size on radiation absorption, growth and yield in strawberry (*Fragaria x ananassa* Duch. *cv.* Elsanta). M.Sc. Thesis, The University of Reading, Reading England.
- Wilson FM and Dixon RM. 1988. Strawberry growth and yield related to plant density using matted row husbandry. *Journal of Horticultural Science* **63** : 221-227.

Evaluation of liliium (*Lilium* spp.) germplasm for growth, flowering and bulb production under midhill conditions of Himachal Pradesh

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ABSTRACT

The experiment was conducted evaluate liliium (*Lilium* spp.) germplasm at the experimental farm of Department of Floriculture and Landscaping, Nauni, during 2008-09 under shade net conditions planted in a randomised block design. Liliium (*Lilium* spp.) is one of the important geophytes, having attractive flowers, appealing colours and durable spikes. Of the 14 cultivars of liliium, nine belonging to Asiatic group and five to LA Hybrid group, were evaluated under All India Coordinated Floriculture Improvement Project to work out their feasibility for commercial cultivation in the midhill areas in Himachal Pradesh. Among Asiatic cultivars, maximum (73.27 cm) plant height was noticed in cv. 'Brunello'. Maximum number (3.93) of flowering buds/plant were observed in cv. 'Toscana'. Longest bud length (8.45 cm) and largest flower size (17.81 cm) were found in cv. 'Prato'. Earliest flowering was noticed in cv. 'Apeldoorn' (56.80 days). Among LA hybrids, plant height (108.27 cm) and number of flowering buds (4.33) were maximum in cv. 'Lateya'. Longest bud length (9.05 cm) and largest flower size (17.96 cm) were noticed in cv. 'Litouwen'. Earliest flowering (69.80 days) was observed in cv. 'Brindsii'. Under Asiatic liliium cultivars, maximum bulb size (3.48 cm) and bulb weight (24.25 g) were found in 'Prato'. Maximum bulblet size (2.14 cm) and weight (5.19 g) were found in cv. 'Grand Cru'. Under LA Hybrid liliium, maximum bulb size (4.20 cm) and bulb weight (29.08 g) were found in 'Litouwen'. Maximum bulblet size (2.53 cm) and weight (8.02 g) were found in cv. 'Litouwen'.

KEY WORDS: Germplasm, Flowering, Bulb, Midhill condition, Asiatic lily, LA hybrid group.

Lily, belonging to the genus *Lilium*, is one of the most important bulbous flowers produced worldwide. About 80 species in this genus are recorded in nature (Bailey, 1925). Asiatic hybrids and interspecific hybrids such as *L. longiflorum* crossed with the Asiatic hybrid lilies have become popular since early 1980s (Roh *et al.*, 1996) is gaining popularity in Indian markets due to its long stemmed flowers, with various colour shades and prolonged vase-life. It belongs to family Liliaceae and most species are native to the temperate northern hemisphere. In Himachal Pradesh, it is one of the promising ornamentals and is fast establishing as an important cut flower crop. A wide range of diversity exists in flower colour, size, shape, flowering duration *etc.* in different liliium cultivars. Therefore, evaluation of liliium cultivars for their suitability to grow in subtropical, midhill region of Himachal Pradesh, was done.

MATERIALS AND METHODS

The experiment was conducted at the experimental farm of Department of Floriculture and Landscaping, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, during 2008-09. The experimental farm of the department is located at an elevation of 1,276 m above mean sea-level at the Latitude of 30° 54" N and Longitude of 77° 66" E and the climate is typically semi-temperate. Of the 14 cultivars of liliium, nine belonging to Asiatic group and five to LA hybrid group, procured from various sources in India, were evaluated under All India Coordinated Floriculture Improvement Project to work out their feasibility of commercial cultivation in the midhill areas of Himachal Pradesh. Well-rotten FYM @ 1 kg/m² was incorporated in the beds at the time of bed preparation.

Healthy, vigorous and disease-free bulbs procured from various sources in India, were planted during

March 2009 at a spacing of 20 cm × 20 cm under 50% shading net conditions in a randomized block design. Depth of planting was twice the size of the bulbs which were planted in a slightly moist soil, with a layer of 6-8 cm soil on the top of the bulbs. After planting, soil was copiously irrigated and immediately mulched with straw. Three weeks after planting CAN was applied @ 1 kg/100 m². Various growth, flowering and bulb production were periodically recorded and data were analyzed statistically.

RESULTS AND DISCUSSION

The variations between cultivars were significant for plant height (cm), number of leaves/plant, number of buds/plant, bud length (cm), days taken to flowering, flower size (cm) (Table 1). Among nine cultivars of Asiatic liliium, cv. 'Brunello' was the tallest (73.27 cm) and was found at par with cv. 'Harmony' (71.77 cm), whereas cv. 'Romneo' was found to be the shortest (49.45 cm). Plant height is an important criteria for selecting liliium cultivars because taller plants are generally preferred for cut flower production. Maximum number of leaves/plant were recorded in cv. 'Harmony' (46.07) and minimum in cv. 'Romneo' (27.67 cm).

Maximum number of buds/plant were observed in cv. 'Toscana' (3.93) which was found to be at par with

cv. 'Alaska' (3.47) and 'Harmony' (3.47), whereas minimum in cv. 'Romneo' (2.27) which was at par with cv. 'Grand Cru' (2.47), 'Prato' (2.53), 'Brunello' (2.73) respectively. Earliest flowering was noticed in cv. 'Apeldoorn' (56.80 days), whereas cv. 'Harmony' was last to flower (78.40 days). The bud initiation and days taken to flowering are desirable characters because cultivars consume less resources and time from planting to harvesting of flowers (Sindhu and Singh, 2012). Days to flowering signifies the earliness or late flowering habit of genotypes which is helpful in determining the availability of flowers for a longer period.

The longest bud length was observed in cv. 'Prato' (8.45 cm), whereas smallest bud length was in cv. 'Apeldoorn' (6.72 cm) and was at par with cv. 'Polyanna' (6.84 cm). Flower size was maximum in cv. 'Prato' (17.81 cm) and minimum in cv. 'Romneo' (10.95 cm). Variation in flower size in these cultivars may be attributed to the inherent genetic and environmental factors. Flower colour of Asiatic liliium cultivars was observed according to Royal Horticulture Society Colour Charts.

Five cultivars of LA hybrid *Lilium*, viz. 'Brindisii', 'Lateya', 'Litouwen', 'Menorca' and 'Pavia' were evaluated in replicated trials under shade net area. Results from analysis of variance shows that variations between cultivars were significant for plant height (cm), number of leaves/plant, number of buds/plant, bud

Table 1. Performance of *Lilium* cultivars during 2008-09

Cultivar	Plant height (cm)	No. of leaves/plant	No. of buds/plant	Bud length (cm)	Days taken to flowering	Flower size (cm)	Flower colour (RHS colour charts)
Asiatic							
Alaska	67.83	33.73	3.47	7.73	71.33	14.70	Creamish white (155 D)
Apeldoorn	55.75	30.07	3.40	6.72	56.80	14.48	Orange(30 C)
Brunello	73.27	42.47	2.73	7.17	67.40	13.96	Orange (28 A)
Grand Cru	65.60	30.33	2.47	6.89	65.20	13.22	Yellow with brown blotches (9 A)
Harmony	71.77	46.07	3.47	8.18	78.40	13.73	Yellow(9 B)
Polyanna	55.97	34.93	2.93	6.84	63.40	14.76	Yellow(13 A)
Prato	59.70	38.40	2.53	8.45	65.60	17.81	Peach (32 B)
Romneo	49.45	27.67	2.27	6.93	61.00	10.95	Red(43 A)
Toscana	64.05	37.00	3.93	6.88	75.80	13.25	Pink(47 C)
CD (0.05)	3.12	1.76	0.47	0.14	1.44	0.44	
LA Hybrids							
Brindisii	84.01	45.67	3.87	7.95	69.80	15.59	Red (55C)
Lateya	108.27	74.73	4.33	8.09	75.80	17.65	Purple(72 A)
Litouwen	83.93	70.33	1.67	9.05	72.80	17.96	White (155 D)
Menorca	88.67	75.47	4.27	7.73	78.00	15.66	Peach (25 C)
Pavia	76.71	68.07	4.00	8.65	79.40	17.86	Yellow (9A)
CD (0.05)	4.32	1.54	0.68	0.20	0.68	0.22	-

Table 2. Bulb diameter(cm) and weight(g) of bulbs of Asiatic and LA Hybrid lilies during 2008-09

Cultivar	Bulb diameter (cm)		Weight (g) of bulb	
	Bulb	Bulblets	Bulb	Bulblets
Asiatic Lilium				
Alaska	2.49	1.33	7.84	2.32
Apeldoorn	2.84	1.38	12.06	1.88
Brunello	3.40	1.78	16.05	3.05
Grand Cru	2.70	2.14	10.30	5.19
Harmony	2.91	1.52	14.01	2.34
Polyanna	2.80	1.76	10.26	3.01
Prato	3.48	1.91	24.25	4.63
Romneo	2.43	1.32	7.76	2.27
Toscana	2.85	1.96	12.30	4.45
CD (0.05)	0.16	0.11	1.96	0.62
LA Hybrids				
Brindsii	3.27	2.41	15.51	6.21
Lateya	3.46	2.14	17.04	4.45
Litouwen	4.20	2.53	29.08	8.02
Menorca	2.79	1.68	10.45	2.38
Pavia	2.96	2.41	11.99	6.74
CD (0.05)	2.85	0.17	2.86	1.19

length (cm), days taken to flowering, flower size (cm) (Table 2). Among five cultivars, cv. 'Lateya' was the tallest (108.27 cm), whereas cv. 'Pavia' was the shortest (76.71 cm). Maximum number of leaves/plant was in cv. 'Menorca' (75.47), which was found to be at par with cv. 'Lateya', whereas minimum in cv. 'Brindsii' (45.67). Maximum number of buds were recorded in cv. 'Lateya' (4.33) which was at par with cv. 'Brindsii' (3.87), 'Pavia' (4.00) and 'Menorca' (4.27) respectively.

The earliest flowering was noticed in cv. 'Brindsii' (69.80 days), whereas cv. 'Pavia' took maximum time to flower (79.40 days) and was at par with cv. 'Menorca' (78.00 days). The longest bud length was observed in cv. 'Litouwen' (9.05 cm), whereas smallest bud length was in cv. 'Menorca' (7.73 cm). Flower size was the largest in cv. 'Litouwen' (17.96 cm) and was at par with cv. 'Pavia' (17.86 cm), whereas minimum in cv. 'Menorca' (15.66 cm). Flower colour of the liliium cv. viz. 'Brindsii', 'Lateya', 'Litouwen', 'Menorca' and 'Pavia' was observed according to Royal Horticulture Society Colour Charts.

The harvesting of bulbs and bulblets of all these cultivars was done after May 2009. Among Asiatic hybrid cultivars of liliium, maximum bulb size (3.48 cm) was recorded in cv. 'Prato' which was found to be at par with cv. 'Brunello' (3.40 cm). In contrast, minimum bulb size was noticed in cv. 'Romneo' (2.43 cm) which was at par with cv. 'Alaska' (2.49 cm). Regarding size of bulblets; it was maximum in cv. 'Grand Cru' (2.14 cm), whereas cv. 'Romneo' recorded minimum bulblet size (1.32 cm) which was found to be at par with cultivars 'Alaska' (1.33 cm) and 'Apeldoorn' (1.38 cm).

Weight of bulbs was observed maximum in cv. 'Prato' (24.25 g). In contrast, bulb weight was observed minimum in cv. 'Romneo' (7.76g) which was found to be at par with cv. 'Alaska' (7.84 g). Regarding, weight of bulblets; it was heaviest in cv. 'Grand Cru' (5.19 g) which was found to be at par with cv. 'Prato' (4.63g). Weight of bulblets was recorded minimum in cv. 'Apeldoorn' (1.88 g) which was found to be at par with cultivars 'Alaska' (2.32 g), and Romneo (2.27 g).

In LA hybrid category of liliium, maximum bulb size was observed in cv. 'Litouwen' (4.20 cm) which was at par with all cultivars, i.e. Menorca (2.79 cm), 'Pavia' (2.96 cm), 'Brindsii' (3.27 cm) and 'Lateya' (3.46 cm). In contrast, minimum bulb size was recorded in cv. 'Menorca' (2.79 cm) which was also found to be at par with all the cultivars.

Regarding bulblet size; it was maximum in cv. 'Litouwen' (2.53 cm) which was found to be at par with cultivars Brindsii and Pavia (2.41 cm). Heaviest bulbs were noticed in cv. 'Litouwen' (29.08 g). However, minimum weight (11.99 g) of bulbs was observed in cv. 'Menorca' (10.45g) which was found to be at par with cv. 'Pavia'. Maximum weight of bulblets was found in cv. 'Litouwen' (8.02 g), whereas minimum in cv. 'Menorca' (2.38 g) (Table 2).

REFERENCES

- Bailey L B. 1925. *The Standard Encyclopaedia of Horticulture*, pp 1862-78, MacMillan Co., New York.
- Roh, M S, Griesbach K C, Gross and Lawson R H. 1996. Evaluation of interspecific hybrids of *Lilium longiflorum* and *L. elegans*. *Acta Horticulturae* 414 : 101-10
- Sindhu S S and Singh R K. 2012. Evaluation of liliium cultivars under northern plains. *International Journal of Agricultural Sciences* 8(2) : 460-61.

Effect of planting distance, pinching and biofertilizers on growth, and flower yield of African marigold (*Tagetes Erecta*) cv. Sierra Orange

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ABSTRACT

A field experiment was conducted at Department of Horticulture, College of Agriculture, Indore, during the rainy (*khari*) season of 2009-10. Maximum plant height was attained in the treatment of 30 cm × 30 cm + 100 % PSB (T₁), followed by 30 cm × 30 cm + 100 % Azotobactor + pinching (T₄) and 40 cm × 40 cm + 125% Azotobactor + pinching (T₈). Observations recorded on number of branches/plant showed at par results with each other among treatments except T₁ (30 cm × 30 cm + 100% PSB), but highest number of branches in 40 cm × 40 cm + 125% PSB + pinching (T₇) and T₈ - 40 cm × 40 cm + 125 % Azotobactor + pinching (T₈). It was also recorded that differences among the treatments in respect of number of leaves/plant were at par except T₁ and T₅. However, it was higher in of treatment 30 cm × 30 cm + 100% Azotobactor (T₂) and 40 cm × 40 cm + 125% PSB + pinching (T₇), followed by 30 × 30 cm + 100% Azotobactor + pinching (T₄), 40 cm × 40 cm + 125% Azotobactor + pinching (T₇) and 30 cm × 30 cm + 100 % PSB (T₁). The higher leaf area/plant associated with treatment of 30 cm × 30 cm + 100% Azotobactor + pinching (T₄) followed by 30 cm × 30 cm + 100% PSB + pinching (T₃), T₁ - 30 cm × 30 cm + 100% PSB (T₁) and 40 cm × 40 cm + 125% PSB (T₅), but result were at par among each other except treatment T₆, T₇ and T₁₀. Similarly stem diameter also showed significant differences among the treatments and ranged between 2.11 and 2.55 cm. The significantly width and stem diameter were attained by the treatment 30 cm × 30 cm + 100% Azotobactor + pinching (T₄), showing significant superiority over rest of the treatments except T₇, T₈ and T₃, which were at par. The maximum yield was recorded with T₄ - 30 cm × 30 cm + 100% Azotobactor + pinching (32928 kg/ha), followed by T₃ - 30 cm × 30 cm + 100% PSB + pinching (32207 kg/ha) and T₅ - 40 cm × 40 cm + 125% PSB (32161 kg/ha) and T₂ - 30 cm × 30 cm + 100% Azotobactor (31707 kg/ha).

KEY WORDS: Planting distance, Pinching, Growth, Yield, Biofertilizers, Marigold

African marigold (*Tagetes erecta* Linn.) is hardy, and 90-100cm tall. The erect and branched leaves are pinnately divided and leaflets are lanceolate and serrate. The productivity and quality of flowers can only be improved by use of high-yielding cultivar and improved package of practices in addition to the use of bio-agents and pruning operation also play very important role in producing quality producer, *viz.* biofertilizers improve the physico-chemical properties

of soil, which is very useful for sustainable crop productivity as well as soil fertility and productivity. Biofertilizers are very popular among farmers because of its eco-friendly nature. Similarly, pinching promotes lateral branches and better framework for balance flower. Therefore, an experiment was conducted during *khari* season of 2009-10 at Hi-Tech Horticulture area College of Agriculture, Indore (M.P.) to assess the treatment effect on growth and flower yield of marigold.

MATERIALS AND METHODS

A field experiment was conducted at Department of Horticulture, College of Agriculture, Indore, during the rainy (*khari*) season of 2009-10 to study the effect of planting distance, pinching and biofertilizers on growth, and flower yield of African marigold. The

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climatic condition of Indore is subtropical and located at 22.43°N and longitude of 75.66°E. The total rainfall received during crop season was 429.1 mm. The soil of experimental plot was clayey textural class, with medium in organic carbon (0.62%) and available N (245.0 kg/ha) and low in P₂O₅ (10.1 kg/ha), but high in K₂O (830.0 kg/ha). The pH and EC (ds/m) of soil was 7.2 and 0.6, respectively.

The experiment was laid out in a factorial randomized block design with three replications and 10 treatments (T₁-30 cm × 30 cm + 100% PSB, T₂-30 cm × 30 cm + 100% PSB, T₃-30 cm × 30 cm + 100% PSB + pinching, T₄-30 cm × 30 cm + 100% Azotobacter + pinching, T₅-40 cm × 40 cm + 125% PSB, T₆-40 cm × 40 cm + 125% Azotobacter, T₇- 40 cm × 40 cm + 125% PSB + pinching, T₈-40 cm × 40 cm + 125% Azotobacter + pinching, T₉-40 cm × 30 cm + 75% PSB + 75% Azotobacter and T₁₀-40 cm × 30 cm +75% PSB + 75% Azotobacter + pinching).

The raised beds were prepared with a fine mixture of soil and farmyard manure. The beds were drenched with 25 g Dithane M-45 in 10 liters of water before sowing to avoid fungal diseases like damping-off. The seeds of cultivar Sierra Orange, were sown on nursery beds in rows across the length 10 cm at the depth of 1 - 1.5 cm. Beds were covered with fine mixture of soil, farmyard manure and watered gently with a rose can just after sowing. The incorporation of farmyard manures @ 100 - 150 q/ha were mixed at the time of land preparation. After executing the plan of layout nitrogen (120 kg/ha); phosphorus (60 kg/ha) and potassium (60 kg/ha) were incorporated in soil as basal dose in the form of urea, single super phosphate and muriate of potash, respectively before transplanting.

Nitrogen at 120 kg/ha was applied in two split doses 20 and 40 days after transplanting of seedling. The 32 days old uniform seedlings having 6-10 cm height were transplanted. The roots of seedlings were treated with Dithane M-45 solution before transplanting. The damaged and dead seedlings were replaced by healthy and vigorous seedlings from the same lot after 10 days of transplanting to maintain optimum plant population in the plots.

RESULTS AND DISCUSSION

Plant height showed non-significant variations at 75 DAS among the treatments (Table 1). Maximum plant height was attained by treatment of 30 cm × 30 cm + 100 % PSB (T₁) which were closely followed by 30 cm × 30 cm + 100% Azotobacter + pinching (T₄) and 40 cm × 40 cm + 125% Azotobacter + pinching (T₈). Observations recorded on number of branches/plant showed at par results with each other among treatments except T₁ (30 cm × 30 cm + 100% PSB), but highest number of branches in 40 cm × 40 cm + 125% PSB + pinching (T₇) and T₈- 40 cm × 40 cm + 125% Azotobacter + pinching (T₈).

There were differences among the treatments in respect of number of leaves/plant were at par except T₁ and T₅. However, it was higher in the treatment 30 cm × 30 cm + 100% Azotobacter (T₂) and 40 cm × 40 cm + 125% PSB + pinching (T₇), followed by 30 cm × 30 cm + 100% Azotobacter + pinching (T₄), 40 × 40 cm + 125% Azotobacter + pinching (T₇) and 30 × 30 cm + 100 % PSB (T₁). These treatments were at par among themselves. The results were in conformity of Shah *et al.* (2005).

The effect of treatment on leaf area/plant was

Table 1. Effect of planting distance, pinching and biofertilizers on growth, and flower yield of African marigold

Treatment	Plant height (cm)	Number of branches /plant	Number of leaves/ plant	Leaf area/ plant (cm ²)	Stem diameter (cm)	Flower yield (kg/ha)
T ₁ - 30 cm × 30 cm +100% PSB	68.00	22.53	69.87	19.42	2.14	20111
T ₂ - 30 cm × 30 cm + 100% Azotobacter	61.80	26.07	77.47	17.34	2.32	31704
T ₃ - 30 cm × 30 cm + 100% PSB + pinching	62.73	24.47	73.93	19.73	2.45	32207
T ₄ - 30 cm × 30 cm + 100% Azotobacter + pinching	66.47	24.80	76.60	20.23	2.55	32928
T ₅ - 40 cm × 40 cm + 125% PSB	65.07	23.33	71.27	18.20	2.44	32161
T ₆ - 40 cm × 40 cm + 125% Azotobacter	63.40	26.73	74.27	16.38	2.42	20944
T ₇ - 40 cm × 40 cm + 125% PSB + pinching	65.80	26.87	77.47	16.51	2.50	21493
T ₈ - 40 cm × 40 cm + 125% Azotobacter + pinching	65.93	26.87	75.47	16.80	2.49	21989
T ₉ - 40 cm × 30 cm + 75% PSB +75% Azotobacter	65.47	26.80	74.13	17.35	2.11	28517
T ₁₀ - 40 cm × 30 cm + 75% PSB + 75% Azotobacter + pinching	64.47	25.93	75.27	16.86	2.17	26103
CD (5%)	NS	2.58	3.89	2.54	0.18	2996

significant (Table 1). It was found that higher leaf area/plant associated with treatment of 30 cm × 30 cm + 100% Azotobactor + pinching (T₄), followed by 30 cm × 30 cm + 100% PSB + pinching (T₃), T₁- 30 cm × 30 cm + 100% PSB (T₁) and 40 cm × 40 cm + 125% PSB (T₅), but result were at par among each other except treatment T₆, T₇ and T₁₀. The finding with parallel results of Shah *et al.* (2005). Similarly, stem diameter also showed significant differences among the treatments and ranged between 2.11 and 2.55 cm. The significantly width and stem diameter was attained by the treatment 30 cm × 30 cm + 100% Azotobactor + pinching (T₄), followed by and showed significant superiority over rest of the treatments except T₇, T₈ and T₃, which showed at par differences. The results were also confirmed by Kumar (2002).

The flower yield of marigold was significantly affected by the treatments (Table 1). The maximum yield was recorded with T₄- 30 cm × 30 cm + 100% Azotobactor + pinching (32928 kg/ ha), followed by T₃- 30 cm × 30 cm + 100% PSB + pinching (32207 kg/ ha) and

T₅- 40 cm × 40 cm + 125 % PSB (32161 kg/ha) and T₂- 30 cm × 30 cm + 100 % Azotobactor (31707 kg/ha). These treatments were at par each other's except T₁, T₆, T₇, T₈ and T₁₀ treatments. The lowest flower yield was recorded by T₁- 30 cm × 30 cm + 100% PSB (20111kg/ ha). Rest of the treatments showed almost similar performance. The similar report was found by Nandre *et al.* (2005).

REFERENCES

- Kumar Ajit. 2002. 'Effect of organic and inorganic fertilizers on growth, yield and post harvest life of marigold'. M.Sc (Agric) thesis, University of Agricultural Sciences, Dharwad.
- Nandre D R, Jogdande N D, Dalal S R, Bansode A B and Chaudhale B S. 2005. Effect of Azotobacter on growth and yield of China aster under reduced nitrogen doses. *Crop Research* 29(2) : 272-74.
- Shah U A, Khan F U, Lone R A, Nanda A B and Beigh M A. 2005. Effect of nitrogen and spacing on growth and flowering in China aster. *Progressive Horticulture* 37(2) : 453-55.

Genetic variability and correlation studies on vegetative and floral characters of gladiolus (*Gladiolus grandiflorus*)

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ABSTRACT

The study was undertaken on genetic variability and correlation of vegetative and floral characters of gladiolus (*Gladiolus grandiflorus*) during November 2011 to June 2013. Ten varieties, Jester, Candyman, Poppy Tears, Summer Sunshine, Wedding Bouquet, Hunting Song, Pacifica, American Beauty, Red Ginger and White Prosperity, were evaluated. The variation was high for spike length (89.67-109.83), followed by days taken for spike emergence after sprouting (60.00-89.00) and plant height (53.47-71.20 cm). Highest phenotypic and genotypic variances were observed for fresh weight of spike (234.87 and 213.78), respectively. The estimates of phenotypic coefficient of variation were higher than genotypic coefficient of variation for all the traits. Maximum phenotypic coefficient of variation and heritability were observed for cormel weight (43.32 and 96.90%). Genotypic coefficient of variance showed variation from 3.77 to 42.64 for diameter of second floret and cormel weight, respectively. However, maximum genetic advance was observed in fresh weight of spike (28.74). The high heritability was associated with high genetic advance of mean for cormel weight, indicating the possible role of additive gene action. The magnitude of genotypic correlation was higher than their corresponding phenotypic correlation for most of the traits, indicating a strong inherent linkage between various traits. At genotypic level, days for sprouting of corms exhibited highly significant and positive correlation with number of florets/spike, fresh weight of spike and vase-life but significant and positive correlation with fresh weight of spike at phenotypic level.

KEY WORDS: Gladiolus, Genetic variability, Heritability, Genetic advance, Correlation

Gladiolus (*Gladiolus grandiflorus* L.) is most popular cut flower in international and domestic markets. There is a huge variability in its crop with respect to shape, size, growth habit, flowering behaviour, vase-life etc. In spite of such variability, very few have desirable characters for yield, vase-life and flower quality. So, there is an urgent need for selection as well as maintenance of good germplasm. The interrelationship of various characters in the form of correlation is an important aspect in crop breeding. Genotypic and phenotypic coefficient of variation, heritability and genetic advance constitute important genetic

parameters which are frequently applied in plant breeding for crop improvement. Coefficient of variation allows meaningful comparison of variation of several traits of plants belonging to the same population as well as a comparison of the variation of the same trait as expressed by different population. Heritability tells us about the additive genetic variance and phenotypic variance (Nyquist, 1991). Nowadays, climatic condition of north-eastern region is highly variable due to climate change and introduced varieties vary in performance. The performance of any crop or variety extensively depends on genotypic and environmental interaction. As a result, cultivars which perform well in one region may not perform same in other regions of varying climatic conditions. Therefore, it is essential to develop varieties suited to specific climatic condition which can be further utilized for genetic improvement.

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However, no systematic efforts were made in the past to identify suitable genotypes of gladiolus for cut flower production and crop improvement programme under agroclimatic condition of Pasighat. Hence, present study on different varieties was undertaken to assess their genetic variability, heritability, genetic advance, correlation coefficient and suitability in crop improvement under agroclimatic conditions of Pasighat, Arunachal Pradesh.

MATERIALS AND METHODS

The studies were undertaken at Instructional Farm, Department of Floriculture, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh, from November 2011 to June 2013. The experiment was laid out in a randomized completely block design with three replications. Ten varieties, Jester, Candyman, Poppy Tears, Summer Sunshine, Wedding Bouquet, Hunting Song, Pacifica, American Beauty, Red Ginger and White Prosperity, were taken for their evaluation under open field condition. Uniform-sized gladiolus corms (3.00-4.00 cm diameter) were planted on raised bed at a spacing 30cm × 30cm under irrigated condition during second fortnight of November. Uniform package of cultural practices were followed.

Observations were recorded for days for sprouting of corms, plant height, number of leaves/plant, length of leaf, breadth of leaf, number of tillers/plant, days taken for spike emergence after sprouting, days taken to flowering after spike emergence, days to first floret open after colour break, spike length, rachis length, number of florets/ spike, diameter of second floret, diameter of flower stalk, fresh weight of spike, corm weight, cormel weight, polar diameter of corm, equatorial diameter of corm, cormel diameter, field life and vase-life. The data collected were pooled and analyzed statistically. Phenotypic and genotypic coefficient of variation were calculated as per the formula of Burton (1952) and Burton and Devane (1953). Heritability in broad sense was worked out according to formula Allard (1960) and genetic advance as per cent of mean was calculated following the method of Johnson *et al.* (1955). Phenotypic and genotypic correlation was computed as suggested by Al Jibouri *et al.* (1958).

RESULTS AND DISCUSSION

The variability in quantitative characters in ten gladiolus genotypes were measured in terms of mean performance, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability, genetic advance and genetic gain in (Table 1). The range of variation was high for spike length (89.67-

109.83), followed by days taken for spike emergence after sprouting of corms (60.00-89.00 cm), and plant height (53.47-71.20 cm), respectively. Highest phenotypic and genotypic variances were observed for fresh weight of spike (234.87 and 213.78), followed by days for sprouting of corms (185.26 and 178.72) and corm weight (139.85 and 133.76) at both the level, respectively, while lowest were observed for days to first floret open after colour break (0.18 and 0.15) at phenotypic and genotypic level, respectively. Kumar *et al.* (2013) and Balaram and Janakiram (2009) also reported higher phenotypic and genotypic variation with corm weight in gladiolus.

The better idea can be gained by comparing the relative amount of phenotypic and genotypic coefficient of variance for actual strength of variability. The genotypic coefficient of variation provides a valid basis for comparing and accessing the range of genetic diversity for quantitative characters and phenotypic coefficient of variation measures the extent of total variance. Phenotypic coefficient of variation and genotypic coefficient of variation are better indices for comparison of characters. The estimates of phenotypic coefficient of variation were higher than genotypic coefficient of variation for all the traits, which is an indicator of additive effect of the environment on the expression of the trait. Maximum phenotypic coefficient of variation was observed for cormel weight (43.32), followed by days for sprouting of corms (42.58) and number of tillers/plant (32.76), while minimum was recorded in diameter of second floret (4.75).

The higher PCV and GCV estimates were found for number of daughter corm/mother corm and cormel production in gladiolus (Kumar *et al.*, 2013) and Balaram and Janakiram (2009) indicated the presence of considerable variability in these traits and scope for selection and improvement. Genotypic coefficient of variance showed a range of variation from 6.44 to 42.64 for vase-life and cormel weight, respectively. Maximum genotypic coefficient of variance was noticed with cormel weight (42.64), followed by days for sprouting of corms (41.82) and number of tillers/plant (32.15). The higher value of phenotypic coefficient of variation and genotypic coefficient of variation were observed by Kadam *et al.* (2014) in gladiolus.

Bichoo *et al.* (2002) also observed high genotypic coefficient of variation for number cormel weight in gladiolus, indicating the presence of sufficient genetic variability for selection. Burton (1952) suggested that genetic coefficient of variation together with heritability estimates would give adequate information for extent of advancement through selection. A vast variation was recorded for heritability (broad sense) in different quantitative characters of gladiolus genotypes. The high

Table 1. Estimates of variance, coefficient of variation, heritability, genetic advance and genetic gain for different characters of gladiolus varieties

Character	Range	General mean	Variance (α^2)			Coefficient of variation				Genetic advance as per cent of mean (GA)
			Phenotypic (α^2_p)	Genotypic (α^2_g)	PCV (%)	GCV (%)	Heritability (broad sense) %	Genetic advance (GA)		
Days for sprouting of corm	16.00-65.47	31.97	185.26	178.72	42.58	41.82	98.47	27.05	84.62	
Plant height	53.47-71.20	62.00	37.62	23.62	9.89	7.84	62.79	7.93	12.80	
Number of leaves/plant	8.67-10.67	9.60	0.84	0.39	9.53	6.50	46.46	0.88	9.12	
Length of leaf	39.30-53.67	44.23	26.20	17.65	11.57	9.50	67.38	7.10	16.06	
Breadth of leaf	3.57-4.97	4.35	0.39	0.28	14.40	12.25	72.30	0.93	21.45	
Number of tillers/plant	1.00-2.67	1.83	0.36	0.35	32.76	32.15	96.34	1.19	65.01	
Days taken for spike emergence after sprouting	60.00-89.00	81.27	83.77	72.77	11.26	10.50	86.87	16.38	20.16	
Days taken to flowering after spike emergence	9.33-15.00	11.40	3.35	2.87	16.05	14.87	85.92	3.24	28.40	
Days to first floret open after colour break	2.00-3.00	2.37	0.18	0.15	17.91	16.31	82.99	0.72	30.62	
Spike length	89.67-109.83	99.75	101.63	33.53	10.11	5.81	32.99	6.85	6.87	
Rachis length	45.83-66.23	55.95	62.68	42.98	14.15	11.72	68.57	11.18	19.99	
Number of florets/spike	10.00-18.33	15.63	8.87	7.06	19.05	17.00	79.62	4.89	31.25	
Diameter of second floret	9.70-11.27	10.87	0.27	0.17	4.75	3.77	63.20	0.67	6.18	
Diameter of flower stalk	8.11-10.05	8.99	0.40	0.22	7.07	5.22	54.61	0.71	7.95	
Fresh weight of spike	38.40-88.10	53.36	234.87	213.78	28.72	27.40	91.02	28.74	53.85	
Corm weight	39.57-74.30	54.98	139.85	133.76	21.51	21.04	95.65	23.30	42.38	
Cornel weight	3.00-14.20	7.26	9.88	9.57	43.32	42.64	96.90	6.27	86.46	
Polar diameter of corm	23.54-33.30	29.13	12.26	5.47	12.02	8.03	44.61	3.22	11.05	
Equatorial diameter of corm	44.85-68.23	56.95	66.43	53.67	14.31	12.86	80.79	13.56	23.82	
Cornel diameter	10.43-14.14	12.00	2.26	1.77	12.52	11.09	78.47	2.43	20.25	
Field life	12.00-23.67	16.02	16.23	14.71	25.15	23.94	90.62	7.52	46.95	
Vase-life	9.67-12.33	11.10	1.28	0.51	10.18	6.44	40.00	0.93	8.39	

value of PCV along with GCV indicated that there is more variability in cormel and corm weight. Closeness between PCV and GCV indicated that phenotypic expression of all the genotypes is mostly under genetic control and environment has less influence on their expression (Singh and Singh, 1987).

High heritability was observed for all the traits under study. Nair and Shiva (2003) and Chobe *et al.* (2010) also reported high heritability for most of the quantitative traits in gerbera. Maximum heritability was recorded for cormel weight (96.90%), while, minimum (32.99%) was noted for spike length. Similar findings were observed by Mahanta and Paswan (1995). Spike length and vase-life showed low heritability and improvement could be achieved for these traits through selection. High heritability showed the possibility of effective base on phenotypic expression. Cormel weight is a potential character for selection of gladiolus cultivars. The environmental influence was considerable for this trait which could be observed from the differences between genotypic and phenotypic coefficient of variation.

Most of the traits indicated the dominance of additive gene effect, hence direct selection of such traits may lead to improvement in quality. Minimum genetic advance was recorded in diameter of second floret (0.67), however, maximum genetic advance was observed in fresh weight of spike (28.74). A range of variation, *i.e.* 6.18 and 86.46, was recorded for spike length and cormel weight, respectively. High heritability associated with high genetic advance proved more useful for efficient improvement of a character through selection. High heritability was associated with high genetic advance percentage of mean for cormel weight (96.90 and 86.46), indicating the possible role of additive gene action.

The similar genetic behaviour had been reported (Balaram and Janakiram, 2009; Archana *et al.*, 2008). The parallelism between magnitude of heritability and degree of genetic gain has been due to additive gene playing a predominant role and therefore, this was more reliable for effective selection. High heritability with high genetic advance was also observed for plant height, days to first floret show colour, weight of corm and cormel production in gladiolus (Kumar *et al.*, 2013).

The analysis of variance revealed significant variation among all the genotypes for all attributes (Tables 2 and 3). In general, phenotypic correlations are smaller than genotypic correlation. This could occur when genes governing two traits are similar and environmental conditions pertaining to the expression of these traits have small and similar effects. The magnitude of genotypic correlation was higher than their corresponding phenotypic correlation for most

of the traits, indicating a strong inherent linkage between various traits under study. Similar trend has been observed by Anuradha (1998) in gerbera for most of the characters; these findings indicate that though there is strong inherent association between various characters. The phenotypic expression is reduced under the influences of environment. In some cases, phenotypic and genotypic correlations were very close indicating less environmental influences. Anuradha and Gowda (2002) and Magar *et al.* (2010) have also reported higher genotypic correlation coefficient than phenotypic correlation coefficient among the various traits in gerbera.

The days for sprouting of corms (Table 2) exhibited positive significant correlation with plant height (0.381), spike length (0.427) and rachis length (0.504), attaining highly significant positive correlation with number of leaves/plant (0.730), number of florets/spike (0.552), fresh weight of spike (-0.579) and vase-life (0.572), (Table 2) while there was significant negative correlation with cormel weight (-0.471) and highly significant negative correlation with days taken for spike emergence after sprouting (-0.686) and cormel diameter (-0.597). Pal and Singh (2012) also noticed similar correlation coefficients among characters in gladiolus. However, length of leaf, breadth of leaf, number of tiller/plant, days taken to flowering after spike emergence, days to first floret opening after colour break, diameter of second floret, diameter of flower stalk, corm weight, polar diameter of corm, equatorial diameter of corm and field life were not significantly correlated with days for sprouting of corms. Plant height was highly significant and positively correlated with number of tillers/plant (0.799), diameter of flower stalk (0.554), polar diameter of corm (0.788) and field life (0.696), whereas there was significant and positive correlation with number of leaves/plant (0.403), length of leaf (0.511), days taken for spike emergence after sprouting (0.414), spike length (0.378), number of florets/spike (0.431), corm weight (0.412), equatorial diameter of corm (0.390) and cormel diameter (0.496). There was significant negative correlation with diameter of second floret (-0.457). The significant and positive association of plant height with spike length in gladiolus was also reported by Gowda, (1989); Kumar *et al.* (2012b), (2013) and Kumar and Kumar, (2010) in snapdragon. The plant height exhibited significant and positive correlation with number of florets/spike. These results are in line with the findings of Kumari (2007). However, number of leaves/plant was highly significant and positive correlation with spike length (0.803), rachis length (0.543) and number of florets/spike (0.784), diameter of second floret (0.473), diameter of flower stalk

Table 2. Inter character association (genotypic correlation) between different gladiolus varieties

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	1	0.381*	0.730**	-0.086	-0.208	-0.355	-0.686**	-0.246	-0.137	0.427*	0.504*	0.552**	0.196	0.068	0.579**	-0.035	-0.471*	-0.325	-0.222	-0.597**	0.060	0.572**
2		1	0.403*	0.511*	0.206	0.799**	0.414*	-0.136	0.305	0.378*	0.011	0.429*	-0.457*	0.554**	-0.092	0.412*	0.087	0.788**	0.390*	0.496*	0.696**	0.137
3			1	0.064	0.173	0.035	0.064	-0.063	-0.115	0.803**	0.543**	0.788**	0.473*	0.669**	0.236	0.654**	0.848**	0.724**	0.767**	0.496*	0.287	-0.378*
4				1	-0.433*	0.066	0.368	-0.525*	-0.330	0.359	0.488*	0.341	-0.742**	-0.094	0.024	-0.408*	-0.427*	-0.045	-0.165	0.656**	-0.280	0.656**
5					1	0.420*	-0.168	0.801**	-0.131	0.415*	0.143	-0.114	0.470*	0.406*	-0.089	0.351	0.613**	0.471*	0.648**	0.536**	0.430*	0.728**
6						1	0.258	0.415*	0.680**	0.667**	0.195	0.125	0.009	0.263	-0.344	0.137	0.193	0.545**	0.158	0.484*	0.430*	0.484*
7							1	-0.219	0.144	-0.386*	-0.378*	-0.244	-0.225	-0.418	-0.857**	-0.387*	-0.315	-0.317	-0.312	0.233	0.199	-0.770**
8								1	0.167	0.099	0.185	0.072	0.332	0.029	-0.203	0.062	0.603**	0.117	0.202	0.729**	-0.015	0.490*
9									1	0.429*	-0.101	-0.090	0.545**	0.053	-0.212	0.083	0.014	0.361	0.005	-0.132	-0.185	0.111
10										1	0.986**	0.404*	0.489*	0.361	0.424*	-0.131	-0.014	0.018	-0.101	-0.092	0.750**	0.962**
11											1	0.698**	-0.468*	-0.132	0.273	-0.407*	-0.211	-0.210	-0.382*	-0.535**	0.640**	0.829**
12												1	0.096	0.082	0.147	-0.158	0.529*	-0.269	-0.434*	-0.731**	0.461*	0.175
13													1	-0.324	-0.130	0.052	-0.025	-0.134	-0.159	-0.340	-0.742**	-0.081
14														1	0.543**	0.993**	0.477*	0.911**	0.951**	-0.024	0.345	0.344
15															1	0.518*	0.256	0.488*	0.419*	-0.024	-0.110	0.549**
16																1	0.556**	0.927**	0.964**	0.553**	-0.097	0.304
17																	1	0.801**	0.769**	0.624**	-0.257	0.329
18																		1	0.988**	0.703**	0.056	0.445*
19																			1	0.745**	-0.015	0.421
20																				1	-0.004	0.061
21																					1	0.456*
22																						1

Characters : 1, Days for sprouting of corms; 2, plant height; 3, number of leaves /plant; 4, length of leaf; 5, breadth of leaf; 6, number of tillers/plant; 7, days taken for spike emergence after sprouting; 8, days taken to flowering after spike emergence; 9, days to first floret open after colour break; 10, spike length; 11, rachis length; 12, number of florets /spike; 13, diameter of second floret; 14, diameter of flower stalk; 15, fresh weight of spike; 16, corm weight; 17, cormel weight; 18, polar diameter of corm; 19, equatorial diameter of corm; 20, cormel diameter; 21, field life; 22, vase-life

Table 3. Inter character association (phenotypic correlation) between different gladiolus varieties

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	1	0.321	0.516*	-0.022	-0.170	-0.351	-0.663**	-0.259	-0.127	0.204	0.412*	0.472*	0.115	0.017	0.568**	-0.024	-0.451*	-0.256	-0.227	-0.515*	0.047	0.371
2		1	0.389*	0.357	0.200	0.606**	0.269	-0.108	0.162	0.348	-0.091	0.429*	-0.249	0.308	-0.074	0.378*	0.048	0.458*	0.329	0.459*	0.467*	0.147
3			1	-0.024	0.005	-0.047	0.067	-0.022	-0.124	0.381*	0.540**	0.408*	0.330	0.272	0.149	0.486*	0.555**	0.619**	0.595**	0.225	-0.225	-0.154
4				1	-0.193	0.052	0.301	-0.530*	-0.296	0.234	0.270	0.178	-0.619**	0.116	-0.199	0.045	-0.288	-0.353	-0.047	-0.378*	0.499**	-0.012
5					1	0.382*	-0.171	0.579**	-0.110	0.073	0.197	-0.130	0.116	0.294	-0.063	0.280	0.546**	0.144	0.452*	0.420*	0.322	0.493*
6						1	0.242	0.392*	0.604**	0.315	0.216	0.123	0.057	0.215	-0.313	0.102	0.186	0.307	0.174	0.139	0.462*	0.258
7							1	-0.192	0.121	-0.104	-0.330	-0.162	-0.199	-0.315	-0.794**	-0.364	-0.309	-0.115	-0.286	0.211	0.223	-0.472*
8								1	0.139	0.070	0.193	0.053	0.327	0.035	-0.238	0.031	0.559**	0.081	0.248	0.090	-0.030	0.150
9									1	0.158	-0.062	0.003	0.482*	0.039	-0.263	0.064	0.046	0.069	0.037	-0.055	-0.158	0.081
10										1	0.370	0.247	0.447*	-0.167	0.160	0.002	-0.022	0.162	0.059	-0.008	0.373	0.442*
11											1	0.472*	-0.101	0.007	0.235	-0.378*	-0.142	-0.249	-0.320	-0.462	0.509*	0.342
12												1	0.067	-0.014	0.085	-0.179	0.448*	-0.141	-0.324	-0.564**	0.438*	0.102
13													1	-0.091	-0.155	-0.014	0.001	-0.147	-0.110	-0.283	-0.561	-0.173
14														1	0.447*	0.687**	0.328	0.585**	0.637**	0.116	0.201	0.324
15															1	0.480**	0.218	0.325	0.324	-0.073	-0.105	0.365
16																1	0.534*	0.684**	0.856**	0.459*	-0.114	0.198
17																	1	0.482*	0.706**	0.565**	-0.257	0.201
18																		1	0.590**	0.079	0.087	0.261
19																			1	0.629**	-0.076	0.261
20																				1	0.002	0.122
21																					1	0.332
22																						1

Characters : 1, Days for sprouting of corms; 2, plant height; 3, number of leaves /plant; 4, length of leaf; 5, breadth of leaf; 6, number of tillers/plant; 7, days taken for spike emergence after sprouting; 8, days taken to flowering after spike emergence; 9, days to first floret open after colour break; 10, spike length; 11, rachis length; 12, number of florets /spike; 13, diameter of second floret; 14, diameter of flower stalk; 15, fresh weight of spike; 16, corm weight; 17, cormel weight; 18, polar diameter of corm; 19, equatorial diameter of corm; 20, cormel diameter; 21, field life; 22, vase-life

(0.669), corm weight (0.654), cormel weight (0.814), polar diameter of corm (0.848), equatorial diameter of corm (0.724) and cormel diameter (0.767), but significant negative correlation was noticed in vase-life (-0.378). Nair and Shiva (2003) also observed positive correlation between numbers of leaves with flower diameter in gerbera, whereas positive correlation of flower yield with number of leaves in gerbera was observed by Anuradha and Gowda (2002).

Length of leaf showed highly significant and positive correlation with field life (0.656), while significant and positive correlation with rachis length (0.488). However, highly significant and negative correlation with diameter of second floret (-0.742), but significant with negative correlation in breadth of leaf (-0.433), days taken to flowering after spike emergence (-0.525), corm weight (-0.408) and cormel weight (-0.427) were noticed. Breadth of leaf was highly significant and positively correlated with days taken to flowering after spike emergence (0.801), cormel weight (0.613), equatorial diameter of corm (0.648), cormel diameter (0.536) and vase life (0.728), whereas significant and positive correlation with number of tillers/plant (0.420), spike length (0.415), diameter of second floret (0.470), diameter of flower stalk (0.406), polar diameter of corm (0.471) and field life (0.430) was observed. Singh and Kumar (2008) also reported highly significant and positive correlation of plant spread and diameter of flower in marigold.

Number of tillers/plant was highly significant, showing positive correlation with days to first floret open after colour break (0.680), spike length (0.667) and polar diameter of corm (0.545), whereas significant but positive correlation was observed with days taken to flowering after spike emergence (0.415), field life (0.484) and vase-life (0.430). However, days taken for spike emergence after sprouting had highly significant but negative correlation with fresh weight of spike (-0.857) and vase-life (-0.770), but significant and negative correlation with spike length (-0.386), rachis length (-0.378) and corm weight (-0.387).

Days taken to flowering after spike emergence were highly significant and positive correlation with cormel weight (0.603) and cormel diameter (0.729) but showed significant and positive correlation with vase-life (0.490). However, days to first floret open after colour break was highly significant but positively correlated with diameter of second floret (0.545) and attained significantly positive correlation with spike length (0.429). Aswath and Parthasarathy (1994) also noticed positive correlation between days taken to flower head with flower stalk diameter in gerbera.

Spike length had highly significant and positive correlation with rachis length (0.986), field life (0.750)

and vase-life (0.962), while number of florets/spike (0.404), diameter of second floret (0.489) and fresh weight of spike (0.424) showed significant and positive association. Kumar and Kumar (2010) also noticed significant and positive correlation of spike length with rachis length and number of florets/spike in snapdragon. Rachis length showed highly significant and positive correlation with number of florets/spike (0.698), field life (0.640) and vase-life (0.829), however, cormel diameter (-0.535) had highly significant and negative correlation, while diameter of second floret (-0.468), corm weight (-0.407) and equatorial diameter of corm (-0.382) observed significant but negative correlation. Number of florets/spike showed highly significant and negative correlation with cormel diameter (-0.731) and significant negative correlation with equatorial diameter of corm (-0.434) but had significant and positive correlation with cormel weight (0.529) and field life (0.461), while diameter of second floret recorded highly significant and negative correlation with field life (-0.742).

However, diameter of flower stalk had highly significant and positive correlation with fresh weight of spike (0.543), corm weight (0.993), polar diameter of corm (0.911) and equatorial diameter of corm (0.951). There was significant and positive correlation with cormel weight (0.477). Highly significant and positive correlation in vase-life (0.549) and significantly positive correlation in corm weight (0.518), polar diameter of corm (0.488) and equatorial diameter of corm (0.419) were noticed with fresh weight of spike. Corm weight showed highly significant and positive correlation with cormel weight (0.556), polar diameter of corm (0.927), equatorial diameter of corm (0.964) and cormel diameter (0.553), while cormel weight had highly significant and positive correlation with polar diameter of corm (0.801), equatorial diameter of corm (0.769) and cormel diameter (0.624). Positive significant correlations were also observed for corm weight and corm diameter in gladiolus at both genotypic and phenotypic levels (Archana *et al.*, 2008).

Polar diameter of corm had highly significant and positive correlation with equatorial diameter of corm (-0.988) and cormel diameter (0.703). There was significantly positive correlation with vase-life (0.445), while equatorial diameter of corm attained highly significant and positive correlation with cormel diameter (0.745). The field life exhibited significant and positive correlation with vase-life (0.456). However, vase-life showed highly significant and positive correlation with days for sprouting of corms, breadth of leaf, spike length, rachis length and fresh weight of spike. There was significant and positive correlation with polar diameter of corm and field life. Similar

results corroborate with the findings Kumar and Sharma (2013).

The days for sprouting of corms attained highly significant and positive correlation with fresh weight of spikes (0.568), while there was significant and positive correlation with number of leaves (0.516), rachis length (0.412) and number of florets/spike (0.472). Highly significant but negative correlation with days taken for spike emergence after sprouting (-0.663), significant but negative correlation with cormel weight (-0.451) and cormel diameter (-0.515) was observed (Table 3).

Plant height had highly significant and positive correlation with number of tillers/plant (0.606), but significant and positive correlation was obtained with number of leaves/plant (0.389), number of florets/spike (0.429), corm weight (0.378), polar diameter of corm (0.458), equatorial diameter of corm (0.385) and field life (0.459).

Kumar *et al.* (2011) also observed that plant height was significantly and positively correlated with number of leaves/plant. Number of leaves per plant showed highly significant and positive correlation with rachis length (0.546), cormel weight (0.555), polar diameter of corm (0.619) and equatorial diameter of corm (0.595). The spike length (0.381), number of florets/spike (0.408), corm weight (0.486) and cormel diameter (0.467) attained significant and positive correlation. Similar findings were observed by Kumar *et al.* (2012a) in gerbera which reveals that cut flower production can be increased by selecting number of leaves. Length of leaf was highly significant and positive correlated with field life (0.499), whereas equatorial diameter of corm (0.378) showed significant and positive correlation. However, diameter of second floret (-0.619) attained highly significant but negative correlation and days taken to flowering after spike emergence (-0.530) noted significant but negative correlation.

Breadth of leaf showed highly significant and positive association with days taken to flowering after spike emergence (0.579) and cormel weight (0.546), while number of tillers/plant (0.382), equatorial diameter of corm (0.452), cormel diameter (0.420) and vase-life (0.493) attained significant and positive association. Number of tillers/plant had highly significant and positive correlation with days to first floret open after colour break (0.604) but showed significant and positive correlation with days taken to flowering after spike emergence (0.392) and field life (0.462). Days taken for spike emergence after sprouting was highly significant and negative association with fresh weight of spike (-0.794) but had significant and negative correlation with vase-life (-0.472).

Days taken to flowering after spike emergence was highly significant and positive association with cormel weight (0.559), but days to first floret open after colour break had diameter of second floret (0.482), while spike length showed significant and positive correlation with diameter of second floret (0.447) and vase-life (0.442). However, rachis length had significant and positive association with number of florets/spike (0.472) and field life (0.509), whereas significant and negative association with corm weight (-0.378). Balaram and Janakiram (2009) also reported positive and significant relationship of floret diameter with spike length in gladiolus. Number of florets/spike showed significant and positive association with cormel weight (0.448) and field life (0.438), while cormel diameter (-0.564) noticed highly significant but negative association.

Diameter of flower stalk was highly significant and positive correlation with corm weight (0.687), polar diameter of corm (0.585) and equatorial diameter of corm (0.637), while it had significant and positive correlation with fresh weight of spike (0.447), while fresh weight of spike attained highly significant and positive correlation with corm weight (0.480). Corm weight showed highly significant and positive association with polar diameter of corm (0.684) and equatorial diameter of corm (0.856) but significant and positive correlation with cormel weight (0.534) and cormel diameter (0.459). However, cormel weight was highly significant and positive correlation with equatorial diameter of corm (0.706) and cormel diameter (0.565) but had significant and positive correlation with polar diameter of corm (0.482).

Polar diameter of corm attained highly significant and positive correlation with equatorial diameter of corm (0.590), while equatorial diameter of corm showed highly significant and positive correlation with cormel diameter (0.629). While, vase-life showed significant and positive correlation with breadth of leaf (0.493) and spike length (0.442). Similar results were also obtained in *dendrobium* orchid (Kumar and Sharma, 2013). Thus, it was concluded that Candyman, Poppy Tears, Red Ginger, Hunting Song, Wedding Bouquet, Pacifica, American Beauty and Summer Sunshine may have scope for evolving noble colour and elite varieties in Pasighat, East Siang District, Arunachal Pradesh.

REFERENCES

- Al-Jibouri H A, Muller P A and Robinson H P. 1958. Genetic and environmental variance and covariance in an upland cotton crop of interspecific origin. *Agronomy Journal* 30 : 633-636.
- Allard, R W. 1960. *Principles of Plant Breeding*. John Wiley & Sons, Inc. New York, USA, 885.

- Anuradha, S. 1998. 'Genetic studies in gerbera (*Gerbera jamesonii* Bolus)'. Ph.D. Thesis, *University of Agricultural Sciences*, Bangalore.
- Anuradha, S and Gowda J V. 2002. Inter-relationship between growth and yield parameters with flower yield in gerbera. *Journal of Ornamental Horticulture* (new series), **5**(1) : 35-37.
- Archana B, Patil A A, Hunje, R and Patil, V S. 2008. Studies on genetic variability analysis in gladiolus hybrids. *Journal of Ornamental Horticulture* **11**(2) : 121-126.
- Ashwath, C, and Parthasarthy, V A. 1994. Association analysis in Gerbera. Prakash, J and Bhandari, K R, (Eds). Floriculture Technology, Trades and Trends. Oxford and IBH Publication Co. Ltd. New Delhi.
- Balaram, M V and Janakiram T. 2009. Correlation and path coefficient analysis in gladiolus. *Journal of Ornamental Horticulture* **12**(1) : 22-29.
- Balaram M V and Janakiram T. 2009. Genetic variability in gladiolus genotypes for corm characters. *Journal of Ornamental Horticulture* **12**(2) : 123-126.
- Bichoo, G A, Jhon, A O and Wani, S A. 2002. Genetic variability in some quantitative characters of gladiolus. *Journal of Ornamental Horticulture* **5**(1) : 22-24.
- Burton, G W. 1952. Quantitative inheritance in grasses. *Proceeding of the Sixth International Grassland Congress* **1** : 277-283.
- Burton, G W and Devane, E W. 1953. Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. *Agronomy Journal* **45** : 475-481.
- Chobe, R R, Pachankar, P B and Warade S D. 2010. Studies on genetic variability and heritability in gerbera. *Asian Journal of Horticulture* **5**(2) : 356-8.
- Falconer, D C. 1981. Introduction to quantitative genetics, Ronald press Co., New York, pp. 66-72.
- Gowda J V N. 1989. Genotypic and phenotypic variability and correlation in quantitative and qualitative characters in gladiolus. *Crop Research* **2**(2) : 235-237.
- Johnson, H W, Robinson, H F and Comstock, R E. 1955. Estimation of genetic and environmental variability in Soybean. *Agronomy Journal* **47** : 354-371.
- Kadam, G B, Kumar, G, Saha, T N, Tiwari, A K and Kumar, R. 2014. Varietal evaluation and genetic variability studies on gladiolus. *Indian Journal of Horticulture* **71**(3) : 379-384.
- Kumar, J, Kumar, R and Pal K. 2011. Variability and character association in gladiolus (*Gladiolus grandiflorus* L.). *Agriculture Science Digest* **31**(4) : 280-284.
- Kumar, P, Maurya, R V, Chakraborty, B, Mer, R and Mishra, D. S. 2013. Genetic variability and correlation studies in *Gladiolus Hybrida* L. under Tarai Condition of Uttarakhand. *Progressive Agriculture* **13**(1) : 68-74.
- Kumar, R, and Kumar, S. 2010. Correlation studies in snapdragon (*Antirrhinum majus* L.). *Journal of Ornamental Horticulture* **13**(2) : 133-137.
- Kumar, R, Deka, B C, and Venugopalan, R. 2012(a). Genetic variability and trait association studies in gerbera (*Gerbera jamesonii*) for quantitative traits. *Indian Journal of Agricultural Sciences* **82**(7) : 615-9.
- Kumar, R, Kumar, S and Yadav, Y C. 2012(b). Genetic variability, heritability, genetic advance, correlation coefficient and path analysis in gladiolus. *Indian Journal of Horticulture* **69**(3) : 369-373.
- Kumar, S and Sharma, S. 2013. Studies on performance, genetic variability, heritability and correlation of *Dendrobium* orchids under agroclimatic conditions of Pasighat, Arunachal Pradesh. *International J. Agriculture Environment & Biotechnology* **6**(1) : 101-108.
- Kumari, J. 2007. 'Evaluation of snapdragon germplasm under Tarai condition'. M. Sc. Thesis, Govind Ballabh Pant University of Agriculture and Technology, Pant Nagar, Uttarakhand.
- Magar, S D, Warade, S D, Nalge, N A and Nimbalkar, C A. 2010. Correlation and path analysis studies in Gerbera (*Gerbera jamesonii*). *International Journal of Plant Science* (Muzaffarnagar) **5**(2) : 553-5.
- Mahanta, P and Paswan, L. 1995. Studies on variability and heritability of some quantitative characters in gladiolus. *South Indian Horticulture* **41**(3) : 166-168.
- Nair, A S, and Shiva, K N. 2003. Genetic variability, correlation and path coefficient analysis in gerbera. *Journal of Ornamental Horticulture* **6**(3) : 180-187.
- Nyquist, W E. 1991. Estimation of heritability and prediction of selection response in plant populations. *Critical Review of Plant Science* **10** : 235-322.
- Pal, S and Singh, R. 2012. Correlation and path coefficient Analysis in gladiolus. *Annals of Horticulture* **15**(1) : 103.
- Singh, B and Singh, M. 1987. Studies on variability and genetic parameters in gladiolus. *Progressive Horticulture* **19** : 271-275.
- Singh, D and Kumar, S. 2008. Studies on genetic variability, heritability, genetic advance and correlation in marigold. *Journal of Ornamental Horticulture* **11**(1) : 27-31.

Genetic variability in tamarind (*Tamarindus indica* L.) from south Gujarat

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ABSTRACT

The studies were carried out in the districts of Dang, Navsari, Tapi, Valsad and adjoining areas in south Gujarat during 2010-11 to 2013-14 for identifying superior tamarind (*Tamarindus indica* L.) genotypes with desirable horticultural traits. A total of 12 genotypes having economically important horticultural traits were identified. These genotypes showed considerable variability in morphological and physico-chemical characters. The pod weight varied from 8.64 to 27.70g, pod length (8.64 - 17.76 cm), pod width (2.48 - 3.16 cm), number of seeds/pod (3.38 - 9.77) seed weight (2.02 - 8.33 g), pulp weight (4.10 - 15.77g), pulp (47-55%) and pod yield (47.44 - 248.8 kg/tree). The TSS (61.7-65.5°Brix), acidity (10-12%), vitamin C content (4.5-12.1mg/100 g pulp), reducing sugars (6-10.8%) and total sugar (14.4-29.9%), ranged in different germplasm accessions evaluated. On the basis of overall assessment, six tamarind genotypes, viz. T₁, T₂, T₅, T₁₀, T₁₁ and T₁₂ were selected as most promising and these might be used as superior trees for clonal multiplication.

KEY WORDS: *Tamarindus indica*, Tamarind, Germplasm, Variability, Genetic, Acidity, Pulp weight

Tamarind (*Tamarindus indica* L.) is a member of dicotyledonous family, Fabaceae and belongs to the sub-family Caesalpinioideae. The name of tamarind is derived from an Arabic word tamarind-e-hind" meaning "date of India" popularly known as "Indian date", is a multipurpose tropical fruit tree used primarily for its fruits, which are eaten fresh or processed, used as a seasoning or spice, or fruits and seeds are processed for non-food uses. Tamarind trees start bearing fruits at the age of 13-14 years and continue to produce fruits even after 60 years and some up to 200 years. Half the pod weight is contributed by pulp in tamarind. Pulp contains both sugars and organic acids (8-18%), predominantly tartaric acid. India is the main producer and consumer of tamarind in the world. India produces 3 million tonnes of fruits and exported 16,000 tonnes (2013-14).

It is a source of timber, fruits, seeds, fodder, medicinal extracts and has potential of industrial use. Owing to its varied uses in home and export market, it has emerged as a significant crop. Due to cross-pollination and predomination of seed propagation over a long period of time, it gives immense opportunity to locate elite trees having desirable horticultural traits. In tribal belt of south Gujarat, tamarind trees are found growing naturally as stray plantation on wastelands. Wide variations were also observed in sweetness, acidity, size, shape and bearing habits in tamarind genotypes. Hence, genetic variability of tamarind was explored.

MATERIALS AND METHODS

An extensive survey was conducted by a team of scientists from KVK, Waghai, in the districts of Dang, Navsari and adjoining areas of south Gujarat to identify promising tamarind trees for selection. Efforts were made to identify only regular and prolific-bearing trees with good fruit size and tolerance to biotic (pest and diseases) and a biotic (frost and drought) stresses. A

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total of 12 genotypes having desirable fruit characters with good bearing performance were marked *in situ*. The methods of random sampling from a population and biased sampling after gathering information about a particular genotype was followed (Sinha, 1981).

Twenty fruits were randomly collected from all the directions in each genotype to record the physical attributes like pod weight, pod length and pod width using standard procedures. Total soluble solids (TSS) were estimated in terms of degree brix with the help of hand refractometer (0-32° Brix). Titrable acidity was estimated by titrating 10 ml juice against 0.1 N NaOH using phenolphthalein as indicator (AOAC, 1960). Reducing sugars and total sugars were estimated by volumetric methods as suggested by Lane and Eynon (1923). Vitamin C content of fruits was determined using standardized 2, 6, dichlorophenol indophenol dye and expressed as mg per 100 g pulp. Three years data were pooled and analyzed statistically as per procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

All the genotypes studied were regular in bearing, flowering was started from march to april and fruits were ready for harvesting during April-May (Table 1). The pod size was observed from straight to vary curved, the shell detachability and removal of seed from the pulp was found to be easy to vary hard similarly, the pulp colour was light brown to dark brown. The data regarding physical attributes of tamarind fruits showed significant difference and high degree of variations in all these studied parameters (Table 2). The pod length varied from 8.48 cm (T₁₁) to 17.62 cm (T₁), fruit width varied from 2.48 cm in T₁₁ to 3.18 in genotype T₄. Pod weight varied from 8.64 g in T₁₁ - 27.7 g in T₁ genotype with pulp recovery of 40 - 55 % respectively.

Higher fruit weight and pulp recovery in tamarind is a preferred character for processing particularly for pulp (Purseglove, 1987; Shankaracharya, 1998). The genotypes T₁, was found high yielder (248kg/tree), the over pod yield was varied from 47.49 to 248 kg per tree in different genotypes. Higher fruit weight with pulp recovery is an important criterion for selection of new tamarind. Variation in tamarind genotypes with regard to above characters were earlier reported from India (Malik *et al.* 2010).

The chemical parameters, *viz.* TSS, acidity, sugars and vitamin C showed wide variation among genotypes evaluated (Table 3). The TSS content varied from 61.1°Brix (T₁₀) to 69 ° Brix (T₇). The titrable acidity is found to be minimum 10% in T₅ and maximum 11.8% in T₁. Reducing sugar was recorded from 6 to 10.8%, while non-reducing sugar was recorded from 4.2 to 21.5% in different genotype. The total sugars were recorded highest (29.9%) in T₅ while it was lowest (14.2%) in T₁₂. The vitamin C content was recorded highest 12.1 mg/100 g in T₁ and lowest 4.5 mg/100 g in T₅, T₆ and T₈ genotypes (Table 3). The large range is associated with heterozygosity since many cultivated forms have been seed propagated (Benero *et al.* 1974).

Thus, it can be concluded that the natural wealth of tamarind available in south Gujarat region has great diversity in morpho-physicocharacters, which offer unique scope for further improvement in tamarind through selection of superior genotypes, especially for higher yield, higher pulp recovery and sugar content. On the basis of overall assessment, six tamarind genotypes, *viz.* T₁, T₂, T₅, T₅, T₁₀, T₁₁ and T₁₂ were selected as most promising. These genotypes have immense potential to be used either for clonal multiplication, further evaluation and selection as a commercial variety or as superior gene source in future tamarind hybridization programme.

Table 1. General characteristics of flowering and fruiting in different treatments

Treatment	Bearing habit	Pod shape	Shell detachability	Seed removal	Pod colour without shell
T ₁ (GT-1)	Regular	Curve	Easy	Easy	Ligth to medium brown
T ₂ (GT-2)	Regular	Curve	Easy	Hard	Medium brown
T ₃ (GT-3)	Regular	Semi-curve	Hard	Hard	Dark brown
T ₄ (GT-4)	Regular	Semi-curve	Easy	Hard	Dark brown
T ₅ (GT-5)	Regular	Very-curve	Very hard	Very hard	Ligth to medium brown
T ₆ (GT-6)	Regular	Semi-curve	Very Easy	Hard	Medium brown
T ₇ (GT-7)	Regular	Straight	Easy	Hard	Medium brown
T ₈ (GT-8)	Regular	Semi-curve	Easy	Easy	Medium to dark brown
T ₉ (GT-9)	Regular	Straight	Easy	Hard	Medium brown
T ₁₀ (GT-10)	Regular	Straight	Easy	Very hard	Light brown
T ₁₁ (GT-11)	Regular	Semi-curve to straight	Hard	Very hard	Light brown
T ₁₂ (GT-12)	Regular	Straight	Easy	Easy	Dark brown

Table 2. Pod characteristics, yield and yield attributes in tamarind genotypes (pooled value of three years)

Treatment	Pod length (cm)	Pod width (cm)	Pod weight (g)	Pulp weight (g)	Pulp recovery (%)	Yield (kg/tree)
T ₁ (GT-1)	17.62	2.95	27.70	15.17	0.54	248.88
T ₂ (GT-2)	16.04	3.16	28.21	14.14	0.50	143.88
T ₃ (GT-3)	12.80	2.55	12.34	5.53	0.44	187.00
T ₄ (GT-4)	12.77	3.18	19.54	7.90	0.40	114.22
T ₅ (GT-5)	16.01	3.00	24.54	13.63	0.55	92.55
T ₆ (GT-6)	11.95	2.76	13.92	5.78	0.41	82.55
T ₇ (GT-7)	12.72	2.86	14.56	5.88	0.40	69.66
T ₈ (GT-8)	9.87	2.68	14.83	6.15	0.41	106.44
T ₉ (GT-9)	10.18	2.73	11.64	4.71	0.40	52.22
T ₁₀ (GT-10)	14.91	2.95	19.50	8.77	0.45	96.11
T ₁₁ (GT-11)	8.48	2.92	8.64	4.10	0.47	47.44
T ₁₂ (GT-12)	11.22	2.48	11.73	7.25	0.47	107.55
SEm±	0.08	0.05	0.10	0.09	0.008	2.28
CD (5 %)	0.23	0.14	0.31	0.25	0.02	6.46
CV (%)	1.9	5.32	1.91	3.33	3.75	6.11
Y						
SEm±	0.04	0.02	0.05	0.04	0.0040	1.14
CD (5 %)	NS	NS	NS	0.12	NS	3.23
YXT						
SEm±	0.1411	0.0877	0.19	0.15	0.0099	3.96
CD (5 %)	NS	NS	NS	NS	NS	NS

Table 3. Pulp quality in different tamarind genotypes

Treatment	TSS (°Brix)	Acidity (%)	Vitamin C (mg/100g)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)
T ₁ (GT-1)	65.5	11.8	12.1	8.8	7.1	16.0
T ₂ (GT-2)	66.1	10.6	7.6	8.6	9.1	17.8
T ₃ (GT-3)	66.2	11.2	6.0	10.8	9.1	20.0
T ₄ (GT-4)	66.1	12.0	9.1	10.2	9.5	19.7
T ₅ (GT-5)	66.4	10.0	4.5	8.4	21.5	29.9
T ₆ (GT-6)	63.9	11.1	4.5	10.0	11.6	21.7
T ₇ (GT-7)	69.0	10.8	6.0	8.9	6.5	15.5
T ₈ (GT-8)	68.8	11.2	4.5	8.5	7.9	16.5
T ₉ (GT-9)	67.6	10.5	10.6	6.0	8.3	14.4
T ₁₀ (GT-10)	67.2	11.7	9.1	9.3	11.8	21.2
T ₁₁ (GT-11)	61.7	11.4	12.1	9.8	10.4	20.2
T ₁₂ (GT-12)	63.9	10.5	10.6	10.0	4.2	14.2
S E m±	0.89	0.42	0.31	0.34	0.41	0.60
CD (5 %)	2.60	NS	0.90	1.00	1.21	1.77
CV (%)	2.32	6.62	6.56	6.47	7.33	5.53

REFERENCES

- AOAC, Washington. 1960. Official Methods of Analysis, 9th edn. Association of Official Agricultural Chemists, Washington, DC.
- Gomez K A and Gomez A A. 1984. *Statistical Procedures for Agricultural Research*, 2nd edn. Jhon Wiley and Sons Inc, New York.
- Lane J H and Eynon J. 1923. Determination of reducing and total sugars by Fehling's solution with methyleneblue as indicator. *J. Soc. Chem. India* **42** : 32.
- Malik S K, Chaudhury R, Dhariwal O P and Bhandari D C. 2010. *Genetic Resources of Tropical Underutilized Fruits in India*, National Bureau of Plant Genetic Resources, New Delhi pp. 139.
- Purseglove J W. 1987. *Tropical Crops. Dicotyledons*, Longman Science and Technology pp, 204-06.
- Shankaracharya N B. 1998. Tamarind - Chemistry, Technology and Uses - a critical appraisal. *Journal of Food Technology* **35**(3) : 193-208.
- Sinha G C. 1981. Gene pool sampling in tree crops. In: *Plant Exploration and Collection*. Mehra K L, Arora R K and Wadhi S R (Eds). NBPGR, New Delhi.

Correlation studies, spoilage and physiological loss in weight in guava (*Psidium guajava*) fruit

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ABSTRACT

A field experiment was conducted during 2011-12 on correlation studies, spoilage (%) and physiological loss in weight in guava (*Psidium guajava* L.) fruits. The shelf-life correlated positively with TSS and TSS: acidity ratio. The spoilage I at 5- day interval correlated positively with spoilage II at 10- day interval and spoilage III at 15- day interval. But spoilage II at 10- day interval correlated positively with acidity and spoilage III. Spoilage III at 15- day interval correlated positively with acidity. The TSS correlated positively with TSS: acid ratio. Maximum average fruit weight was recorded in the control without packing (165.67g), whereas minimum average fruit weight (109 g) was found in packing of fruits with 2% ventilation. Maximum spoilage loss (%) and physiological loss in weight (%) of fruits was found in the control without packing (46.67, 73.33 and 100%) and (7.59, 18.97 and 36.07%) and minimum spoilage and physiological loss was found in packing of fruits without ventilation (0.00, 0.00 and 13.13%) and (00, 4.36 and 22.30%) at 5, 10 and 15 days.

KEY WORDS: Guava, Correlation, Spoilage loss, Physiological loss and Post-harvest treatments

Guava (*Psidium guajava* L.) is grown all over the tropics and subtropics. In India, guava is grown in 205 thousand ha with a total production of 2,462 thousand tonnes and average productivity of 12 tonnes /ha (NHB, 2011). In Madhya Pradesh, guava is grown in 9.7 thousand ha with a total production of 228.8 thousand tonnes and productivity of 29 tonnes /ha. Guava is highly perishable in nature. It should be marketed immediately after harvesting. Therefore, certain measures for increasing its shelf-life need to be done for its availability in distant market, maintaining the quality of fruits. The post-harvest deterioration in fruits occur as a result of physiological changes, spoilage losses, dehydration and mechanical injury. This is the critical stage for transportation to distant market due to more changes in spoilage loss. Various technologies for improving shelf-life and storage of horticultural commodities for improving self-life and storage have evolved. Use of fungicides in cold storage, control

atmosphere storage, anti-transparent, wax coatings, oil coatings, growth retardants, irradiation and different types of packing material etc. are used to increase the longevity of harvested fruits, but in spite of these available techniques the percentage of post-harvest losses of fruits is still high. Therefore, an experiment was conducted on correlation studies, spoilage (%) and physiological loss in weight in guava fruits.

MATERIALS AND METHODS

The field experiment was conducted at Department of Horticulture, College of Agriculture, Rewa, during winter cropping season of 2011-2012 on correlation studies and spoilage (%) and physiological loss in weight of guava fruits. The experiment was laid out in a randomized block design having three replications. The research farm is situated at a latitude 24° 31' N, longitude 81° 15' E and altitude of 365.7 m above mean sea-level. The soil of experimental site has clay loam texture. The land is slightly sloppy and drainage is normal. The experiment consisted of seven treatments: packing of fruits without ventilation in polythene bags, packing of fruits with 1% ventilation in polythene bags,

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packing of fruits with 2% ventilation in polythene bags, pre-harvest treatment spray of 50 ppm GA₃ + post-harvest dip 50 ppm + 1% ventilation in polythene bags, pre-harvest treatment spray of 50 ppm GA₃ + post-harvest dip 50 ppm + 2 % ventilation in polythene bags, pre-harvest + post-harvest spray of 50 ppm GA₃ without ventilation in polythene bags, and the control without packing. The observation were recorded to see correlation studies, average fruit weight (g), spoilage (%) and physiological loss in weight (%).

RESULTS AND DISCUSSION

The data on correlation (biochemical characters) indicated that shelf-life was negatively and significantly correlated with spoilage I at 5 days interval (-.801*), spoilage II at 10 days interval (-.866**) and spoilage III at 15 days interval (-.882**), whereas it was negatively non-significantly correlated with acidity (-.307) (Table 1). Spoilage I was positively significantly correlated with spoilage II (.987**) and spoilage III (.974**) and negative non-significantly correlated with acidity (-.048) and TSS: acid ratio (-.392). Spoilage II

positively significantly correlated with spoilage III (.991**) but positively non-significantly correlated with acidity (.032) and negatively non-significantly correlated with TSS: acidity ratio (-.459). Spoilage III positively non-significantly correlated with acidity (.084) but negatively non-significantly correlated with TSS: acidity ratio (-.515). Acidity negatively non-significantly correlated with TSS (-.532) but negatively significantly correlated with TSS: acid ratio (-.874**).

The increase in spoilage in fruits was found to be significantly less in packing of fruits without ventilation (0.00, 0.00 and 13.33%) at 5, 10 and 15 days of storage, which was at par with pre-harvest + post-harvest spray of 50 ppm GA₃ without ventilation (0.00, 6.67 and 20%) at 5,10 and 15 days of storage respectively. Maximum spoilage was found under the control without packing (46.67, 73.33 and 100) at 5, 10, and 15 days, which was at par with packing of fruits with 2% ventilation (33.33, and 86.67%) 5 and 15 days of storage. The spoilage was high in T₇ (46.6, 73.3 and 100%) at 5, 10, and 15 days of storage, while minimum in T₁ (0.00, 0.0 and 13.3 %), followed by T₆ (0.0, 6.7 and 20%)

Table 1. Correlation between biochemical characteristics

Characteristic	Shelf-life	Spoilage I	Spoilage II	Spoilage III	acidity	TSS	TSS: acid
Shelf-life	1	-.801**	-.866**	-.882**	-0.307	.653*	.660*
Spoilage I		1	.987**	.974**	-0.048	-.626*	-0.392
Spoilage II			1	.991**	0.032	-.636*	-0.459
Spoilage III				1	0.084	-.605*	-0.515
Acidity					1	-0.532	-.874**
TSS						1	.653*

* Correlation is significant at 0.05 level (2-tailed); ** Correlation is significant at 0.01 level (2-tailed)

Table 2. Effect of treatment on spoilage of fruits (%)

Treatment	Spoilage (%)		
	5 day	10 day	15 day
T ₁ , Packing of fruits without ventilation in polythene bags	0.00	0.00	13.33
T ₂ , Packing of fruits with 1% ventilation in polythene bags	13.33	33.33	60.00
T ₃ , Packing of fruits with 2% ventilation in polythene bags	33.33	53.33	86.67
T ₄ , Pre-harvest treatment spray of 50 ppm GA ₃ + post-harvest dip 50 ppm + 1% ventilation in polythene bags	26.67	46.67	67.67
T ₅ , Pre-harvest treatment spray of 50 ppm GA ₃ + post-harvest dip 50 ppm + 2% ventilation in polythene bags	33.33	53.33	80.00
T ₆ , Pre-harvest + post-harvest spray of 50 ppm GA ₃ without ventilation in polythene bags	0.00	6.67	20.00
T ₇ , Control without packing	46.67	73.33	100.00
SEm	7.27	6.34	8.66
CD (5%)	22.41	15.54	26.71

Table 3. Effect of treatment on physiological loss in weight (%)

Treatment	Physiological loss (%) after packing		
	5 day	10 day	15 day
T ₁ Packing of fruit without ventilation in polythene bags	00	4.36	22.30
T ₂ Packing of fruits with 1% ventilation in polythene bags	2.71	9.93	27.77
T ₃ Packing of fruits with 2% ventilation in polythene bags	6.80	19.97	35.73
T ₄ Pre-harvest treatment spray of 50 ppm GA ₃ + post-harvest dip 50 ppm + 1% ventilation in polythene bags	3.63	11.50	29.80
T ₅ Pre-harvest treatment spray of 50 ppm GA ₃ + post-harvest dip 50 ppm + 2% ventilation in polythene bags	5.90	17.80	35.47
T ₆ Pre-harvest + post-harvest spray of 50 ppm GA ₃ without ventilation in polythene bags	00	4.83	25.53
T ₇ Control without packing	7.59	18.97	36.07
SEm	0.79	1.98	2.40
CD (5%)	2.43	6.11	7.42

(Table 2). It might be due to the increased carbon dioxide level inside the packages and low oxygen in atmosphere that extended the storage life of fruits than other treatments. Similar results were recorded by Sudha *et al.* (2007), Combrink *et al.* (1990) and Chaitany *et al.* (1997).

Different packaging treatments significantly influenced the physical and quality characters of guava fruits. Moisture losses through transpiration during storage affected the soluble weight and eventually the fruits became insoluble as a result of shrinking. The PLW was continuous phenomena during storage due to moisture loss. The increase in physiological weight loss of guava fruits treated and packed in polyethylene bags. However, increase in physiological weight loss was recorded to be significantly less in fruits treated and packing of fruits without ventilation (0.00, 4.36, and 22.30%), which is at par with pre-harvest + post-harvest spray of 50 ppm GA₃ without ventilation (00, 4.83 and 25.53%) at 5,10 and 15 days from packing day.

The maximum physiological weight loss was found under the control without packing (T₇) (7.59, 18.97 and 36.07%) which was at par with packing of fruits with 2 % ventilation (T₃) (6.80, 17.97 and 35.73 %) at 5, 10 and 15 day from packing days (Table 3). They were evidently due to lesser transpiration losses than helps in checking the loss in fruit weight. The recorded oxygen level inside the packages would have reduced the oxidative processes, reduce the respiration rate and post harvest the climacteric stage. The results are in close conformity with finding of Yanshita and Benassi

(1998), Singh and Singh (1999) and Hiwale and Singh (2003). Maximum fruit length, girth was recorded in T₅ (6.78 cm and 22.5 cm). This may be due to polythene bags suppresses positive oxygen level and interferes with the ethylene formulation.

REFERENCES

- Chaitany C G, Kumar Ganesh, Raina B L and Muthoo A K. 1997. Effect of zinc and boron on the shelf life of guava cv. Sardar (*Psidium guajava* L.). *Advance in Plant Science* 10(2) : 45-49.
- Combrink J C, Kock S L de and Eeden C J van. 1990. Effect of post-harvest treatment and packaging on the keeping quality of fresh guava fruit. *Acta Horticulturae* 27(5) : 639-45.
- Hiwale S S and Singh S P 2003. Prolonging shelf-life of guava. *Indian Journal of Horticulture* 60(1) : 1-9.
- NHB, Gurgaon. 2011. *Indian Horticulture Database*, National Horticulture Board, Gurgaon.
- Singh J P and Singh S P. 1999. Effect of pre-harvest spray of calcium nitrate on shelf-life of guava (*Psidium guajava* L.) fruits cv. Allahabad Safeda. *Journal of Applied Biology* 9(2) : 149-52.
- Sudha R, Ponnuswani V and Kavino M 2007. Influence of packaging treatments on the physical and biochemical characteristics of sapota fruits. *Indian Journal of Horticulture* 64(3) : 222-25.
- Yanashita F and Benassi M de T. 1998. Influence of different modified atmosphere packaging on overall acceptance of white guavas (*Psidium guajava* L.), var. Kumagai stored under refrigeration. *Alimentos-e-Nutricao* 9 : 9-16.

Effect of intercroppings on growth and yield of banana (*Musa paradisiaca*) cv. Grand Naine under drip irrigation

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ABSTRACT

An experiment was conducted to find out the effect of different intercroppings on growth and yield of banana (*Musa paradisiaca* L.) cv. Grand Naine at Soil and Water Management Research Farm, Navsari Agricultural University, Navsari, during 2009-10. The growth parameters, viz. plant height, girth of pseudostem, number of leaves and leaf area of banana reduced due to intercropping 3 and 5 months after planting. However, banana intercropped with onion, garlic and cauliflower showed similar growth to that of sole banana. The days required to inflorescence emergence and harvesting did not influence significantly due to various treatments. The yield and yield attributes also affected due to imposition of intercrops and reduction were increased under cauliflower. However, intercropping remain non-significant for yield attributes, viz. number of hands/bunch, average weight of fingers, number of fingers/bunch, and length and girth of fingers. However, banana + garlic (A₂) gave higher yield-attributing characters. Among intercrops, cauliflower caused severe reduction in banana yield under all planting patterns.

KEY WORDS: Banana, Grand Naine, Intercrops, Drip, Growth is Yield

Banana is extensively cultivated throughout India. It is an important fruit crop grown in south Gujarat. It ranks second in area after mango. In India, annual production of banana is 26.51 million tonnes from 7.76 lakh ha (NHB, 2014). Initial growth of banana is slow which offers an opportunity to take short duration intercrop like onion, garlic, cauliflower and cabbage. There has been an increase in growers' interest in intercropping, growing two or more crops simultaneously on the same land. Intercropping could reduce management inputs and results in sustainable production. It uses effectively and even potentially replenish natural resources used during crop production for long-term management of farmland. Some benefits of intercropping to growers are risk minimization, effective of available resources and food security. However, with adoption of drip method of irrigation in banana, it is possible to grow intercrop in between the rows. So, there is a

need to develop intercropping system in drip irrigated banana which will enhance the water-use efficiency as well as net income. Keeping in view an experiment was conducted on banana cv. Grand Naine

MATERIAL AND METHODS

An experiment was conducted at Soil and Water Management Research Farm, Navsari Agricultural University, Navsari, during 2009-2010. The Randomized block design with four replications including nine treatment combinations was followed. The treatments compared : A₁, 25% (cauliflower) and 27% (onion and garlic) (without lateral shifting); A₂, 33% (with lateral shifting in between rows); A₃, combination of both above described and three intercrops, viz. onion, garlic and cauliflower. Sole crops were grown outside the experimental plot as the control. Effects of intercropping pattern were assessed by recording effect of treatments on different growth parameters like height of pseudostem, girth of pseudostem, number of leaves, total leaf area and

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Table 1. Effect of intercropping on growth of banana cv. Grand Naine

Treatment	Plant height				Girth				Number of leaves				Leaf area			
	3 rd MAP	5 th MAP	7 th MAP	At inflorescence emergence	3 rd MAP	5 th MAP	7 th MAP	At inflorescence emergence	3 rd MAP	5 th MAP	7 th MAP	At inflorescence emergence	3 rd MAP	5 th MAP	7 th MAP	At inflorescence emergence
T ₁ , banana + onion (A ₁)	33.82	101.23	209.06	235.71	30.97	39.89	65.25	67.13	13.75	16.55	18.99	20.49	0.23	0.33	1.85	2.11
T ₂ , banana + onion (A ₂)	34.06	102.44	212.14	242.55	34.34	46.38	66.53	70.06	13.62	17.03	19.79	21.24	0.17	0.36	2.01	2.18
T ₃ , banana + onion (A ₃)	30.10	85.57	203.43	229.17	30.86	42.03	64.46	62.90	13.76	16.04	18.04	19.48	0.20	0.46	1.79	1.96
T ₄ , banana + garlic (A ₁)	34.24	104.15	209.51	237.96	35.18	47.38	65.30	68.72	14.57	17.34	19.23	20.96	0.19	0.40	1.91	2.12
T ₅ , banana + garlic (A ₂)	36.16	108.09	216.14	243.20	39.70	52.48	66.78	71.72	15.44	17.78	19.86	22.19	0.26	0.44	2.07	2.20
T ₆ , banana + garlic (A ₃)	34.51	105.44	206.65	232.45	38.15	49.25	64.92	66.52	14.85	16.81	18.79	20.29	0.23	0.38	1.81	2.08
T ₇ , banana + cauliflower (A ₁)	23.82	76.04	201.18	224.25	25.26	35.29	64.38	62.05	12.15	15.78	17.88	19.27	0.14	0.29	1.73	1.95
T ₈ , banana + cauliflower (A ₂)	28.21	90.44	205.38	230.95	32.46	43.15	64.71	65.87	12.69	15.94	18.24	19.59	0.18	0.34	1.81	1.97
T ₉ , banana + cauliflower (A ₃)	24.76	69.94	187.49	222.57	23.12	34.03	64.02	61.27	11.99	14.44	16.83	19.20	0.16	0.30	1.70	1.94
T ₁₀ , sole banana	39.20	113.31	211.94	239.13	38.20	49.74	65.78	69.87	14.77	17.44	19.77	21.04	0.25	0.41	1.96	2.14
SEm ±	1.95	4.50	8.13	8.96	1.71	1.89	1.85	2.44	0.47	0.59	0.72	0.73	0.014	0.029	0.081	0.107
CD (5 %)	5.65	13.08	NS	NS	4.96	5.48	NS	NS	1.36	1.73	NS	NS	0.04	0.08	NS	NS
CV (%)	12.37	9.42	7.88	7.66	10.42	8.59	5.68	7.31	6.83	7.21	7.68	7.13	14.42	15.75	8.71	10.43

crop duration. Each plant of banana was fed with 180g N; 90g P₂O₅; 120g K₂O (40% saving of N and K). Complete dose of phosphorus and 40% nitrogen and potash were applied 1 and 2 months after planting in two equal split doses by ring method. The remaining dose of nitrogen and potash, *i.e.* 60% were applied in 6 equal splits at 15 days interval after 3 months through drip irrigation system.

RESULTS AND DISCUSION

The results revealed that growth parameters, *viz.* plant height, girth of pseudostem, number of leaves and leaf area of banana reduced due to intercropping 3 and 5 months after planting (Table 1). It might be due to intercropping, which also required essential nutrients, space, light and water for growth and development. They are competitors at initial stage of growth but at 7 months after planting and harvesting there is non-significant effect on plant height. Rainfall after May, however, allowed banana in various intercropping to make a recovery in girth. Similar result was also observed by Rao and Edmunds (1983). However, banana when intercropped with onion, garlic and cauliflower showed similar growth as the sole banana. In contrast, days required to inflorescence emergence and harvesting did not influence significantly due to various treatments.

Various growth parameters such as plant height, girth of pseudostem, number of leaves and leaf area were significantly maximum in plant with the treatment banana + garlic A₂ (T₅). Increase in growth may be attributed to resources given to intercrop which also utilized by main crop (banana).

Chundawat *et al.* (1982) reported that none of the intercrops reduced vegetative growth of banana.

The results indicated that early inflorescence emergence and less total crop duration were not significantly altered by intercrops (Table 2). Minimum days required from planting to harvesting were observed in banana + garlic A₂ (T₅) as compared to other treatments and the control. This might be due to reduced flowering and maturity duration which could be attributed to shorter duration of intercrops (Rao and Edmunds 1983). Similar results were also observed by Chundawat *et al.* (1982) Devos and Wilson (1978) also observed no delay in plantain harvesting with cocoyam intercropping.

The yield attributes were not significantly influenced due to intercropping (Table 3). Banana + garlic A₂ (T₅) gave maximum number of hands/bunch, number of fingers/bunch, bunch weight, average weight of fingers, and length and girth of fingers which played vital role in increasing productivity. Among yield-attributing characters bunch weight was significantly influenced by different intercropping patterns. Treatment T₅ (banana + garlic A₂) was recorded maximum bunch weight/plant. Number of hands/bunch, number of finger/bunch, average weight of finger, length and girth of finger were remained unaffected. However, intercropped banana with garlic (A₂) recorded higher yield than sole banana, this is because of higher bunch characters. Chundawat *et al.* (1982) revealed that fruiting characters were not altered by any intercrop as production capacity of banana plant is mainly dependent on vegetative growth before floral initiation and since vegetative growth was

Table 2. Effect of intercropping on duration of banana crop cv. Grand Naine

Treatment	Number of days planting to inflorescence emergence	Number of days inflorescence emergence to harvesting	Total crop duration (days)
T ₁ , banana + onion (A ₁)	246.65	82.30	328.95
T ₂ , banana + onion (A ₂)	244.91	78.34	323.25
T ₃ , banana + onion (A ₃)	249.75	86.08	335.83
T ₄ , banana + garlic (A ₁)	245.15	81.39	326.54
T ₅ , banana + garlic (A ₂)	243.85	77.96	321.82
T ₆ , banana + garlic (A ₃)	247.40	82.71	330.12
T ₇ , banana + cauliflower (A ₁)	250.09	87.32	337.40
T ₈ , banana + cauliflower (A ₂)	248.26	85.19	333.45
T ₉ , banana + cauliflower (A ₃)	252.57	88.20	340.77
T ₁₀ , sole banana	245.06	80.10	325.15
SEm ±	8.73	3.49	7.87
CD (5 %)	NS	NS	NS
CV (%)	7.06	8.41	4.76

Table 3. Effect of intercropping on yield attributes of banana cv. Grand Naine

Treatment	Number of hands /bunch	Average weight of fingers	Number of fingers/bunch (g)	Length of finger (cm)	Girth of finger (cm)	Weight of bunch (kg)	Yield (tonnes/ha)
T ₁ , banana + onion (A ₁)	10.29	158.19	172.78	21.92	13.02	23.68	82.22
T ₂ , banana + onion (A ₂)	10.32	160.19	179.31	22.15	13.12	25.67	89.14
T ₃ , banana + onion (A ₃)	10.22	156.56	166.58	21.80	12.78	23.26	80.76
T ₄ , banana + garlic (A ₁)	10.30	158.30	174.55	22.02	13.08	24.41	84.75
T ₅ , banana + garlic (A ₂)	10.37	162.45	180.25	22.30	13.25	26.45	91.84
T ₆ , banana + garlic (A ₃)	10.28	157.90	169.88	21.88	12.96	23.49	81.56
T ₇ , banana + cauliflower (A ₁)	10.19	156.45	165.52	21.76	12.74	22.74	78.95
T ₈ , banana + cauliflower (A ₂)	10.24	157.29	168.65	21.81	12.88	23.39	81.21
T ₉ , banana + cauliflower (A ₃)	10.00	156.05	161.57	21.63	12.65	21.37	74.20
T ₁₀ , sole banana	10.31	159.84	177.10	22.12	13.11	24.68	85.70
SEm ±	0.36	5.76	6.27	0.83	0.46	0.95	3.30
CD + (5 %)	NS	NS	NS	NS	NS	2.76	9.59
CV (%)	7.01	7.28	7.30	7.63	7.11	7.96	7.96

not influenced by intercrops at 7 month after planting.

Significantly, highest yield (91.84 tonnes/ha) was recorded when banana intercropped with garlic A₂ (T₅). Subbiah *et al.* (1980) found that raising an onion intercrop in banana field did not affect bunch yield of banana. Das and Maharana (1995) also reported that yield of banana was higher when intercropped with onion and chilli because nutrient removed by this crops are less. Devos and Wilson (1978) similarly, found no yield reduction with cocoyam intercropping. Singh *et al.* (2003) reported that intercropping with potato, garlic and pea with autumn planted cane produced higher cane yield than sugarcane mono-cropping.

REFERENCES

Chundawat B S, Joshi H H and Patel N L. 1982. Studies on

intercropping in Basrai banana. *South Indian Hort.* **32**(1) : 23-25.

Das A K and Maharana T. 1995. Profitable intercrops in banana. *Orissa J. Hort.* **23**(1) : 127-28.

Devos P and Wilson K F. 1978. Productivity and efficiency of plantain/cocoyam intercropping. *Paradisica* **3** : 6-11.

NHB, Gurgaon. 2014. *Indian Horticulture Database*. National Horticulture Board, Gurgaon.

Rao M M and Edmunds J E. 1983. Intercropping of banana with food crops: cowpeas, maize and sweet potato. *Trop. Agric.* **61**(1) : 9-11.

Singh S B, Singh S C and Singh A. 2003. Studies on intercropping with sugarcane in Uttar Pradesh. *Cooperative Sugar* **34**(11) : 883-92.

Subbiah K K, Ramachandra S N M, Boopathi and Kolandaiswamy S. 1980. Intercropping in banana. *Madras Agric. J.* **67**(11) : 712-15.

Exploring variability in bitter gourd (*Momordica charantia*) var. *muricata* in Tamil Nadu

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ABSTRACT

An experiment was conducted at Tamil Nadu Rice Research Institute, Tamil Nadu Agricultural University, Aduthurai, during 2010-12 to evaluate the accessions of small type bitter gourd (*Momordica charantia* L. var. *muricata*) collected from Tamil Nadu. Bitter gourd vines do not require pandal (support) for cultivation and the vines can creep on ground. The vines grow up to a length of 1.5 m on the ground with the duration of 120 days. Variation in foliage, flowers, size and weight of individual fruits was observed. MCM 12 recorded the highest fruit length (5.48 cm), followed by MCM 18 (5.20 cm). In contrast, the shortest fruit was recorded in MCM 2 (2.27 cm), followed by (2.29 cm). The individual fruit width ranged from 1.36 to 2.52 cm. The accession, MCM 12, registered significantly higher fruit weight (7.48 g) than other accessions evaluated in all three seasons. Number of seeds / fruit ranged from 4.00 to 6.67. In MCM 4, number of fruits / plant was significantly higher than other accessions evaluated in all three seasons. The highest yield was recorded in MCM 12 (2,146 kg/ha), followed by MCM 4 (2,024 kg/ha). MCM 4 had 3.8 mg iron, 86 mg calcium and 75 mg vitamin C in 100 g of immature fruits.

KEY WORDS: Bitter gourd, Calcium, Vitamin C, Iron, Yield, Variability, Bitter gourd, Subtropical

Small type bitter gourd (*Momordica charantia* L. var. *muricata*) belongs to the family, Curcubitaceae. It grows well in tropical and subtropical climates. Immature fruits are a power house of health-promoting chemicals such as charantin, momordicin and insulin like peptides. Bitter gourd is used as medicine (Grower and Yadav, 2004). Fruits are known to possess antihyperglycemic (Zhang, 1992 and Ali, 1993), anti-cholesterol, antiulcerogenic, antiviral, antitumorigenic, anti-inflammatory properties. Unripe fruits have been found to have a similar function of insulin to treat the diabetic patients caused by diabetes mellitus. Antihyperglycemic properties of fruits are mainly due

to the presence of charantin which is a mixture of sitosteryl glucoside and stigmasteryl glycoside. Charantin replaces insulin injection to stimulate the pancreas of the diabetic patients to lower the blood sugar level. Immature fruits delay the progress of diabetic complications such as neuropathy, nephropathy, gastroaprosis and cataract. The bitterness in leaves and fruits is due to the presence of momordicin which have antiviral properties. Unlike synthetic chemicals, plant based medicines have no side effects. In addition, immature fruits contain appreciable amounts of iron, calcium and vitamin C.

Small type bitter gourd is an herbaceous tendril bearing vine. It does not require pandal (support) as followed in the cultivation of common bitter gourd. The vine grows up to a length of 1.5 m on the ground with the duration of 120 days. The vines have deeply lobed leaves, yellow flowers and very small fruits

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without grooves. Since there is a wide variability in bitter gourd, studies were conducted to explore variability in bitter gourd for further improvement.

MATERIALS AND METHODS

An experiment was conducted at Tamil Nadu Rice Research Institute, Tamil Nadu Agricultural University, Aduthurai, to evaluate 25 accessions of small type bitter gourd collected from Thanjavur and Trichy districts during 2010-13. Seeds were sown in channels at a spacing of 2.0 m × 1.5 m in January, March and December. Small type bitter gourd vine was allowed to creep on the ground. Observation on number of days taken for flowering, fruit weight, length, width, number of fruits / plant, number of seeds/fruit, yield (kg/ha), calcium, iron and vitamin C were recorded.

Ascorbic acid was determined by titrating a known weight of sample with 2, 6- dichlorophenol indophenols dye using metaphosphoric acid as stabilizing agent (AOAC, 1984). Calcium was precipitated as calcium oxalate. Then the precipitate was dissolved in hot

dilute H₂SO₄ and titrated with standard potassium permanganate (Ranganna, 1999). Iron was converted into ferric form using hydrogen peroxide and treated with potassium thiocyanate to form red ferric thiocyanate which was measured colorimetrically at 480 nm (Ranganna, 1999).

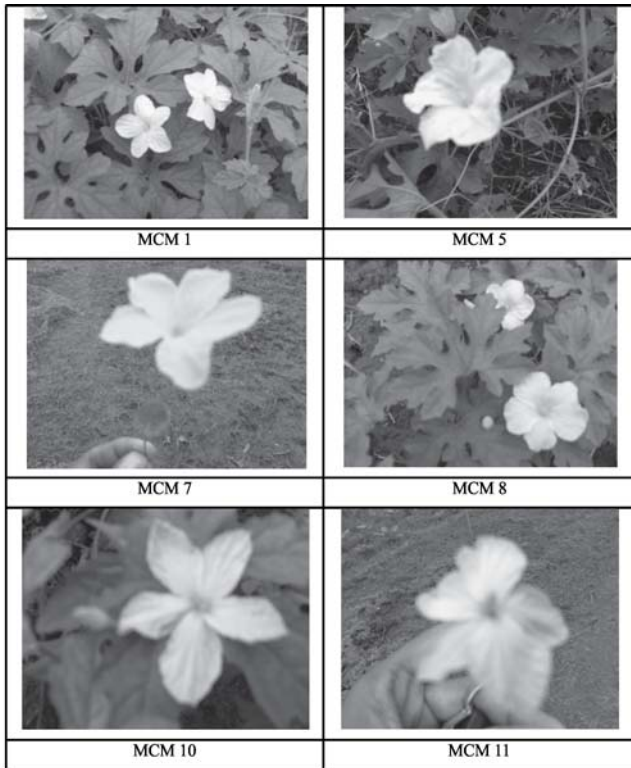
RESULTS AND DISCUSSION

Vines have deeply lobed leaves on long petioles, herbaceous pentangular stem with ridges and furrows. Male and female flowers were pentamerous with range of yellow colour on long pedicel. Fruits were very small, oval in shape with bulged centre and without grooves. Wide variation in size and wartyness of fruits was recorded. Immature fruits were filled with seeds without hollow. Immature fruits can be cooked and eaten along with soft seeds. Ripe fruits were orange in colour with bright red pulp enclosed seeds and splits longitudinally. Seed recovery was about 34 %. 1000 seed weight was about 115 g.

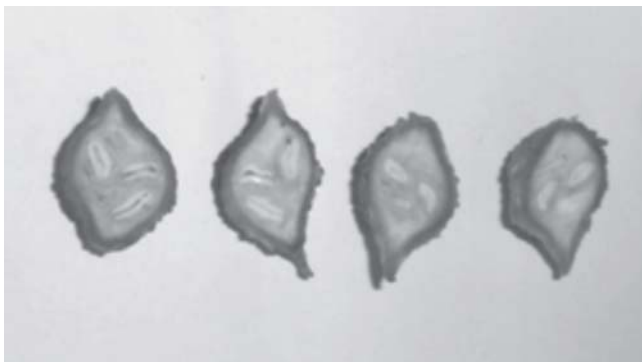
Time taken for flowering and first harvesting was

Table 1. Performance of bitter gourd accessions grown during 2010-12

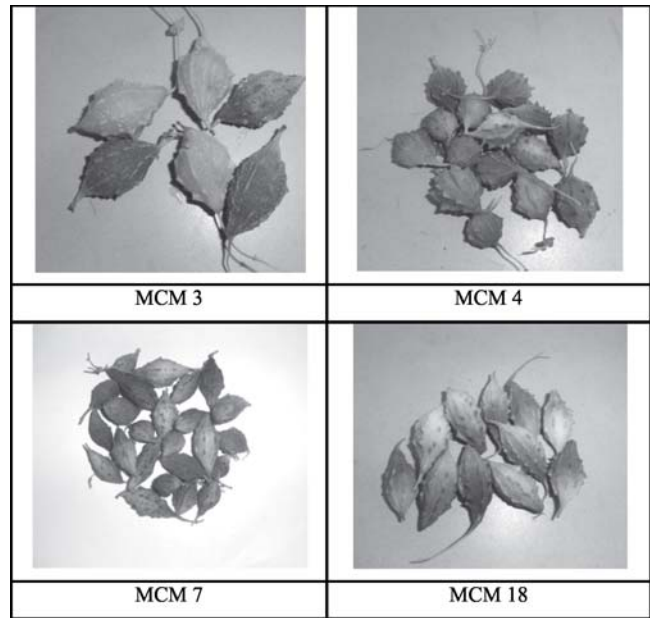
Accession No.	Fruit length (cm)			Fruit width (cm)			Fruit weight (g)		
	Jun	Dec	Mar	Jun	Dec	Mar	Jun	Dec	Mar
MCM 1	3.97	3.95	2.50	2.12	2.38	2.07	4.06	3.97	2.77
MCM 2	2.27	2.25	2.30	2.22	2.25	2.20	2.06	2.57	2.40
MCM 3	2.22	2.42	2.23	1.65	1.72	1.83	2.84	3.15	3.23
MCM 4	3.07	3.57	3.63	2.08	2.40	2.30	2.94	3.72	3.73
MCM 5	2.47	2.57	2.63	1.98	2.18	2.23	2.53	2.93	2.57
MCM 6	2.83	2.80	2.33	2.63	1.75	1.67	2.35	2.77	2.53
MCM 7	4.07	4.07	4.17	2.20	2.50	2.40	5.40	5.77	6.13
MCM 8	3.85	3.72	3.17	2.33	2.43	2.37	4.25	4.23	2.50
MCM 9	2.30	2.42	2.53	2.02	2.25	2.20	2.41	2.78	2.53
MCM 10	3.23	3.15	2.50	1.82	1.78	1.70	3.73	3.98	4.07
MCM 11	3.63	3.80	3.23	1.97	2.15	1.80	4.20	4.25	2.50
MCM 12	5.50	5.43	5.50	2.73	2.57	2.27	7.36	7.48	7.00
MCM 13	2.73	2.78	2.77	2.05	1.67	1.73	2.38	2.32	2.47
MCM 14	3.17	3.13	3.27	1.87	1.83	1.60	3.93	3.98	5.13
MCM 15	3.35	3.47	3.30	1.60	1.63	1.60	3.97	4.08	3.47
MCM 16	3.73	3.67	3.37	1.73	1.80	1.63	5.37	6.40	6.40
MCM 17	4.33	4.50	4.43	1.37	1.40	1.30	5.80	6.27	6.23
MCM 18	5.13	5.20	5.27	1.57	1.50	1.47	4.77	6.47	6.47
MCM 19	3.43	3.50	3.63	1.80	1.73	1.80	3.23	6.27	5.93
MCM 20	2.63	2.77	2.73	1.63	1.80	1.60	3.77	3.70	5.93
MCM 21	2.43	2.57	2.80	1.33	1.57	1.30	4.70	4.50	3.53
MCM 22	4.53	4.73	2.47	1.30	1.40	1.60	5.57	6.33	4.67
MCM 23	-	-	4.73	-	-	1.87	-	-	5.60
MCM 24	-	-	4.40	-	-	2.40	-	-	5.57
MCM 25	-	-	4.73	-	-	2.33	-	-	5.37
Mean	3.44	3.49	3.39	2.00	2.01	1.89	3.91	4.28	4.35
SED	0.06	0.06	0.05	0.03	0.03	0.03	0.07	0.07	0.07
CD (0.05%)	0.12	0.11	0.11	0.05	0.06	0.07	0.14	0.15	0.15



Variation in the petals and pollen of bitter gourd



Longitudinal section of bitter gourd, (MCM 4) with soft seeds



Variation in size, shape and wartyness of fruits



Bitter gourd growing in field

30-40 and 50 days respectively. Among 25 accessions evaluated, MCM 12 recorded highest fruit length (5.47 cm) followed by MCM 18 (5.20 cm). In contrast, shortest fruit was recorded in MCM 2 (2.27 cm), followed by MCM 3 (2.29 cm). The mean individual fruit width ranged from 1.36 to 2.52 cm. The accession MCM 12 registered significantly higher fruit weight than other accessions evaluated in all three seasons (Table 1).

Number of seeds / fruit ranged from 4.00 to 6.67. In MCM 4, number of fruits / plant was significantly higher than other accessions evaluated in all three seasons (Table 2). The highest yield was recorded in

March sown MCM 12 (2,146 kg/ha) followed by MCM 4 (2,024 kg/ha). Iron content in immature fruits of MCM 4 was 3.8 mg / 100g. Calcium and vitamin C in immature fruits were 86 mg / 100 g and 75 mg/ 100 g respectively. MCM 4 recorded the highest score in taste and consumer preference. All accessions were field tolerant to fruit fly, stem fly and red pumpkin beetle. Plants were moderately tolerant to mosaic.

Thus, MCM 12 and MCM 4 were found to have better yield performance in all three seasons. Small type bitter gourd recorded the highest yield when seeds were sown in March followed by December. All the accessions showed field tolerance to fruit flies. The

Table 2. Yield parameters of bitter gourd grown during 2010 - 12

Accession No.	No. of fruits / plant			No. of seeds / fruit			Yield (kg/ha)		
	Jun	Dec	Mar	Jun	Dec	Mar	Jun	Dec	Mar
MCM 1	22.50	23.17	24.00	9.00	8.00	3.67	805.75	853.94	885.33
MCM 2	34.83	36.00	28.00	4.67	4.17	2.67	716.08	915.44	896.00
MCM 3	34.83	34.50	25.00	5.00	6.17	4.67	1001.92	1093.78	1077.78
MCM 4	43.00	41.83	40.67	5.67	5.00	4.33	1292.04	1560.50	2024.30
MCM 5	29.17	31.33	25.00	6.00	5.83	5.33	730.63	913.11	855.56
MCM 6	27.50	27.50	28.67	3.83	4.83	4.33	635.66	757.33	968.30
MCM 7	23.50	23.00	22.00	8.67	5.33	5.67	1268.50	1319.00	1799.11
MCM 8	21.17	21.50	23.67	6.50	5.17	3.33	832.76	855.28	788.89
MCM 9	30.33	29.50	23.00	5.00	6.33	3.33	722.20	807.89	776.89
MCM 10	26.67	20.33	32.00	8.50	8.00	4.67	1044.47	820.78	1735.11
MCM 11	29.17	22.17	30.33	4.67	9.00	5.33	1066.11	847.56	1011.11
MCM 12	24.17	25.50	23.00	8.17	8.17	11.00	1776.77	1908.17	2146.67
MCM 13	24.83	22.17	24.67	9.00	4.00	8.33	593.11	506.50	811.26
MCM 14	23.83	24.50	25.00	6.17	5.50	4.00	1021.06	1005.17	1711.11
MCM 15	26.33	26.67	32.00	4.17	7.00	6.67	985.44	1047.89	1479.11
MCM 16	25.00	25.33	16.00	7.00	6.00	5.67	1341.67	1621.33	1365.33
MCM 17	18.00	16.33	17.67	10.00	6.00	4.00	1044.00	1023.56	1468.30
MCM 18	25.33	22.67	23.00	5.33	4.67	4.67	1207.56	1465.78	1983.11
MCM 19	29.00	24.00	21.00	6.33	5.67	4.33	937.67	1504.00	1661.33
MCM 20	34.67	35.33	32.67	5.67	4.33	4.00	1305.78	1307.33	2004.30
MCM 21	25.00	26.67	18.67	3.67	4.67	3.67	1175.00	1200.00	879.41
MCM 22	22.33	24.33	24.00	7.67	9.67	8.67	1243.22	1541.11	1493.33
MCM 23	-	-	19.67	-	-	6.33	-	-	1468.44
MCM 24	-	-	20.67	-	-	5.33	-	-	1533.93
MCM 25	-	-	23.33	-	-	4.67	-	-	1669.63
Mean	27.23	26.33	24.95	6.52	6.06	5.15	1004.76	1073.50	1379.75
SED	0.55	0.54	0.52	0.11	0.1	0.09	98.7	99.50	105.30
CD (0.05%)	0.21	0.25	0.25	0.22	0.22	0.20	202.1	210.30	223.70

immature fruits are suitable for preparing fry, sambar, chips and preparation with tamarind. All the preparations scored more than 8 in hedonic scale method of sensory evaluation.

REFERENCES

- Ali L. 1993. Studies on hypoglycemic effects of fruit pulp, seed and whole plant of *Momordica charantia* on normal and diabetic model rats. *Planta Med.* **59**(5) : 408-12.
- AOAC 1984. *Official Methods of Analysis*, 9th edn. Association of Official Agricultural Chemists, Washington, D.C.
- Grower J K and Yadav S P. 2004. Pharmacological actions and potential uses of *Momordica charantia*. *Journal of Ethnopharmacology* **93** : 123-32.
- Ranganna S. 1999. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*, 2nd edn. Tata McGraw Hill Pub. Co. Ltd., New Delhi. India.
- Zhang Q C. 1992. Bitter melon: a herb warranting a closer look. *PWA Coalition Newslines* **81** : 48-49.

Effect of season and growing environment on success of soft wood grafting in cashew nut (*Anacardium occidentale*) under south Gujarat agroclimatic conditions

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ABSTRACT

An experiment was conducted to find out suitable time period for soft wood grafting and effect of rootstock growing on success of soft wood grafting in cashew (*Anacardium occidentale* L.) cv. Vengurla 4, at Agriculture Experimental Station, Navsari Agricultural University, Paria (Gujarat) under heavy rainfall zone-I and situation-II during 2013-14. Among different treatment combinations of season of grafting and growing environment of rootstocks tried, soft wood grafting in August under *in situ* conditions (S2E3) was found to be the best. The maximum number of sprouted grafts (8.83/10), sprouting percentage (86.66%), number of leaves/graft (5.63), length of the graft (23.50 cm), girth of graft (0.81cm) and highest percentage of survival was recorded were treatment combination S2E3 (grafting in August under *in situ* conditions).

KEY WORDS: Cashew nut, Soft wood grafting, Season of grafting, Growing environment

Cashew nut (*Anacardium occidentale* L.), a member of the family Anacardiaceae, is commercially produced in India, Brazil, the Philippines, Kenya, Malaysia and Sri Lanka. At present, it is popular nut crop in the Konkan region of Maharashtra, Goa, Karnataka and is also grown as a rainfed horticultural crop in coastal regions of Kerala, Tamil Nadu, Odisha, West Bengal, Tripura, Pondicherry and Gujarat. India is emerging as a leading producer, processor, exporter and consumer of cashew globally (Wadkar *et al.*, 2007). India has an area of about 8,93,000 ha under cashew with an estimated annual production of 6,95,000 tonnes with a productivity of 0.8 tonnes/ha (2008-09) (NHB, 2009). In Gujarat, area under cashew cultivation is 6,000 ha with a total production of 4,000 tonnes (2008-09) (DH, 2009). The area under cashew is increasing. There is a great demand of cashew grafts in south Gujarat. Non-availability of quality planting material is a major bottleneck in its rapid expansion. Cashew can be multiplied successfully by softwood grafting, but time

of grafting, proper maturity of scion and growing environment for raising rootstock have to be standardized under local agroclimatic conditions. Hence, to meet out the demand of quality material of cashew nut cv. Vengurla 4, an experiment was conducted to find out most suitable time period for soft wood grafting and to study the effect of rootstock growing on success of soft wood grafting.

MATERIALS AND METHODS

The experiment was conducted at Agriculture Experimental Station, Navsari Agricultural University, Paria (Gujarat), under heavy rainfall zone-I and situation-II during 2013-14. The experiment was laid out in a factorial randomized block design with three replications and 15 treatments. Three type of transplanted rootstock growing environment, viz. E1: open condition, E2: net house condition, and E3: *in-situ* condition; five season of grafting, viz. S1: grafting on 20 July, S2: grafting on 20 August, S3: grafting on 20 September, S4: grafting on 20 October and S5: grafting on 20 November, were tested on three-month-old seedling rootstocks using soft wood method of grafting.

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Various effects of these treatments on time taken for sprouting, sprouting percentage, number of leaves/graft, height and girth of graft and survival of grafted plants were studied. The data obtained on growth and development of grafted plants were statistically analysed under factorial randomized block design as per Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Growing environment of rootstock, season of grafting and their interactions played an important role in the success of grafting in cashew. The maximum sprouting percentage (86.66) was recorded when grafting was done in August under *in-situ* condition. Similar results were obtained by Sawke *et al.* (1985) and Sarada *et al.* (1991) in cashew. Similarly, maximum number of leaves/graft (3.73, 5.20, and 5.63), graft height (20.23, 22.70 and 23.50 cm), girth of graft (0.59 cm, 0.73 cm and 0.81 cm) and highest percentage of survival (88.33, 85.00 and 66.66%) at 30, 60 and 90 days after grafting respectively, was recorded when grafting was done in August under *in-situ* conditions (S2E3) as

compared to open condition and net house raised rootstock.

Similar results were obtained by Dhakal and Honda (1986) and Amin (1974) in mango. Success of grafting depends to a great extent on the environmental conditions, which may vary from place to place. The month of August under West Indian conditions, particularly in South Gujarat and surrounding areas receives maximum rainfall. With the result maximum humidity and optimum temperature prevail in August, which is very conducive for graft setting, emergence of new shoots, growth and overall success of the grafts.

The most likely reason for better growth and survival of soft wood grafting under *in-situ* condition could be that rootstocks raised in *in-situ* conditions find good environment for its growth as compared to polybag conditions. Therefore, a healthy, vigorous and robust rootstock raised in *in-situ* condition would lead to good graft union and subsequent quick sprouting of new shoots as explained by (Patil *et al.*, 1983). Thus, it can be concluded that treatment combination S2E3, *i.e.* grafting in August using *in-situ* raised rootstocks

Table 1. Effect of different seasons of grafting and growing environment on sprouting, growth and survival of grafts of cashew *cv.* Vengurla 4.

Treatment	Graft sprouting (%)	No. of leaves/graft			Length of graft (cm)			Graft survival (%) 120 DAG
		30 DAG*	60 DAG	90 DAG	30 DAG	60 DAG	90 DAG	
T ₁ (S ₁ E ₁)	55.00	2.50	3.60	4.20	16.33	18.46	19.80	43.33
T ₂ (S ₁ E ₂)	46.66	3.26	4.36	4.76	19.00	19.66	23.26	36.66
T ₃ (S ₁ E ₃)	75.00	2.83	4.10	4.36	16.26	19.50	21.26	48.33
T ₄ (S ₂ E ₁)	71.66	2.63	4.13	4.66	18.06	21.43	21.73	51.66
T ₅ (S ₂ E ₂)	65.00	2.96	3.53	4.16	17.66	20.06	21.46	56.66
T ₆ (S ₂ E ₃)	86.66	3.73	5.20	5.63	20.23	22.70	23.50	66.66
T ₇ (S ₃ E ₁)	61.66	2.90	3.20	3.73	17.06	19.60	20.73	31.66
T ₈ (S ₃ E ₂)	46.66	2.46	4.26	4.80	16.83	18.93	20.20	33.33
T ₉ (S ₃ E ₃)	58.33	3.63	4.53	5.00	18.26	19.83	20.73	38.33
T ₁₀ (S ₄ E ₁)	28.33	2.76	4.10	4.63	12.96	14.86	15.93	21.66
T ₁₁ (S ₄ E ₂)	56.66	2.73	3.80	4.43	12.83	15.80	16.60	36.66
T ₁₂ (S ₄ E ₃)	53.33	3.43	3.93	4.56	15.36	16.50	17.63	28.33
T ₁₃ (S ₅ E ₁)	50.00	2.60	3.16	3.70	12.00	13.86	15.93	25.00
T ₁₄ (S ₅ E ₂)	43.33	2.33	3.13	3.90	14.03	14.63	15.13	16.66
T ₁₅ (S ₅ E ₃)	46.66	2.10	2.90	3.56	11.46	13.86	14.30	28.33
SEM±	1.63	0.17	0.1875	0.1595	0.2090	0.3439	0.3421	1.6981
CD (5%)	4.72	0.51	0.543	0.462	0.605	0.996	0.990	4.918
CV (%)	5.01	10.71	8.41	6.27	2.27	3.31	3.08	7.83

* DAG, das after grafting

required minimum days to sprouting along with highest number of graft sprouted, sprouting percentage, total number of leaves, height and girth of newly emerged shoots and survival percentage of graft in cashew nut *cv.* Vengrula 4, under south Gujarat agroclimatic conditions.

REFERENCES

- Amin R S. 1974. A study on the establishment of mango orchard with wedge graft on in situ grown mango seedling in dry region of the Gujarat State. *Haryana J. Hort. Sci.*, 3(3/4) : 160-7.
- NHB, Gurgaon. 2009. *Indian Horticulture Database*, NHB, Gurgaon, Haryana
- DH, Gandhinagar. 2009. *Department of Horticulture*, Gujarat State, Gandhinagar.
- Dhakal B R and Honda M N. 1986. Vigour of mango veener grafts in relation to defoliation period and storage of scion shoots. *South Indian Horticulture* 34 : 184-186.
- Panse V G and Sukhatme P V. 1985. *Statistical Method for Agriculture Workers*. ICAR, New Delhi.
- Patil J D, Worke D C, Patil V K and Gunjkar S N. 1983. Studies on wedge grafting in mango. *Panjab Horticulture Journal* 23(1) : 29-33.
- Sarada C, Rao V P, Sankar R and Rao N S. 1991. Studies on soft wood grafting cashew. *South Indian Horticulture*, 39(3) : 119-23.
- Sawke D P, Salvi M J and Patil M M. 1985. Prospects of clonal propagation in Cashew nut by soft wood grafting. *Indian Cashew Journal* 17(4) : 15-18.
- Wadkar S S, Bagade S R and Jalgaonkar V N. 2007. *Indian Cashew : Processing and Export*. Pointer Publisher, Jaipur, 1-11.

Effect of mycorrhizal species on growth and nutrient uptake by seedlings of Citrus (*Citrus sinensis*) under three soil growth conditions

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Citrus (*Citrus Sinensis* L.) is a subtropical fruit plant, which is commonly grown in the Çukurova region (East Mediterranean coast in Turkey). Since Cukurova region in East coast of Mediterranean Sea' soil are poor in nutrient content, nearly in 75% of citrus-growing area use of mycorrhizae is for better quality seedling production. The cultivation of citrus is expected to expand in the near future after crop plants will be shifted to the South East Anatolia. Particularly, P and Zn are not sufficient for citrus plant growth in Çukurova soils (Ortas *et al.*, 1999). For an optimum growth and balanced nutrition, fertilization is needed. With increasing environmental concern on pollution of soil and water, by excess fertilizer application, it is very important to produce mycorrhizal inoculation in order to reduce the amount of chemical fertilizers. Since plants are strongly mycorrhizal dependent, producing mycorrhizal inoculated seedlings became more important (Onkarayya *et al.*, 1993; Ortas *et al.*, 2001a and b).

The AM infection can also maintain citrus yield and quality at low inputs of nutrients. Nemeč *et al.* (1981) reported that citrus orchard soils contain communities of AM fungi rather than a single species, and several or all of these species might colonize citrus roots at the same time. It has been reported that mycorrhizal infection and plant yield were increased with increasing P application either as a soluble P levels or rock phosphate addition. Srivastava *et al.* (2002) reported that phosphorus nutrition of mycorrhizal-treated citrus trees was best improved by using rock phosphate as a source of P as opposed to other sources. Therefore, an experiment was conducted to screen and select the most suitable arbuscular mycorrhizae (AM) and growth media for enhancing Citrus seedling growth by improving nutrient uptake.

MATERIALS AND METHODS

The experiment was conducted in a greenhouse at the Department of Soil Science, Çukurova University, and Adana, Turkey. Eight different mycorrhizal species and three different growth media were tested. The growth media used were Konya, Menzilat soils and mixture medium [compost, volcanic material (scoria) and soil in a 4:2:1 ratio by volume]. Under greenhouse conditions, following germination of Citrus seeds (*Citrus sinensis* L.) in prelate and seedling growth up to five leaves. The seedlings were transplanted to 3 litre containers. Before transplantation, each seedling received 5000-spore (Ortas *et al.*, 2001a). Non-mycorrhizal plants also received the same amount of medium free of mycorrhizal spores.

The roots were analyzed for degree of mycorrhizal infection in root cortex, and was assessed as per the method of Koske and Gemma (1989). Root colonization was determined using a gridline-intersect method for AM treatments (Giovannetti and Mosse, 1980). The concentration of P was determined as per the method of Murphy and Riley (1962) by using a spectrophotometer. The concentration of Zn, Fe, Cu, and Mn were determined by an atomic absorption spectrophotometer.

The growth media were Konya soil, Menzilat soil and mixture medium (compost, volcanic material scoria). Inoculation with vesicular arbuscular mycorrhizae (VAM) with :

- *G. mosseae* (1), collected from the UK
- *G. mosseae* (2), collected from Germany
- *G. caledonium*
- *G. clarum*
- *G. etunicatum*
- Dr. Kinkdom (found from Japan)

- Local indigenous (collected from citrus plantation)
- Cocktail: *G. mosseae* (1) collected from the UK; *G. mosseae* (2) collected from Germany.

At the end of the growing season, seedlings were harvested. Dried material from each pot was ground with a Tema mill, 0.2 g of the ground plant material was then ashed at 550°C, followed by dissolution in 3.3% HCl. After digestion of the plant material, the concentration of P in this solution was determined calorimetrically. An atomic absorption spectrophotometer (Perkin Elmer) was employed to determine the Zn content of the plant samples.

At harvesting, the roots were separated from the soil by washing with running tap water and distilled water. Small sub-samples of roots were taken and preserved for the determination of mycorrhizal infection. Roots were prepared by the method of Koske and Gemma (1989). Mycorrhizal fungus (%) root colonization was determined using the gridline-intersect method of Giovanetti and Mosse (1980).

RESULTS AND DISCUSSION

The results showed that mycorrhizal inoculation significantly increased dry matter content, root infection and nutrient uptake. The efficiency of mycorrhizal species and growth media were different. Of the three growth media, *G. caledonium* and *G. clarium* were determined as the best inoculum for growth (Fig. 1). The Plants grew better and responded to mycorrhizal inoculation in Konya and Menzilat soils than in the mixture media. Previously, we found that *G. clarium*

was the best inoculum for growth of seedlings of sour orange and root infection (Ortas *et al.*, 2001a and b, ortas and Ustuner 2014a).

Mycorrhizal inoculation significantly increased root infection compared to the non-inoculated control (Table 1). The mycorrhizal species significantly increased the root colonization xompews in the control. In the control treatments, Konya, Menzilat and mix use soils have 3.3, 15 and 3.3% root colonization respectively. However in Konya soil, *G. clarium* inoculated plants had 60%, in Menzilat soil, plant inoculated with *G. clarium*, *G. mosseae* (2), Dr Kinkdom had 40% root colonization and mix growth medium had less root colonization.

Usually, seedlings grown in Konya soil had higher root colonization that other two soils Menzilat and Mixture growth media (Table 1).

Mycorrhizal inoculation also significantly increased plants P and Zn uptake (Tables 2 and 3). Phosphorus uptake was especially remarkable in Konya and Menzilat soils. The Zn content also increased with mycorrhizal inoculation, however small differences were determined in plants grown in the mixture medium. The contribution of mycorrhizae is predicted to be a function of an increase in P uptake due to mycorrhizal infection. In present experiment, mycorrhizal species significantly increased plants P (%) concentration in three soils. The results are parallel with Ortas *et al.* (2001 a and b). Similarly Wu and Zou (2009) showed that the sole AMF inoculation significantly increased leaf and root P contents of seedlings, compared to the non-AMF control seedlings. Ortas *et al.* (2002a) tested effect of P and Zn level and

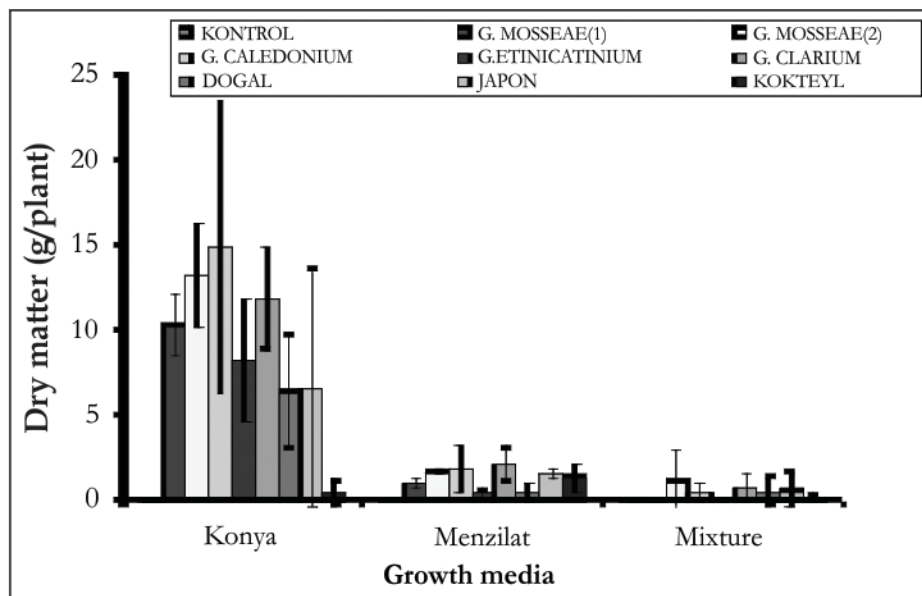


Fig.1. Effect of screening mycorrhizal species and growth media on shoot growth of Citrus plants.

Table 1. Effect of screening mycorrhizal species and growth media on root infection (%) in Citrus plants

Mycorrhizal species	Konya Soil	Menzilat soil	Mixture medium
	Root infection (%)		
<i>G. mosseae</i> (1)	40.0±0.0	35.0±7.1	25.0±7.1
<i>G. mosseae</i> (2)	40.0±10.0	40.0±0.0	15.0±7.1
<i>G. caledonium</i>	55.0±7.1	25.0±7.1	25.0±7.1
<i>G. etinacatinium</i>	50.0±10.0	20.0±0.0	30.0±0.0
<i>G. clarium</i>	60.0±10.0	40.0±0.0	25.0±7.1
Local Indigenous	55.0±7.1	20.0±0.0	20.0±14.1
Dr. Kinkdom	30.0±0.0	40.0±0.0	35.0±7.1
Cocktail	15.6±3.9	35.0±7.1	30.0±14.1
Control	3.3±5.8	15.0±7.1	3.3±5.8

Table 2. Effect of screening mycorrhizal species and growth media on Citrus P concentration

Mycorrhizal species	Konya soil	Menzilat soil	Mixture medium
	%P		
<i>G. mosseae</i> (1)	0.106±0.02	0.058±0.01	0.054±0.05
<i>G. mosseae</i> (2)	0.161±0.03	0.055±0.01	0.067±0.02
<i>G. caledonium</i>	0.168±0.06	0.071±0.01	0.063±0.01
<i>G. etinacatinium</i>	0.113±0.02	0.046±0.02	0.042±0.0
<i>G. clarium</i>	0.140±0.03	0.085±0.01	0.066±0.02
Local Indigenous	0.131±0.02	0.038±0.01	0.081±0.03
Dr. Kinkdom	0.096±0.04	0.063±0.01	0.071±0.01
Cocktail	0.049±0.02	0.061±0.02	0.051±0.01
Control	0.030±0.01	0.019±0.01	0.049±0.01

Table 3. Effect of screening mycorrhizal species and growth media on Citrus Zn uptake

Mycorrhizal species	Konya soil	Menzilat soil	Mixture medium
	Zn/mg/kg		
<i>G. mosseae</i> (1)	23.5±3.4	43.6±5.9	40.9±5.2
<i>G. mosseae</i> (2)	35.0±7.8	33.1±1.1	55.9±0.5
<i>G. caledonium</i>	34.3±4.6	44.4±11.7	51.6±4.0
<i>G. etinacatinium</i>	35.8±8.8	25.2±7.9	40.7±4.6
<i>G. clarium</i>	37.7±7.1	41.0±2.5	60.8±5.1
Local Indigenous	34.4±1.8	36.0±17.3	47.8±1.6
Dr. Kinkdom	36.4±2.5	43.9±0.2	58.2±3.4
Cocktail	44.0±5.7	30.3±1.8	31.5±5.8
Control	26.0±11.3	11.8±4.0	33.9±2.1

mycorrhizal inoculation on citrus growth. Mycorrhizae inoculated plants were significantly stimulated by mycorrhizal infection have high P concentration and plant are strongly mycorrhizal dependent in term, of P nutrition.

Mycorrhizae-inoculated plants generally had higher Zn concentration compared to the control treatments. Similar to P concentration, Zn concentrations showed some harmony with those of Ortas and Ustuner (2014 a and b); Wu *et al.* (2011).

CONCLUSION

Finally, seedlings were inoculated with different mycorrhizal spores, using different soil growth media, and then tested after a period of 12 months. In all the three soil studied, increased plant growth and nutrient uptake were observed for seedlings grown after inoculation with *G. caledonium*, *G. clarium* and *G. mosseae*, Dr Kingdom, which were efficient species for production seedlings of sour orange. Ortas and Ustuner

(2014a and b) found similar results with present work. The plants grown in Konya soil produced more growth than the other soil. This may be the effect of soil sterilization or nutrient supply capacity. Overall, results indicated that mycorrhiza species can significantly inoculate citrus seedlings. Growth media especially soil properties seems to be important. Mycorrhizae inoculation may effectively be used to increase citrus seedling P and Zn concentration.

REFERENCE

- Giovannetti M and B Mosse. 1980. An evaluation of techniques for measuring vesicular arbuscular mycorrhizal infection in roots. *New Phytologist* **84** : 489-500.
- Koske R E and Gemma J N. 1989. A modified procedure for staining roots to detect VAM. *Mycological Research* **92** : 486-505.
- Murphy J and Riley, J P. 1962. A modified single solution method for the determination of phosphate in natural waters. *Anal. Chim. Acta* **27**:31-36.
- Nemec S, Menge J A, Platt R G, Johnson E L V. 1981. Vesicular-arbuscular mycorrhizal fungi associated with citrus in Florida and California and notes on their distribution and ecology. *Mycologia* **73** : 112-127.
- Onkarayya H, Sukhada M and Mohandas S. 1993. Studies on dependency of citrus rootstocks to VAM inoculation in Alfisol soil. *Advances in Horticulture Forestry* **3** : 81-91.
- Ortas I, Ortakçi D and Kaya Z. 2001a. Various Mycorrhizal Fungi propagated on different hosts have different effect on Citrus growth and nutrient uptake. *Communication Soil Science and Plant Analyses* (in press).
- Ortas I, Ortakçi D and Kaya Z. 2001b. Mycorrhizal dependency of sour orange (*Citrus aurantium* L.) in term of phosphorus (P) and zinc (Zn) nutrition by different levels of P and Zn application. *Journal of Plant Nutrition* (in press).
- Ortas I, Ortakçi D, Kaya Z, Çinar A and Önelge N. 1999. The effect of phosphorus (P) and zinc (Zn) levels and mycorrhizal inoculation on P and Zn uptake of citrus plant. *In: COST 838 meeting on Arbuscular Mycorrhizas and Plant Health under Abiotic Stress, held during 10-11 December 1999 at Nancy, France.*
- Ortas I and Ustuner O. 2014a. Determination of different growth media and various mycorrhizae species on citrus growth and nutrient uptake. *Scientia Horticulturae* **166** : 84-90.
- Ortas I and Ustuner O. 2014b. The effects of single species, dual species and indigenous mycorrhizal inoculation on citrus growth and nutrient uptake. *European Journal of Soil Biology* 1-6.
- Srivastava A K, Singh S and Marathe R A, 2002. Organic citrus: Soil fertility and plant nutrition. *Journal of Sustainable Agriculture* **19** : 5-29.
- Wu Q S and Zou Y N. 2009. Mycorrhizal influence on nutrient uptake of Citrus exposed to drought stress. *Philippine Agricultural Scientist* **92** : 33-38.
- Wu Q S, Zou Y N and Wang G Y. 2011. Arbuscular mycorrhizal fungi and acclimatization of micro propagated citrus. *Communications in Soil Science and Plant Analysis* **42** : 1825-32.

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