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Short communication

Effect of paclobutrazol on fruit quality attributes in mango (*Mangifera indica* L.) cv. Totapuri

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ABSTRACT

Paclobutrazol application restricts vegetative growth while improving flowering and fruiting in mango. In the present study, effect of soil drenching with Paclobutrazol @ 3.0ml m^{-1} canopy diameter, applied during the 3rd week of August, on fruit quality attributes was investigated in cv. Totapuri. Parameters like fruit weight, total soluble solids (TSS), % acidity, and content of ascorbic acid, carotenoids, lycopene and individual sugars was estimated. Paclobutrazol application increased average fruit weight, TSS and content of ascorbic acid and total carotenoids, and reduced the acidity in fruits compared to fruits in untreated trees. Lycopene content was only marginally influenced by paclobutrazol. In fruits of paclobutrazol treated trees, increase of 23.4% in total sugars, 29.6% in reducing sugars, 77.4% in glucose and 27.8% in sucrose content was recorded over fruits from the untreated trees. Results indicated that, paclobutrazol application improved quality in mango fruit.

Key words: Fruit quality, mango, Paclobutrazol

Mango is a commercially important tropical fruit crop of India and exhibits wide variations in growth habit, flowering and fruiting. Orchard efficiency and productivity of mango is affected by problems of biennial bearing, high fruit-drop during initial stages of fruit development and unfavourable environmental conditions resulting in low fruit set (Murti and Upreti, 2000). Plant growth retardants especially paclobutrazol, has been found beneficial in combating some of the production-related problems. Studies have shown paclobutrazol application to be promising for improving flowering and fruiting in several mango varieties (Yadava and Singh, 1998; Kulkarni, 1988). Beneficial effects of paclobutrazol in mango have been attributed to manipulation in phytohormones, water relations and C:N ratio (Upreti *et al*, 2013). In this study, an assessment was made on the effect of paclobutrazol on fruit quality attributes. Although studies have been conducted on effects of paclobutrazol on fruit quality in other fruit crops, these studies are limited with reference to Indian mango varieties. In the present study, effect of soil drenching treatment with paclobutrazol on some fruit-quality parameters in commercially important mango variety Totapuri was investigated.

The experiment was conducted at the experimental farm of Indian Institute of Horticultural Research, Hessaraghatta, Bengaluru, on 19 year old, uniform trees of the regular bearing cv. Totapuri, planted at 10 x 10m spacing. Soil at the experimental site was sandy loam, and the average canopy diameter of trees was 6.3m. Paclobutrazol (Cultar, 23% w/w paclobutrazol, Syngenta Limited, UK) was applied once, as soil drench, at a concentration of 3.0ml m^{-1} of average canopy diameter by spreading the solution in a circular band of 25cm width around the tree, three feet from the trunk, during the 3rd week of August 2010 and 2011. Both control and paclobutrazol treatment consisted of four trees each. The experimental design adopted was Completely Randomized Design (CRD) for drawing statistical inferences. During the course of the experiment, maximum and minimum temperature ranged between 27.6-31.2°C and 19.8-21.0°C, respectively; relative humidity was in the range of 56.7-62.8% at 1400 hr, and 75.7-81.1% at 0800 hr.

Samples of five mature fruits from each tree of paclobutrazol-treated and untreated trees were collected and ripened at room temperature (around 28°C). Appearance of colour on fruit peel and olfactory perception of fruit aroma were employed as indices of fruit ripening. Total soluble solids (TSS) were estimated in ripe fruits using

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a hand-held ERMA refractrometer. Titratable acidity (TA) was determined by AOAC (1990) method using phenolphthalein indicator. Total carotenoid and lycopene content was estimated spectrophometrically in pulp of the ripened fruit as per Jensen (1978) and Ranganna (1976), respectively. Molar extinction coefficient of 2500M^{-1} cm^{-1} at 450nm for total carotenoids, and 1.72x10^5M^{-1} cm^{-1} at 503nm for lycopene were used for calculation. All estimations were made in triplicate. Reducing sugars were measured in fruit pulp using the procedure of Somagyi (1952). Total sugars were estimated using anthrone reagent as per the standard procedure of Hansel and Moller (1975).

Fructose, glucose and sucrose content was analyzed using high-performance liquid chromatography (HPLC) (Sánchez-Mata *et al*, 2002) with some modification. Shimadzu (Japan) Prominence HPLC system equipped with Refraction Index Detector (RID) (Model 10A, Shimadzu, Japan), and NH_2 reversed-phase column (25cm x 4.6mm, 5µm, Supelco, USA) were used. Both RID cell temperature and column temperature were maintained at 40°C during analysis. The mobile phase consisted of water:acetonitrile (25:75 v/v) at a flow rate of 1.0ml min^{-1}. Standards of fructose, glucose and sucrose (Sigma-Aldrich, USA) were used for quantification. Five grams of fruit pulp was extracted in 20ml of 70% ethanol and contents were kept in boiling water bath for 45 minutes. After cooling to room temperature, the contents were centrifuged at 10,000rpm at 4°C. The residue was re-extracted with an additional 10ml of 80% ethanol and centrifuged again. The two supernatants were mixed together and the volume adjusted to 25ml with water. The samples were filtered using 0.45µm syringe filter (Millipore, USA) and stored in glass tubes at -20°C for HPLC analysis.

Significant differences were recorded in fruit quality parameters (Table 1). Average fruit weight, TSS and the content of ascorbic acid and total carotenoid increased, whereas % acidity declined in fruit pulp by paclobutrazol treatment compared to that in untreated trees. Lycopene content was influenced only marginally by paclobutrazol treatment. Maximum average fruit weight (266g $fruit^{-1}$), TSS (13.5°Brix), ascorbic acid content (8.42mg 100g^{-1}), total carotenoid (3.9mg 100g^{-1}) and lycopene content (0.67mg 100g^{-1}) were recorded in the fruit pulp under paclobutrazol treatment. Average increase in fruit weight by paclobutrazol treatment has been reported in mango cvs. Sensation (Oosthuse and Jacob, 1997), Amrapali (Sarkar and Rahim, 2012) and Kaew (Benjawan *et al*, 2006). In contrast, there is also a report of decline in average fruit weight in cv. Tommy Atkins (Oosthuyse and Jacobs, 1997) by paclobutrazol application. This indicates that, the effect of paclobutrazol on fruit size is cultivar dependent. Rebolledo-Martinez *et al* (2008) found at decline in fruit weight was dependent on the dose of paclobutrazol used, with high concentration exhibiting loss in fruit weight. Oosthuse and Jacobs (1997) also found average fruit weight to increase by virtue of an increase in fruit length. Increase in fruit weight could be a consequence of better resource-mobilization as propounded by Davis *et al* (1988) as also manipulation of plant water relations in preference for the developing sinks (fruits) by paclobutrazol treatment. Kurian *et al* (2001) reported favourable alteration in source-sink relationship in mango with paclobutrazol to support fruit growth in cvs. Langra and Dashehari. It is speculated that, paclobutrazol, while inducing growth restriction, may tend to reduce photo-assimilate demand of the growing shoot in favour of superfluous sinks (fruits). This is expected to increase fruit soluble solids, and a corresponding decrease in acidity. However, source-sink manipulation by paclobutrazol needs further investigations for a better understanding. Rebolledo-Martinez *et al* (2008) also reported paclobutrazol treatment to be effective in increasing TSS, and corresponding decrease in acidity, in mango fruit. Ascorbic acid, carotenoids and lycopene are well-documented as potent antioxidants and, thus, their content in the fruit serves as an important phytonutrient descriptor for fruit quality. An increase in the content of ascorbic acid and carotonoids following paclobutrazol treatment indicates

Table 1. Effect of paclobutrazol on fruit quality attributes in mango cv. Totapuri

Treatment	Fruit weight(g)	TSS (°B)	Acidity (%)	Ascorbicacid (mg 100 g^{-1})	Total carotenoids (mg 100 g^{-1})	Lycopene (mg 100 g^{-1})
Control	245.79	12.10	0.21	6.59	3.17	0.61
Paclobutrazol treated	266.09*	13.51*	0.18*	8.42**	3.89*	0.69*
(3.0 ml m^{-1} canopy diameter)	(8.26)	(11.65)	(16.67)	(27.77)	(22.71)	(13.11)
CD *(P=0.05)*	13.75	0.14	0.02	0.02	0.03	0.003

**Significant @ 1%; *Significant @ 5%; Values in parentheses represent per cent change over Control

Table 2. Effect of paclobutrazol on content of total sugars, reducing sugars, non-reducing sugars and important individual sugars in mango cv. Totapuri

Treatment	Total sugars ($mg\ g^{-1}$)	Reducing sugars ($mg\ g^{-1}$)	Non-reducing sugars($mg\ g^{-1}$)	Fructose ($mg\ g^{-1}$)	Glucose ($mg\ g^{-1}$)	Sucrose ($mg\ g^{-1}$)
Control	74.41	53.31	21.12	7.76	3.27	13.33
Paclobutrazol treated	91.79*	69.07*	22.79	7.23	5.80**	17.04**
(3.0 ml m^{-1} canopy diameter)	(23.36)	(29.56)	(7.91)	(0.53)	(77.37)	(27.83)
CD *(P=0.05)*	3.51	1.69	2.96	0.92	0.71	1.95

**Significant @ 1%; *Significant @ 5%; Values in parentheses represent percent change over Control

distinct improvement in fruit quality. Paclobutrazol-induced increase in ascorbic acid and total carotenoids have been reported in fruit crops like papaya (Auxcilia *et al*, 2010) and avocado (Kohne and Kremer-Kohne, 1990).

Data on total sugars (reducing, non-reducing and individual sugars) are presented in Table 1. Paclobutrazol treatment modified the content of total sugars, reducing sugars, glucose and sucrose in fruits harvested from treated trees. Under paclobutrazol treatment, fruits showed an increase of 23.4% in total sugars, 29.6% in reducing sugars, 77.4% in glucose and 27.8% in sucrose content over that in fruits from untreated trees. The content of total sugars, reducing sugars, glucose and sucrose was 91.79mg g^{-1}, 69.07mg g^{-1}, 5.80mg g^{-1} and 17.04mg g^{-1}, respectively, in paclobutrazol-treated fruits. These parameters indicate production of better quality fruits under paclobutrazol application. Increase in sugar content by paclobutrazol application is presumed to be the result of favourable mobilization of photo-assimilates to the developing sink created by maturing fruits. Increase in the content of reducing sugars and sucrose by paclobutrazol treatment in mango has been reported by Abdel Rahim *et al* (2011). Further, Zaharah *et al* (2013) reported significant increase in sugars in mango fruit by abscissic acid treatment. Thus, a possible induction of abscissic acid by paclobutrazol, as reported in an earlier study (Upreti *et al*, 2013), may also be another reason for increase in sugars. Murti and Upreti (1997) reported presence of high abscissic acid content in mango fruit during maturation and ripening. Another possible mechanism which may contribute to increase in sugar content may be an improved nutrient uptake and nutrient mobilization from the soil by paclobutrazol application. However, this aspect needs to be further investigated.

To conclude, we found that paclobutrazol application in mango cv. Totapuri helps increase fruit weight and produces fruits with high-quality attributes viz., a high content of sugars, ascorbic acid and carotenoids.

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