



## Tip pruning for synchronized vegetative growth and controlling alternate bearing in mango (*Mangifera indica*)

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Received: 21 June 2017; Accepted: 22 December 2017

### ABSTRACT

Alternate bearing in many mango (*Mangifera indica* L.) cultivars including Dashehari is one of the main hurdles in maximising fruit production thus causing a major threat to the expansion of mango industry. Therefore an experiment was conducted for four consecutive years on 10-12 years mango cv. Dashehari spaced at 7.5 m × 7.5 m to induce synchronous vegetative growth to get same physiological stage of shoots for regular uniform flowering and fruiting in mango cv. Dashehari. For this purpose, whole tree was tip pruned just below first node after crop harvest and thereafter drenched with paclobutrazol @ 3.2 ml/m canopy diameter during September. Tip pruning was also performed in October to study its effect on panicle emergence bypassing vegetative flushing. The result exhibited significant influence of post-harvest pruning cum paclobutrazol application on uniform flowering, fruit yield and quality parameters while October pruning had positive effects on light availability below tree canopy, however increased vegetative growth at the expense of flowering and fruiting. Thus whole tree tip pruning after harvest of ‘on’ year fruits followed by soil drenching with paclobutrazol, a month prior to flower bud differentiation, could be adopted for regulating flowering and fruiting during ‘off’ year.

**Key words:** Alternate bearing, Dashehari, Light interception percent, Paclobutrazol, Post-harvest tip pruning, Synchronized flushing

The mango (*Mangifera indica* L.), commonly known as ‘King of the fruits’ in India, is the most important fruit crop in the tropical and subtropical regions of the world, belonging to the family Anacardiaceae. Because of its delicious taste and appealing aroma, it is ranked as one of the choicest fruits in the national and international markets. However, the productivity of mango continues to remain below its potential level in India. Many mango cultivars including Dahehari has a long-standing problem of alternate bearing which denotes yield variation in alternate years i.e. ‘on’ year of optimum or heavy fruiting is followed by ‘off’ year of little or no fruiting. Thus it renders mango cultivation less remunerative to the orchardist and is one of the main hurdles in maximising mango production thus causing a major threat to the expansion of mango industry.

Growth of mango is not continuous but it occurs as intermittent, short lasting flushes of shoots from apical or lateral buds. The flushing refers to the emergence of new shoots on the terminals of old shoots. Generally, a

healthy mango shoot completes four to five flushes per year depending upon cultivar and growing conditions. New shoots as primary growth arise as laterals from auxiliary buds around the fruited twigs of the previous year. Mango trees produce basically three types of shoots, viz. (i) vegetative shoots which bears only leaves, (ii) generative shoots which bears terminal panicles and (iii) mixed shoots produces both leaves and inflorescences within the same internodes. Existence of florigenic promoter (FP) induces flowering, which is continuously synthesized in mango leaves and is translocated through phloem to apical buds (Makhmale *et al.* 2015). It is up regulated on exposure to cool temperature (<18° C) in sub-tropical conditions. Vegetative promoter (VP) is closely associated with gibberellin synthesis pathway, and is age dependant. High ratio of FP/VP favours floral induction, low FP/VP favours vegetative growth and intermediate ratios favours mixed shoots. Thus, to induce flowering, the levels of VP must drop to sufficiently low levels with stem age (4 months) to raise the FP/VP ratio (Makhmale *et al.* 2015).

It has been now established that flower bud differentiation in mango depends upon ‘on’ and ‘off’ year phase of the tree rather than on the initiation and cessation of growth of shoots. Shoots which fruited in one year, rarely produced a new vegetative flush, soon after crop harvest, and did not flower and fruit in the following year. In mango, shoots with

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single and double flushes, respectively, were proved more fruitful than triple flush for regular bearing (Davenport and Nunez-Elisea 1997). Sant Ram (1999), while investigating on alternate bearing in mango cv. Dashehari, reported a major vegetative flush in March – April followed by two minor flushes in June – July and September – October. The major vegetative flushes only fruited while the minor did not. Thus it is required to induce uniform growth flushes only once a year by tip pruning, instead of asynchronous growth flushes throughout the year to minimize alternate bearing. Moreover, productivity of mango tree could be increased by manipulation of physiological growth characteristics of the crop (Subhadrabandhu *et al.* 1999).

The whole tree tip pruning is the pruning of terminal shoots anywhere from the apex to a point down the stem that is not more than 1 cm diameter (Davenport 2006). It not only caused a uniform flush of growth throughout the canopy, but also removed the flower inhibiting factors in stems derived from the previous seasons of flowering panicles. Thus it stimulates the lateral shoot development at 5 to 10 times of the original number of productive stems (Davenport 2006). It had also beneficial effects on light penetration, as reported in mango cv. Amrapali (Sharma *et al.* 2006) because sunlight not only influences the flowering and fruit yield, but also enhances quality of fruits (Hampson *et al.* 2002).

Tip pruning during first week of October can induce buds to produce inflorescence, as most of the buds that were bursted after pruning were exposed to sufficient cold spells during the winter (Yeshitela *et al.* 2003). Nunez-Elisea and Davenport (1995) also indicated that growth of induced buds in the presence of cool temperature was found to be essential for floral initiation.

In biennial mango cultivars, it was propounded that higher activity of GA-like substances inhibited flowering in the ‘off’ year, while a high level of auxin-like substances promoted flowering in ‘on’ year either by reducing the effectiveness of GA or by decreasing the permeability of the cell membrane (Singh and Sharma 2008). The growth retardant like paclobutrazol [(2RS, 3RS)-1-(4-chlorophenyl)-4, 4-dimethyl-2-(1H-1, 2, 4-triazol-1-yl) pentan-3-ol] (PP<sub>333</sub>) is reported to induce flowering by its direct effect on flower bud differentiation by inhibiting GA biosynthesis or by altering the assimilation partitioning pattern in plants during flowering (Singh and Sharma 2008).

Thus the objective of this experiment was to induce synchronous vegetative growth to get same physiological stage of shoots for regular uniform flowering and fruiting in mango cv. Dashehari.

#### MATERIALS AND METHODS

The experiment was conducted from 2011 to 2015 at the experimental farm of Central Institute for Subtropical Horticulture, located at Rehmankhera, which stands at 26° 45' to 27° 10' N latitude, 80° 30' to 80° 55' E longitude and 123 m above the sea level, approximately 25 km away from the city of Lucknow, Uttar Pradesh, India. Agro

meteorological observations recorded at the institute’s meteorological observatory during the experimental period revealed that the location had maximum temperature during May-June, minimum temperature during December-January, maximum atmospheric humidity during July-August, and had maximum rainfall from South-West Monsoon during July-September (Table 1).

The mango cv. Dashehari of 10-12 years old, spaced at 7.5 m × 7.5 m, was selected for conducting the experiment. The whole tree was tip pruned just below first node immediately after harvesting of fruits in June and thereafter drenched with paclobutrazol @ 3.2 ml/m canopy diameter during September (T<sub>1</sub>) for inducing flowering during the same year. Tip pruning was also performed in October (T<sub>2</sub>) to study its effect on panicle emergence bypassing vegetative flushing. Thus the adopted experimental design was randomized block design with three treatments and seven replications per treatment, where treatments included T<sub>1</sub> = post harvest tip pruning followed by paclobutrazol soil drench, T<sub>2</sub> = pruning during fruit bud differentiation in October, and T<sub>3</sub> = control. The five years experimental data were analyzed using the Web Agri Stat Package version WASP2.0 (ICAR Research Complex for Goa, Ela, Goa- 403 402, India). The visual indication of data dispersion on bar and line graphs was achieved by means of the standard error of the mean. Treatment difference was evaluated using the least significant difference (LSD) at  $P \leq 0.05$ .

The interception of solar light by tree canopy was calculated by measuring quantum of radiant energy penetrated through tree canopy using Hemi view tree canopy analyser (Delta – T Devices Ltd.) during morning (10 AM – 12 PM). The per cent of vegetative flushes and inflorescence emergence was recorded during March. Physiologically mature fruits were harvested during third week of June so as to know the effect of different treatments on yield and quality parameters. Two fruits of each replication were taken for measuring fruit dimension. Thereafter they were washed with tap water, wiped with tissue paper and then kept at room temperature for ripening. The biochemical parameters like fruit TSS and acidity were measured at 7 days after storage.

#### RESULTS AND DISCUSSION

The importance of tree leaf structure (shape, surface, and orientation) for assimilate production is generally associated with the effect of light interception on leaf photosynthesis (Li and Lakso 2004). Our study recorded significantly lower leaf area index in T<sub>2</sub> (tip pruning in October) followed by T<sub>1</sub> (post-harvest tip pruning cum paclobutrazol application), as compared to T<sub>3</sub> (control) (Table 2). The reduction in foliage owing to removal of apical portion of all the shoots of tree (mostly 1.8 inch from top, viz. just below first node of the shoot) emerging can be attributed to lower values of leaf area index.

In fruit trees, fruit yield and quality depend on the light microclimate. At the tree scale and for a given tree, light interception is affected by pruning and training procedures

Table 1 Meteorological data, recorded at Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow, during 2012-15

Month	T <sub>max</sub> (°C)	T <sub>min</sub> (°C)	RH (%)	RF (mm)	Month	T <sub>max</sub> (°C)	T <sub>min</sub> (°C)	RH (%)	RF (mm)
June 2011	34.90	24.90	82.30	267.50	June 2013	33.20	25.00	73.40	280.70
July 2011	33.20	25.70	89.00	351.00	July 2013	32.80	25.20	77.20	265.60
Aug 2011	31.90	25.30	88.40	481.80	Aug 2013	32.80	24.60	78.35	293.60
Sep 2011	32.90	24.40	88.70	247.80	Sep 2013	34.30	24.10	71.80	36.80
Oct 2011	32.60	17.00	84.30	0.00	Oct 2013	30.70	19.60	70.90	30.40
Nov 2011	28.20	11.70	90.10	0.00	Nov 2013	27.50	9.20	60.20	0.00
Dec 2011	22.00	6.60	88.70	0.00	Dec 2013	23.10	6.50	65.75	0.00
Jan 2012	19.90	8.70	92.10	2.01	Jan 2014	17.70	7.80	77.85	60.80
Feb 2012	24.50	10.40	83.34	1.16	Feb 2014	21.80	8.90	67.95	26.40
Mar 2012	31.10	10.40	47.42	4.20	Mar 2014	29.50	12.20	56.75	9.80
Apr 2012	37.10	17.70	50.20	0.00	Apr 2014	36.20	15.80	40.80	0.00
May 2012	40.40	20.10	58.80	0.00	May 2014	38.80	21.10	42.80	0.00
June 2012	41.50	24.20	60.20	14.20	June 2014	39.80	25.20	57.95	24.00
July 2012	33.00	25.40	84.10	388.60	July 2014	33.10	25.80	77.35	178.10
Aug 2012	31.90	25.20	87.90	320.40	Aug 2014	34.40	25.40	73.10	109.20
Sep 2012	31.80	23.80	87.50	243.20	Sep 2014	33.00	23.80	74.60	231.40
Oct 2012	32.10	16.40	82.70	2.20	Oct 2014	31.30	18.60	69.90	87.60
Nov 2012	27.80	9.10	83.60	0.00	Nov 2014	28.20	9.70	59.10	0.00
Dec 2012	21.80	6.10	82.10	0.00	Dec 2014	19.30	6.20	72.05	19.40
Jan 2013	19.40	4.10	89.20	7.50	Jan 2015	17.20	7.00	76.50	22.40
Feb 2013	23.40	8.90	87.60	107.20	Feb 2015	25.70	9.70	67.75	6.00
Mar 2013	30.80	12.80	76.70	0.00	Mar 2015	28.80	13.30	64.00	54.20
Apr 2013	37.00	17.30	45.70	0.00	Apr 2015	34.00	17.90	53.65	41.80
May 2013	39.90	23.80	58.80	0.00	May 2015	39.80	22.20	47.90	18.00

Tmax = Maximum temperature; Tmin = Minimum temperature; RH = Atmospheric relative humidity; RF = Rainfall.

(Stephan *et al.* 2008). In our study, the pooled mean of per cent interception of radiant energy (diffused, direct and total) from October to March revealed significantly lesser interception in T<sub>2</sub> followed by T<sub>1</sub> while maximum interception in un-pruned control trees (T<sub>3</sub>) thereby indicating superiority of T<sub>2</sub> over other treatments for penetration of solar radiation through tree canopy (Table 2). The result has in agreement with that of Buler and Mika (2009) who stated that light interception could be increased by suitable size and shape of tree canopies and high leaf area index. Thus sparse canopy and lower leaf area index due to whole tree tip pruning might result in lesser light interception in pruned trees, as compared to control. Our result revealed that tip pruning improved light penetration and distribution within the tree canopy.

In mango, flowering and fruit production occurs on stem terminals. Maturity of terminal shoots and accumulation of carbohydrates in the shoot apex are associated with the synthesis of the floral stimulus, the absence of which can result in a lack of flowering or biennial bearing in mango cultivar like Dashehari (Pandey 1988). The key factor when managing mango flowering in off year is to produce new vegetative growth in the 'on' year which should also be

mature to be ready to enter into reproduction phase and give out flower in following season. We recorded per cent of vegetative flushes and inflorescence emergence during March from 2011 to 2015. The per cent of vegetative flush was significantly higher in T<sub>3</sub> in 2011-12 and 2012-13 (82.14 and 81.43%, respectively), which was statistically at par with T<sub>2</sub> (75.00%) in 2012-13. However, in 2013-14 and 2014-15, T<sub>2</sub> recorded 33.93 and 105.87% more vegetative flushes over T<sub>3</sub>. The reproductive flush was increased by 179.96, 115.40, 30.48 and 34.92% in T<sub>1</sub> over T<sub>3</sub> from 2011-12 to 2014-15, respectively, although it was statistically at par with T<sub>3</sub> during 2014-15. The mixed flush was recorded only in 2013-14 and it was more in T<sub>3</sub> (34.64%) (Table 3). Tip-pruning, immediately after crop harvest, during June, produced a specifically timed uniform flush of vegetative growth from pruned stems throughout the tree canopy during July, thereby checked flushing frequency at the expense of flowering, but it also removed growth- and flower-inhibiting factors in stems derived from the previous season's flowering and fruiting panicles (Davenport 2009). In our study, tip pruning of trees, immediately after harvest, encouraged the trees to produce enough new vegetative growth, due to sufficient rainfall and high atmospheric humidity in Northern India

Table 2 Effect of tip pruning and paclobutrazol application on per cent light interception and leaf area index in mango cv. Dashehari

Per cent light interception (%)	Total solar radiation												Leaf area index			
	Diffused solar radiation				Direct solar radiation				Total solar radiation							
	2011-12	2012-13	2013-14	2014-15	2011-12	2012-13	2013-14	2014-15	2011-12	2012-13	2013-14	2014-15	2011-12	2012-13	2013-14	2014-15
T <sub>1</sub>	60.24 <sup>b</sup>	61.38 <sup>b</sup>	66.57	63.23 <sup>b</sup>	44.57 <sup>b</sup>	49.80 <sup>b</sup>	62.79	51.20 <sup>b</sup>	46.80 <sup>b</sup>	51.13 <sup>b</sup>	63.22	51.87 <sup>b</sup>	1.32 <sup>b</sup>	1.40 <sup>b</sup>	1.36	1.12 <sup>b</sup>
T <sub>2</sub>	57.19 <sup>c</sup>	59.46 <sup>c</sup>	68.57	48.69 <sup>c</sup>	43.89 <sup>b</sup>	49.25 <sup>b</sup>	64.25	39.91 <sup>c</sup>	45.40 <sup>b</sup>	50.41 <sup>b</sup>	64.74	40.92 <sup>c</sup>	1.10 <sup>c</sup>	1.20 <sup>c</sup>	1.33	0.79 <sup>c</sup>
T <sub>3</sub>	65.27 <sup>a</sup>	65.75 <sup>a</sup>	70.26	70.50 <sup>a</sup>	56.04 <sup>a</sup>	56.14 <sup>a</sup>	65.87	66.19 <sup>a</sup>	57.09 <sup>a</sup>	57.29 <sup>a</sup>	66.37	66.68 <sup>a</sup>	1.92 <sup>a</sup>	1.99 <sup>a</sup>	1.42	1.35 <sup>a</sup>
CV	0.55	1.77	5.72	7.94	2.62	2.13	7.91	9.75	3.50	2.08	7.59	9.60	3.39	2.69	9.29	10.63
LSD (P=0.05)	0.39	1.29	NS	5.62	1.47	1.29	NS	5.95	2.03	1.29	NS	5.94	0.06	0.05	NS	0.14

Table 3 Effect of tip pruning and paclobutrazol application on vegetative and reproductive flushes in mango cv. Dashehari

Treatment	Vegetative flush (%)				Reproductive flush (%)				Mixed flush (%)				Fruit yield (kg/ tree)			
	2011-12	2012-13	2013-14	2014-15	2011-12	2012-13	2013-14	2014-15	2011-12	2012-13	2013-14	2014-15	2011-12	2012-13	2013-14	2014-15
T <sub>1</sub>	50.00 <sup>b</sup>	60.00 <sup>0</sup>	22.14 <sup>c</sup>	13.33 <sup>b</sup>	50.00 <sup>a</sup>	40.00 <sup>a</sup>	48.93 <sup>a</sup>	86.67 <sup>a</sup>	0.00 <sup>b</sup>	0.00	28.93 <sup>b</sup>	0.00	15.64 <sup>a</sup>	25.87 <sup>a</sup>	44.27 <sup>a</sup>	53.76 <sup>a</sup>
T <sub>2</sub>	56.43 <sup>b</sup>	75.00 <sup>a</sup>	37.50 <sup>a</sup>	73.62 <sup>a</sup>	32.14 <sup>b</sup>	25.00 <sup>b</sup>	33.93 <sup>b</sup>	26.38 <sup>b</sup>	11.43 <sup>a</sup>	0.00	28.57 <sup>b</sup>	0.00	7.78 <sup>b</sup>	12.08 <sup>b</sup>	22.18 <sup>b</sup>	32.55 <sup>c</sup>
T <sub>3</sub>	82.14 <sup>a</sup>	81.43 <sup>a</sup>	28.00 <sup>b</sup>	35.76 <sup>b</sup>	17.86 <sup>c</sup>	18.57 <sup>b</sup>	37.50 <sup>b</sup>	64.24 <sup>a</sup>	0.00 <sup>b</sup>	0.00	34.64 <sup>a</sup>	0.00	7.98 <sup>b</sup>	12.66 <sup>b</sup>	25.62 <sup>b</sup>	37.91 <sup>b</sup>
CV	11.56	9.72	11.88	58.23	19.73	25.18	10.15	40.30	57.28	12.73			15.14	14.03	10.76	4.59
LSD (P=0.05)	8.46	8.17	4.03	27.74	7.66	8.17	4.75	27.74	2.54	4.56			1.85	2.75	3.84	2.21

during July, which might affect more carbohydrate reserve replenishment. Thus flushing was important because new mango leaves were efficient producers of carbohydrates, the tree's building materials (Yeshitela *et al.* 2003), and all the stems in the tree canopy reached to the same physiological stage of maturity. Thereafter paclobutrazol was applied in the rhizospheric soil, a month prior to flower bud differentiation, which might induce early shoot maturity and increase photosynthesis rate (Singh and Singh 2009), accumulate carbohydrate reserves in the shoots (Abdel Rahim *et al.* 2011), and decline flowering reducing hormone like gibberellins (Upreti *et al.* 2013), thereby ultimately leading to uniform flowering. The result was in agreement with those of Karki and Dhakal (2003) and Uddin *et al.* (2014). The fact that the control group ( $T_3$ ) was similar to  $T_1$  during 2014-15 might have resulted from the fact that the trees were on an "on" period of alternance, and because of having more reserves after having spent a year "off", they had more mature vegetative buds, thus differentiating more vegetative buds to floral ones (Martinez *et al.* 2008). In the case of the control trees, the occurrence of mixed flush was due to sprouting of apical buds or just random development from previous harvest and inflorescence development wounds that activated auxiliary buds. The observation of greater flowering uniformity in the pruned trees supports the view that postharvest pruning, in forcing uniform flushing, affects greater uniformity of flowering.

In our study, October pruned shoots were dormant from October to January, and were forced to form buds during February when the day/night temperature was gradually rising. Thus the vegetative re-growth caused by October pruning, elevates the level of endogenous gibberellins, and thereby affects floral bud development. It might be ascribed to inadequate canopy recovery following pruning due to conditions not being favourable for vegetative growth during winter, or to a delay in bud development to a period when environmental conditions were no longer inductive for flowering (Oosthuysen 1994). In mango, vegetative flushes act as physiological sinks which decrease flower induction in the plants (Jannoyer and Lauri 2009). Thus the per cent of vegetative flush was higher in October pruning, though some buds could develop into inflorescence. It might be attributed to the fact that due to break of apical dominance, axillary buds could produce lateral inflorescence, bypassing vegetative growth (Yeshitela *et al.* 2003). Generally, it is clear from the observation that, October pruning didn't cause a failure of flowering and fruiting.

The physiologically mature fruits were harvested for yield and quality parameters. The data pertaining to tree yield was significantly superior in  $T_1$  than  $T_2$  by 101.03, 114.16, 99.59 and 65.16% and  $T_3$  by 95.99, 104.34, 72.79 and 41.81% during 2011-12, 2012-13, 2013-14 and 2014-15, respectively (Table 3). By tip pruning at immediately after harvest, synchronized trees switched from biannual (half of the stems flowered during each of two seasons) to annual (all of the stems flowered in synchrony). Moreover, the tip-pruning event removed floral-inhibiting rachises and

increased the number of bearing stems on each tree resulting in elimination of alternate bearing and a substantial increase in annual yields (Ramirez *et al.* 2010). The soil application of paclobutrazol in September to trees, which were tip pruned just after harvest, also increased flowering intensity which resulted higher fruit number (Upreti *et al.* 2013). We observed that due to tip pruning in October, new branch organs were emerged from the cut portion of shoots during the time of panicle formation. Thus, competition between vegetative and generative sinks for carbon partitioning affected caused less flowering and fruiting (Wünsche and Lakso 2000), thereby affecting fruit yield.

The average individual fruit weight was significantly higher in  $T_1$  by 71.95, 60.05, 45.93 and 32.53% over  $T_3$  during 2011-12, 2012-13, 2013-14 and 2014-15, respectively. The average fruit length was 38.51, 25.85, 14.48 and 22.96 % more in  $T_1$  over  $T_3$  during 2011-12, 2012-13, 2013-14 and 2014-15, respectively. Similarly,  $T_1$  also recorded significantly higher average fruit diameter, when compared to  $T_3$ , by 33.87, 18.36, 11.47 and 12.25% during 2011-12, 2012-13, 2013-14 and 2014-15, respectively (Table 4). Thus the result indicated that postharvest tip pruning affected prolific and synchronous vegetative growth shortly after its performance, and application of paclobutrazol, a month prior to flower bud differentiation, induced shoot maturity for uniform flowering and bearing of fruits, whose dimension were more than those of October pruning and control, which could be due to an improved microclimate and higher photosynthetic rates (Asrey *et al.* 2013). Application of paclobutrazol reduced vegetative growth by interrupting the biosynthesis of gibberellins (Hoda *et al.* 2001) and reduction of vegetative growth resulted in physiological changes such as higher chlorophyll content, carbohydrate content and carbohydrate-nitrogen ratio in leaves and shoots (Kumar *et al.* 2014), thereby leading to improved fruit growth. In case of trees tip pruned in October, emergence of young leaves affected the fruit development and quality (Rushidah and Razak 2001), thereby limiting the increase in fruit dimensions.

The fruit TSS was higher in  $T_1$  than other treatments including control, though statistically non-significant. The fruit acidity was lower in  $T_1$  from 2011 to 2015, though non-significant between the treatments, except in 2012-13 and 2013-14, when fruit acidity was significantly lower in  $T_1$  than  $T_3$  by 10.00 and 29.03%, respectively (Table 4). Thus whole tree pruning at immediately after crop harvest induced synchronous flushing, and paclobutrazol induced flowering and fruiting on the current season shoots, and also increased fruit TSS during the condition of physiological ripeness (Singh and Dhillon 1992). The observed trend of a greater TSS content in the treatments with PBZ uphold the hypothesis that PBZ treatments lead to an accumulation of a greater amount of reserve substances (Martinez *et al.* 2008). Acidity content of fruits ripe for consumption markedly diminished as a result of the ripening process, with fruits treated with PBZ showing the lowest values (Martinez *et al.* 2008).

Table 4 Effect of pruning and paclobutrazol application on fruit quality parameters in mango cv. Dashehari

	Average fruit weight (g)				Fruit length (mm)				Fruit diameter (mm)				Fruit T.S.S (° Brix)				Fruit acidity (%)			
	2011-12	2012-13	2013-14	2014-15	2011-12	2012-13	2013-14	2014-15	2011-12	2012-13	2013-14	2014-15	2011-12	2012-13	2013-14	2014-15	2011-12	2012-13	2013-14	2014-15
T <sub>1</sub>	252.39 <sup>a</sup>	268.94 <sup>a</sup>	316.09 <sup>a</sup>	392.86 <sup>a</sup>	116.86 <sup>a</sup>	124.15 <sup>a</sup>	130.44 <sup>a</sup>	129.64 <sup>a</sup>	56.32 <sup>a</sup>	57.75 <sup>a</sup>	60.75 <sup>a</sup>	66.71 <sup>a</sup>	15.19	17.11	19.11	22.59	0.96	1.08 <sup>c</sup>	1.10 <sup>b</sup>	1.18
T <sub>2</sub>	166.57 <sup>b</sup>	198.77 <sup>b</sup>	218.77 <sup>b</sup>	267.86 <sup>b</sup>	93.49 <sup>b</sup>	104.35 <sup>b</sup>	115.78 <sup>b</sup>	103.57 <sup>b</sup>	46.01 <sup>b</sup>	50.87 <sup>b</sup>	55.59 <sup>b</sup>	57.86 <sup>b</sup>	15.14	17.00	18.27	20.67	1.08	1.14 <sup>b</sup>	1.55 <sup>a</sup>	1.22
T <sub>3</sub>	146.78 <sup>b</sup>	168.03 <sup>c</sup>	216.61 <sup>b</sup>	296.43 <sup>b</sup>	84.37 <sup>c</sup>	98.65 <sup>c</sup>	113.94 <sup>b</sup>	105.43 <sup>b</sup>	42.07 <sup>c</sup>	48.79 <sup>b</sup>	54.50 <sup>b</sup>	59.43 <sup>b</sup>	15.07	16.93	19.39	20.49	1.10	1.20 <sup>a</sup>	1.55 <sup>a</sup>	1.31
CV	13.88	12.07	8.67	16.82	5.81	3.45	5.18	7.81	3.71	5.62	4.86	6.29	3.31	2.96	5.25	7.44	12.54	4.15	22.64	21.48
LSD (P=0.05)	30.50	29.80	25.29	62.48	6.64	4.38	7.25	10.27	2.08	3.44	3.23	4.49	NS	NS	NS	NS	NS	0.06	0.37	NS

Although the direct effects of paclobutrazol (PBZ) on early induction of flowering of mango have been well documented, however, continuous application of PBZ may cause soil pollution and its residual effect may increase in fruit (Swamy 2012). Residual limit of PBZ accepted by the FAO in stone fruit is 0.05 mg/kg (Singh and Ram 1998). Thus, it can only be applied after post harvest tip pruning only during 'on' year to produce flowers during 'off' year.

Our findings contributed to the overall physiological interpretation of the positive effects of post-harvest tip pruning cum paclobutrazol application on uniform flowering, improving fruit yield and quality during 'off' year, and thus maintaining regularity of yield across consecutive years.

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