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PRUNING AND PACLOBUTRAZOL INDUCED CHANGES ON FRUIT YIELD AND FRUIT QUALITY IN MANGO (*Mangifera indica* L.)

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ABSTRACT

A study was conducted to evaluate the effects of pruning (current or previous season's vegetative growth) and paclobutrazol (PBZ) @ 3 ml m^{-1} canopy diameter on the fruit yield and fruit quality of mango cvs. Raspuri, Dashehari and Amrapali during 2013-2014. Trees pruned to current season's growth recorded 53.4, 17.3 and 11.8 per cent higher yields than unpruned trees. Similarly application of PBZ recorded 242.4, 163.1 and 52.8 per cent more number of fruits per tree, 13.4, 14.8 and 26.1 per cent decline in average fruit weight, and 171.2, 180.0 and 49.3 per cent higher yields than control trees of Raspuri, Dashehari and Amrapali respectively, when compared to control. Among the interaction effects, trees pruned to current season's growth and with PBZ application recorded significantly higher fruit number (143.7) and higher yileds per tree (28.1 kg). Raspuri and Dashehari trees pruned to current season's growth recorded high TSS (20.13 and 20.16 °Brix, respectively) compared to control trees (P_3). Similarly, trees without PBZ application (C_2) recorded higher TSS of 19.89 and 21.25 °Brix in cvs Raspuri and Dashehari, respectively. PBZ application recorded significantly higher ascorbic acid and carotenoid contents in Dashehari and Amrapali cultivars. The effects of PBZ alone or in combination with pruning were nonsignificant with respect to total sugars, nonreducing sugars and reducing sugars. The study indicated that, the responses of pruning and PBZ treatments varied with the bearing habit of the cultivars. Pruning of current season's growth and application of PBZ treatment was more pronounced in influencing the fruit yield and fruit quality of alternate bearing cultivars of Raspuri and Dashehari.

KEYWORDS: Mango, Pruning, Paclobutrazol, Fruit yield, Fruit quality

INTRODUCTION

Mango (*Mangifera indica* L.) is one of the important tropical fruit crops grown in both tropical and subtropical regions of India for its delicious taste, excellent flavor and nutritive value. More than thousand cultivars exist in India (Dinesh, 2014), among which about 30 cultivars are commercially grown with varied production potentials. India ranks first in mango production, contributing 45.5 per cent total world's mango production (Anon, 2013). Although India is the largest producer of mango, its productivity is very less compared to Israel's productivity (30 tonnes ha^{-1}) and its share in export market is comparatively less due to inferior fruit quality. Besides alternate bearing, overcrowding of branches is one of the reasons for low productivity and poor fruit quality (Balamohan and Gopu, 2014). Pruning and application of growth retardants like paclobutrazol (PBZ) are the important strategies recommended in many fruit crops, including mango for controlling the tree vigour, promoting flowering, and enhanced production efficiency. Pruning is an effective means of maintaining canopy architecture in order to achieve optimum productivity of superior quality fruits (Singh *et al.*, 2009). Most of the pruning studies in mango were targeted to get early and uniform flowering and to rejuvenate the senile and old trees. Similarly, PBZ is the most promising and widely used growth retardant in mango for regular and increased production. Although, the effects of PBZ on tree vigour, flowering and fruit yield are well documented (Abdel Rahim *et al*., 2011, Upreti *et al.,* 2013); the effects of PBZ on fruit quality are limited with reference to Indian mango cultivars. Limited studies have been carried on the efficiency of combined effects of pruning and PBZ in mango. In the studies made earlier reported that, pruning in combination with PBZ is effective in influencing the tree growth and development of different mango cultivars and the response was cultivar dependent (Srilatha *et al.,* 2015). In the present investigation we reported the effects of pruning and PBZ on fruit yield and fruit quality attributes in three mango cultivars differing in their bearing habits.

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MATERIALS AND METHODS

The investigation was conducted during the year 2013-2014 at the experimental farm of Indian Institute of Horticultural Research, Bengaluru on 4 years old trees of three mango cultivars namely Raspuri (early and alternate bearing), Dashehari (late and alternate bearing) and Amrapali (late and regular bearing hybrid) raised on Olour rootstock and maintained at 7 × 7 m spacing. The experiment was laid out with three replications in a factorial randomized block design with various combinations of pruning (current season's growth, previous season's growth and no pruning) and PBZ application (0.75 g a.i./m canopy diameter and no PBZ). Each variety had a total of 36 plants (2 plants in each replication) under different treatment combinations. Pruning was carried out by removing tree branches according to the pruning level during 3rd week of July, 2013. PBZ (25% w/v a.i., Zeneca Limited, Surry, UK) was applied once as soil drench during the last week of September, 2013 by spreading in a circular band of 25 cm width at a radial distance of 75 cm from the tree trunk. Only water was used for the PBZ untreated trees. During the experimentation, the average maximum and minimum temperatures were 29.4 and 19.0°C respectively, relative humidity 74.5 per cent and total rainfall 732.7 mm.

After the emergence of new shoots, 50 shoots were tagged in all the directions of tree for recording data on yield parameters. Observations on number of fruits per plant, average fruit weight and fruit yield per plant were recorded at the time of harvesting. Fruit quality parameters such as peel weight, pulp weight and stone weight were recorded in ripened fruits by weighting the peel, pulp and stone after separating. Total soluble solids (TSS) were determined using a digital refractometer (Serie Palette, ATAGO, Japan). Total sugars content was determined by using anthrone reagent method (Dubois, 1951). Reducing sugar content was measured by following Nelsons modifications of Somogyi's method, (Somogyi, 1952) using arsenomolybdate colour forming reagent. Nonreducing sugar was obtained by subtracting reducing sugar from the amount of total sugar and multiplying the resultant by factor 0.95. Titratable acidity was determined by an acid base titration method using 0.1 N NaOH with phenolphthalein colour indicator (AOAC, 1980). Ascorbic acid content was determined with the method of AOAC (1980). Total carotenoids contents were analysed by modified method of Ranganna (1997) using acetone as solvent and measuring the absorbance at 450 nm. All the data were statistically analyzed using Agri Stat software and the difference in the means were compared at 5% level of significance.

RESULTS AND DISCUSSION

Fruit yield

The effects of pruning and PBZ were significant with respect to fruit number per tree, average fruit weight, yield per tree and yield per hectare in all the three cultivars. Trees pruned to current season's growth (P_1) recorded more fruit number per tree (66.5, 72.3 and 121.1) recording 53.4, 17.3 and 11.8 per cent higher yields than unpruned trees in Raspuri, Dashehari and Amrapali, respectively (Table 1). The trees pruned to previous season's growth recorded lower yields than unpruned trees in all the three cultivars. Pruning besides better light penetration, forces the early initiation of newshoots causing them to reach maturity which have the sufficient time for accumulation of photosynthates that are promotory for flowering (Oosthuyse, 1997). Pruning induced enhancement in fruit yield have been reported in different mango cultivars (Singh *et al.,* 2009). Yield reduction in trees pruned to previous season's growth than unpruned trees can be attributed to the reason that, part of photosythates might be diverted to maintain the vegetativeness induced by pruning (Gross, 1996), further trees tends to grow vegetatively inorder to replenish vegetative growth lost through severe pruning. Lower fruit yields in trees pruned to previous season's growth is in accordance with the reports of Balamohan and Gopu (2014) and Das and Jana (2012) in different mango cultivars.

Application of PBZ (P_1) recorded 242.4, 163.1 and 52.8 per cent more fruit number per tree 13.4, 14.8 and 26.1 per cent decline in average fruit weight, and 171.2, 180.0 and 49.3 per cent higher yields (Table 1) than PBZ untreated trees of Raspuri, Dashehari and Amrapali, respectively when compared to control. Decline in average fruit weight could be because of more number of fruits per tree as a result of increased flowering intensity in PBZ treated trees. PBZ induced reduction in fruit weight has also been reported by Reddy and Kurian (2008), Rebolledo-Martinez *et al.* (2008) and Reddy *et al.* (2014). Inspite of the decline in average fruit weight, the higher yields in the PBZ treated trees is ascribed due to high

Table 1. Effects of pruning and paclobutrazol on yield attributes in different cultivars of mango

Treatments	Number of fruits plant^{-1}			Average fruit weight (g)			Yield plant^{-1} (kg)		
	Raspuri	Dashehari	Amrapali	Raspuri	Dashehari	Amrapali	Raspuri	Dashehari	Amrapali
Pruning									
P_1	66.50	72.30	121.10	180.40	132.90	180.20	13.40	13.30	18.10
P_2	43.70	45.40	64.70	187.90	146.20	192.30	8.80	7.00	17.00
P_3	102.10	116.10	123.80	156.90	141.10	171.60	22.50	19.70	17.30
SEm±	16.96	19.87	20.51	7.53	10.29	11.34	3.33	3.33	3.12
CD at 5%	76.01	62.59	64.61	23.75	32.41	35.74	10.50	10.50	9.84
PBZ									
C_1	109.50	112.90	124.70	162.40	128.80	154.20	21.70	19.60	20.90
C_2	32.00	42.90	81.60	187.70	151.30	208.60	8.00	7.00	14.00
SEm±	13.85	16.22	16.74	6.15	8.40	9.26	2.72	2.72	2.55
CD at 5%	62.06	51.11	52.76	19.39	26.46	9.18	8.58	8.58	8.03
P × PBZ									
P_1C_1	146.70	119.30	154.30	166.40	122.10	134.80	28.10	22.10	22.60
P_1C_2	29.30	25.20	87.80	194.40	143.80	225.50	5.40	4.50	13.50
P_2C_1	78.00	84.00	70.70	159.20	133.40	167.90	15.70	12.80	19.50
P_2C_2	9.30	6.70	58.70	216.60	158.90	216.60	1.90	1.20	14.50
P_3C_1	103.70	135.50	149.20	161.70	130.90	159.50	21.30	24.00	20.60
P_3C_2	57.50	96.70	98.30	152.20	151.30	183.60	16.80	15.30	14.00
SEm±	23.98	28.10	29.00	10.66	14.55	16.04	4.71	4.71	4.41
CD at 5%	107.49	NS	NS	33.58	NS	NS	11.01	NS	NS

P - Pruning,
P_1 - pruning of current season's growth
P_2 - pruning of previous season's growth
P_3 - no pruning

PBZ - Paclobutrazol
C_1 - PBZ @ 3 ml m^{-1} canopy spread
C_2 - no PBZ

Table 2. Effect of pruning and paclobutrazol on fruit quality in different cultivars of mango

Treatments	Number of fruits plant^{-1}			Average fruit weight (g)			Yield plant^{-1} (kg)		
	Raspuri	Dashehari	Amrapali	Raspuri	Dashehari	Amrapali	Raspuri	Dashehari	Amrapali
Pruning									
P_1	31.04	28.41	31.91	117.43	79.47	118.89	27.20	25.04	29.38
P_2	55.12	32.52	31.04	100.60	89.50	132.13	32.42	24.15	29.08
P_3	35.04	27.63	27.12	102.44	79.92	114.48	24.35	23.60	29.94
SEm±	1.94	3.50	1.49	6.83	6.98	12.42	0.93	1.06	2.43
CD at 5%	6.11	NS	NS	NS	NS	NS	2.95	NS	NS
PBZ									
C_1	31.43	28.26	25.53	108.49	76.89	100.74	28.10	23.64	27.81
C_2	49.37	30.77	34.51	105.15	89.03	142.92	27.87	24.87	31.12
SEm±	1.58	2.85	1.22	5.57	5.70	10.14	0.76	0.86	1.98
CD at 5%	4.99	NS	3.84	NS	NS	31.97	2.41	NS	NS
P × PBZ									
P_1C_1	29.44	25.96	22.87	125.11	73.07	88.42	29.43	23.00	23.51
P_1C_2	32.63	30.85	40.94	109.75	85.87	149.36	24.96	27.07	35.24
P_2C_1	35.25	30.65	27.37	95.21	77.96	110.08	28.90	24.80	30.48
P_2C_2	74.99	34.39	34.7	105.98	101.04	154.17	35.93	23.49	27.68
P_3C_1	29.60	28.17	26.36	105.15	79.64	103.72	25.98	23.13	29.43
P_3C_2	40.48	27.08	27.88	99.73	80.19	125.23	22.71	24.06	30.45
SEm±	2.74	4.94	2.11	9.65	9.88	17.57	1.32	1.50	3.43
CD at 5%	8.64	NS	6.66	NS	NS	NS	4.18	NS	NS

P - Pruning,
P_1 - pruning of current season's growth
P_2 - pruning of previous season's growth
P_3 - no pruning

PBZ - Paclobutrazol
C_1 - PBZ @ 3 ml m^{-1} canopy spread
C_2 - no PBZ

Table 3. Effect of pruning and paclobutrazol on fruit quality in different cultivars of mango

Treatments	Number of fruits plant^{-1}			Average fruit weight (g)			Yield plant^{-1} (kg)		
	Raspuri	Dashehari	Amrapali	Raspuri	Dashehari	Amrapali	Raspuri	Dashehari	Amrapali
Pruning									
P_1	20.13	20.16	20.58	163.15	119.85	161.95	40.75	43.54	43.20
P_2	18.58	20.29	22.83	165.05	115.05	164.65	37.06	43.36	42.85
P_3	18.17	20.03	22.38	165.55	106.75	163.30	38.04	43.03	43.63
SEm±	0.16	0.54	1.48	1.70	5.05	2.43	1.49	1.32	2.91
CD at 5%	0.52	1.70	NS	NS	NS	NS	NS	NS	NS
PBZ									
C_1	18.03	19.07	20.38	162.67	112.93	163.17	38.26	44.64	44.93
C_2	19.89	21.25	23.48	166.50	114.83	163.43	38.97	41.97	41.52
SEm±	0.13	0.44	1.20	1.39	4.12	1.99	1.21	1.07	2.37
CD at 5%	0.42	1.39	NS	NS	NS	NS	NS	NS	NS
P × PBZ									
P_1C_1	19.00	18.31	17.33	160.70	112.60	163.10	39.41	45.58	45.45
P_1C_2	21.25	22.00	23.83	165.60	127.10	160.80	42.08	41.49	40.95
P_2C_1	17.33	19.25	22.16	162.50	113.40	165.00	35.04	44.35	45.58
P_2C_2	19.83	21.33	23.50	167.60	116.70	164.30	39.08	42.37	40.12
P_3C_1	17.75	19.65	21.66	164.80	112.80	161.40	40.33	44.00	43.75
P_3C_2	18.58	20.41	23.10	166.30	100.70	165.20	35.74	42.05	43.50
SEm±	0.23	0.76	2.09	2.40	7.14	3.45	2.11	1.86	4.12
CD at 5%	0.74	NS	NS	NS	NS	NS	NS	NS	NS

P - Pruning,
P_1 - pruning of current season's growth
P_2 - pruning of previous season's growth
P_3 - no pruning

PBZ - Paclobutrazol
C_1 - PBZ @ 3 ml m^{-1} canopy spread
C_2 - no PBZ

Table 4. Effect of pruning and paclobutrazol on fruit quality attributes in different cultivars of mango

Treatments	Number of fruits plant^{-1}			Average fruit weight (g)			Yield plant^{-1} (kg)		
	Raspuri	Dashehari	Amrapali	Raspuri	Dashehari	Amrapali	Raspuri	Dashehari	Amrapali
Pruning									
P_1	2.38	1.38	1.25	0.41	0.33	0.57	0.123	0.113	0.148
P_2	2.13	1.38	1.50	0.39	0.32	0.59	0.113	0.092	0.149
P_3	2.06	1.50	1.25	0.41	0.33	0.59	0.143	0.111	0.154
SEm±	0.14	0.14	0.24	0.02	0.01	0.02	0.014	0.066	0.011
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
PBZ									
C_1	2.12	1.25	1.25	0.42	0.35	0.58	0.128	0.121	0.157
C_2	2.25	1.58	1.42	0.38	0.30	0.58	0.124	0.089	0.143
SEm±	0.11	0.12	0.20	0.02	0.01	0.02	0.011	0.054	0.095
CD at 5%	NS	0.38	NS	NS	0.03	NS	NS	0.017	0.030
P × PBZ									
P_1C_1	2.50	1.25	1.25	0.42	0.36	0.57	0.124	0.133	0.164
P_1C_2	2.25	1.50	1.25	0.39	0.30	0.57	0.122	0.093	0.131
P_2C_1	2.00	1.25	1.25	0.42	0.33	0.57	0.109	0.099	0.153
P_2C_2	2.25	1.50	1.75	0.36	0.30	0.60	0.117	0.084	0.144
P_3C_1	1.87	1.25	1.25	0.42	0.36	0.60	0.151	0.130	0.155
P_3C_2	2.25	1.75	1.25	0.39	0.30	0.57	0.134	0.091	0.153
SEm±	0.20	0.20	0.35	0.03	0.01	0.03	0.020	0.094	0.016
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

P - Pruning,
P_1 - pruning of current season's growth
P_2 - pruning of previous season's growth
P_3 - no pruning

PBZ - Paclobutrazol
C_1 - PBZ @ 3 ml m^{-1} canopy spread
C_2 - no PBZ

flowering intensity which resulted from higher fruit number. PBZ has been reported to alter source and sink relationship and exert influence on partitioning the photosynthates to the sites of flowering and fruit production with a reduction in vegetative growth (Kurian *et al.,* 2001). Yield advantage following PBZ application was in agreement with the findings of Upreti *et al.* (2013) and Sarkar and Rahim (2012) in different mango cultivars. Similarly, the interaction effect of pruning and PBZ was significant only in cv. Raspuri. Unpruned trees of Raspuri with application of PBZ (P_3C_1) recorded more fruit number per plant (146.7) followed by 103.7 fruits in trees pruned to current season's growth and with application of PBZ (P_1C_1). The cumulative effect of pruning and PBZ is expected to enhance the yields as evident from the results.

Fruit quality parameters

The effects of pruning and PBZ were significant on peel weight and stone weight in cv. Raspuri only. However, effects of pruning, PBZ and the interaction effects of pruning and PBZ were found non-significant with respect to pulp content in all the three cultivars (Table 2). PBZ treated trees of Raspuri recorded 7.24 per cent decline in peel weight than PBZ untreated trees. Growth retardants affect the peel weight to some extent directly or indirectly through their effect on cell division and cell expansion could be the reason for less peel content in fruits of PBZ treated Raspuri trees. PBZ induced decrease in peel content and increase in pulp content is also reported in litchi (Rani and Bramhachari, 2000).

Effects of pruning and PBZ on TSS were significant in Raspuri and Dashehari cultivars and their interaction effects were signifcant only in Raspuri (Table 3). Raspuri and Dashehari trees pruned to current season's growth recorded high TSS (20.13 and 20.16 °Brix, respectively), while the lower TSS was recorded in unpruned control trees (P_3). Similarly trees without PBZ application (C_2) recorded higher TSS of 19.89 and 21.25 °Brix in cvs Raspuri and Dashehari, respectively. Interaction effect was significant only in cv. Raspuri. Highest TSS (21.25 °Brix) was recorded in trees pruned to current seasons's growth with out PBZ (P_1C_2) followed by 19.83 °Brix in trees pruned to previous season's growth without PBZ application (P_2C_2). Higher TSS in trees pruned to current season's growth than previous season's growth treatments could be due to availability of more carbohydrates among the sink in trees pruned to current season's growth.

Ascorbic acid and carotenoid contents differed significantly only with PBZ in Dashehari (Table 4). Dashehari trees with application of PBZ (C_1) recorded higher ascorbic acid content (0.35 mg g^{-1}) and highest total carotenoids (0.121 mg g^{-1}) than PBZ untreated trees. Similarly PBZ application recorded higher carotenoid contents (0.157 mg g^{-1}) in Amrapali, than control trees. Increase in the contents of ascorbic acid and carotenoids, and reduction in acidity with PBZ application in Dashehari and Amrapali cultivars indicated the improvement in the fruit quality, as they are documented as potential antioxidants. The increase in TSS, ascorbic acid and reduction in acidity due to the application of PBZ in the present investigation might be because of accumulation of more minerals and carbohydrates (Vijaylakshmi and Srinivasan, 2000). Effectiveness of PBZ in enhancing the ascorbic acid and carotenoids have also been reported in mango (Reddy *et al.,* 2014), papaya (Auxcilia *et al.,* 2010) and guava (Jain and Dashora, 2011).

The study indicated that, the effects of different treatments on fruit yield and fruit quality varied with bearing habit of cultivars. Pruning of current season's growth and application of PBZ @ 0.75 g a.i./m canopy diameter was more pronounced in alternate bearing cultivars Raspuri, and Dashehari as compared to regular bearing hybrid Amrapali.

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