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PRUNING AND PACLOBUTRAZOL INDUCED VIGOUR, FLOWERING AND HORMONAL CHANGES 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 canopy diameter) on tree vigour, flowering and hormonal contents of three mango varieties, Raspuri, Dashehari and Amrapali differing in their bearing habits. Trees pruned to current season's growth and with application of PBZ recorded 62, 52 and 61.5% lesser plant height, 50.2, 27.3 and 35.3% lesser trunk girth and 51.5, 45.8, 35.3% lesser canopy spread, 39.6, 35.2 and 26.5% decline in shoot length, 23.7, 19.0 and 14.9% decline in shoot girth and 20.4, 13 and 14.7 days advanced fruit harvesting followed by unpruned trees with PBZ application in the cvs Raspuri, Dashehari and Amrapali respectively compared with control. Trees pruned to current season's growth and with PBZ application recorded decline in gibberellin (GA_3) contents and increase in abscisic acid (ABA) levels at 45 and 75 days after PBZ application compared to control. From the study, it was apparent that the pruning of trees to current season's growth and PBZ application are beneficial for regulating tree size, early flowering and advancing fruit harvest in mango and such effects are mediated through increase in ABA and decrease in GA_3 contents.

INTRODUCTION

Mango is one of the most widely cultivated and popular fruits in tropics and subtropics of India being cultivated in an area of 2.50 million ha with 18.08 million tonnesof fruit production. Although India is the largest producer of mango, its productivity (6.8 tonnes/ha) is very less compared to Israel's productivity (30 tonnes/ha) and its share in export market (Anon, 2013). Besides alternate bearing, overcrowding of branches in the absence of pruning resulting in poor penetration of sunlight is one of the reasons for low productivity of mango (Balamohan and Gopu, 2014). Pruning and application of growth retardants like paclobutrazol (PBZ) are the simple and effective strategies recommended in many fruit crops, including mango for controlling the tree vigour and promoting flowering, and enhanced production efficiency.

Synchronization of vegetative growth of tree canopies is necessary step in the flowering management which can be accomplished by pruning (Singh *et al.*, 2009; Balamohan and Gopu, 2014). Pruning is an important tree management practice to regulate vegetative growth and flowering in many fruit crops including mango. The beneficial effects of pruning are associated with management of canopy architecture, alteration of biochemical system and early flowering (Singh *et al.*, 2009). Similarly, chemical induced manipulations in vegetative growth have been attempted in many fruit crops (Erez, 1984; Aron *et al.*, 1985; Sarkar and Rahim, 2012; Gurung *et al.*, 2014; Muralidhara *et al.*, 2014). Investigations have revealed the beneficial effects of PBZ in restriction of vegetative growth and successful induction of flowering in mango. Such effects of PBZ are brought out by modifying physiological and biochemical processes (Abdel Rahim *et al.*, 2011; Upreti *et al.*, 2013). Nafeez *et al.* (2010) reported PBZ induced change in vigour, biochemical and hormonal contents of mango varies with cultivar and bearing habit. Most of the studies undertaken with respect to growth regulation and flowering in mango are confined to independent use of pruning and paclobutrazol. The present investigation was hypothesized that the combined effect of pruning and PBZ can effectively regulates the tree vigour and enhances flowering through phytohormonal changes in mango.In the present investigation, attempts have been made to investigate the combined effects of pruning and PBZ on tree vigour restriction, induction of flowering and fruit yield through their effects on phytohormonesin 3 commercially important mango cultivars.

MATERIALS AND METHODS

The investigations were conducted during the years 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 X 7 m spacing.The experiment was laid out

with three replications in a factorial randamized block design with various combinations of pruning (current season's growth, previous season's growth and no pruning) and PBZ application at @ 3 ml/m canopy diameter. 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. The different treatment combinations were coded as T_1- pruning of current season's growth + PBZ application @ 3 ml/ m canopy diameter, T_2- pruning of current season's growth, T_3- pruning of previous season's growth + PBZ application @ 3 ml/m canopy diameter, T_4- pruning of previous season's growth, T_5- no pruning + PBZ application @ 3 ml/m canopy diameter, T_6- no pruning and no PBZ application (control). During the experimentation, the average maximum and minimum temperatures were 29.4 and 19.0ºC respectively, relative humidity 74.5 % and total rainfall 732.7 mm.

The data of the morphological characters like plant height, trunk girth and canopy spread were measured before and after six months of PBZ application and difference increases between each parameter were calculated. Canopy spread in a span of six months after treatments were measured and presented as the average spread in E-W and N-S directions. After the emergence of new shoots, 50 shoots were tagged in all the directions of tree and the girth and length of new shoots were recorded during the month of December. Similarly, observations on days for 50% flowering and percent flowering were recorded from tagged shoots. Data on number of days from flowering to harvest and fruit yield were also recorded. Calculation of fruit yield per hectare was also made. Besides, leaf samples at 45 and 75 days after PBZ application were drawn for determining the phytohormonal contents.

Phytohormonal analysis

The phytohormones like gibberellic acid (GA_3) and abscisic acid (ABA) were analyzed following the HPLC procedure of Kelen *et al.* (2004) with modifications. The HPLC system (Model: Prominence, Shimadzu, Japan) was equipped with photodiode array detector (SPD-M20A) and Synergi 4 μm fusion RP-C_{18} column (Phenomenex, USA, 250 X 4.6 mm). The mobile phase consisted of acetonitrile: water (pH 4.0, adjusted with 1.0 M o-phosphoric acid) (30:70, v/v) at 0.8 ml/ min flow rate. The GA_3 and ABA were detected at 200 and 260 nm, with retention times of 6.37 and 16.2 minutes, respectively. The quantification of these phytohormones was carried out using GA_3 and ABA (Sigma-Aldrich, USA) as external standards.

All the data were statistically analyzed according to Panse and Sukhatme (1985) and the difference in the means were compared at 5% level of significance.

RESULTS AND DISCUSSION

Morphological attributes

From the results it was apperant that the morphological attributes like plant height, trunk girth and canopy spread were significatly reduced by pruning alone in cvs Raspuri and Dashehari and by PBZ in all the three cultivars (Table1). However, interaction effects between pruning and PBZ were non-significant. T_1 treatment recorded 62, 52 and 61.5% lesser plant height, 50.2, 27.3 and 35.3% lesser trunk girth and 51.5, 45.8 and 35.3% lesser canopy spread in the cvs Raspuri, Dashehari and Amrapali, respectively followed by T_5 treatment when compared with control (T_6). Length and girth of new shoots also differed significantly among the treatments with PBZ and non-significantly with pruning as well as interaction of pruning and PBZ (Table 2). Raspuri, Dashehari and Amrapali

Table 1: Extents of reduction in vegetative growth parameters in different cultivars of mango by pruning and paclobutrazol application

Treatments	Plant height (m)			Tree girth (cm)			Canopy spread (m)		
	Raspuri	Dashehari	Amrapali	Raspuri	Dashehari	Amrapali	Raspuri	Dashehari	Amrapali
T_1	0.16	0.11	0.10	0.95	1.03	0.93	0.303	0.233	0.188
T_2	0.36	0.25	0.20	1.54	1.16	1.10	0.433	0.458	0.258
T_3	0.26	0.21	0.21	0.90	1.34	0.74	0.333	0.283	0.233
T_4	0.41	0.35	0.36	1.75	1.68	1.16	0.416	0.466	0.291
T_5	0.21	0.13	0.18	1.13	1.11	0.90	0.325	0.266	0.218
T_6	0.43	0.23	0.26	1.91	1.43	1.48	0.626	0.491	0.291
SEM									
Pruning	2.51	4.97	0.2	0.25	0.18	0.1	3.38	4.03	3.24
PBZ	2.00	4.05	0.16	0.21	0.14	0.08	2.76	3.29	2.64
Pruning X PBZ	3.56	7.03	0.28	0.36	0.25	0.14	4.7	5.7	4.58
CD at 5%									
Pruning	7.93	0.15	0.63	0.81	0.57	0.32	0.1	0.12	0.1
PBZ	6.48	0.12	0.51	0.66	0.46	0.26	8.7	0.1	8.33
Pruning X PBZ	0.11	0.22	0.89	1.15	0.81	0.45	0.15	0.17	0.14
Significance at 5 %									
Pruning	21.05	NS	6.29	NS	NS	NS	6.46	4.2	NS
PBZ	58.39	7.3	14.2	9.31	5.38	17.37	36.6	31.4	NS
Pruning X PBZ	NS	NS	NS	NS	NS	NS	NS	NS	NS

*PBZ- paclobutrazol; T_1 – pruning of current season's growth + soil application of PBZ @ 3 ml/m canopy diameter; T_2 – pruning of current season's growth; T_3 – pruning of previous season's growth + soil application of PBZ @ 3 ml/m canopy diameter, T_4 – pruning of previous season's growth; T_5 – no pruning + soil application of PBZ @ 3 ml/m canopy diameter; T_6 – no pruning + no PBZ (control)

Table 2: Extents of reduction in shoot length and shoot girth in different cultivars of mango by pruning and paclobutrazol application

Treatments	Shoot length (cm)			Shoot girth (mm)		
	Raspuri	Dashehari	Amrapali	Raspuri	Dashehari	Amrapali
T_1	16.35	17.45	14.55	6.55	6.86	6.15
T_2	24.98	22.78	18.61	8.39	7.37	7.4
T_3	18.40	20.25	16.60	6.68	6.87	6.65
T_4	26.91	24.63	18.14	8.54	7.86	7.83
T_5	17.51	19.75	16.16	6.57	7.12	6.38
T_6	27.10	26.98	19.80	8.59	8.47	7.23
SEM						
Pruning	0.8	1	0.63	0.2	0.23	0.2
PBZ	0.65	0.81	0.51	0.16	0.19	0.16
Pruning X PBZ	1.13	1.41	0.89	0.28	0.32	0.29
CD at 5%						
Pruning	2.52	3.15	1.99	0.64	0.73	0.65
PBZ	2.06	0.57	1.63	0.52	0.59	0.53
Pruning X PBZ	3.57	4.45	2.82	0.9	1.03	0.92
Significance at 5 %						
Pruning	NS	NS	NS	NS	NS	NS
PBZ	92.49	23.92	20.03	65.97	12.45	21.02
Pruning X PBZ	NS	NS	NS	8.73	0.82	NS

*PBZ- paclobutrazol; T_1 – pruning of current season's growth + soil application of PBZ @ 3 ml/m canopy diameter; T_2 – pruning of current season's growth; T_3 – pruning of previous season's growth + soil application of PBZ @ 3 ml/m canopy diameter; T_4 – pruning of previous season's growth; T_5 – no pruning + soil application of PBZ @ 3 ml/m canopy diameter; T_6 – no pruning + no PBZ (control)

Table 3: combined effects of pruning and paclobutrazol on flowering characters in different cultivars of mango

Treatments	% flowering shoots			Days to 50% flowering			No. of days from flowering to harvest		
	Raspuri	Dashehari	Amrapali	Raspuri	Dashehari	Amrapali	Raspuri	Dashehari	Amrapali
T_1	82.8	91.0	82.8	135.6	142.0	155.0	128.3	138.0	149.0
T_2	42.2	38.0	56.7	159.3	157.3	174.3	148.3	155.6	161.6
T_3	65.2	50.7	61.8	145.6	153.3	162.3	130.3	140.3	150.3
T_4	23.9	30.9	40.4	160.6	166.6	177.3	149.3	159.0	161.0
T_5	79.9	82.1	72.8	138.3	142.3	155.6	128.6	141.0	150.6
T_6	49.4	33.3	46.9	152.6	162.6	174.0	149.0	154.0	165.3
SEM									
Pruning	3.68	2.86	2.59	1.03	1.12	1.35	0.71	0.93	0.90
PBZ	3.01	2.33	2.11	0.84	0.92	1.1	0.58	0.76	0.74
Pruning X PBZ	5.21	4.05	3.66	1.4	1.59	1.91	1.01	1.32	1.28
CD at 5%									
Pruning	11.6	9.02	8.16	3.26	3.55	4.26	2.26	2.94	2.85
PBZ	9.48	7.36	6.66	2.66	2.9	3.48	1.84	2.40	2.33
Pruning X PBZ	16.4	12.76	11.54	4.6	5.03	6.02	3.20	4,16	4.03
Significance at 5 %									
Pruning	8.55	6.48	12.4	18.83	22.7	4.73	NS	NS	NS
PBZ	80.37	72.34	68.0	217.64	99.33	126.22	646.9	232.4	146.4
Pruning X PBZ	NS	NS	NS	NS	NS	NS	NS	NS	NS

*PBZ- paclobutrazol; T_1 – pruning of current season's growth + soil application of PBZ @ 3 ml/m canopy diameter; T_2 – pruning of current season's growth; T_3 – pruning of previous season's growth + soil application of PBZ @ 3 ml/m canopy diameter; T_4 – pruning of previous season's growth; T_5 – no pruning + soil application of PBZ @ 3 ml/m canopy diameter; T_6 – no pruning + no PBZ (control)

trees recorded 39.6, 35.2 and 26.5% decline in shoot length and 23.7, 19.0 and 14.9% decline in shoot girth under T_1, followed by 35.3, 26.7 and 18.3% decline in shoot length and 23.5, 18.8 and 11.7% decline in shoot girth under T_5 treatment as compared to control (T_6). The above results confer the findings of Balamohan and Gopu (2014) in Alphonso that the light pruning of current seasons's growth is advantageous for tree vigour regulation without influencing the flowering. Such growth reduction responses of pruning might be result of decline in photosynthate production by pruning induced decline in total photosynthetic area, delay in leaf development and changes in phytohormonal production and their translocation. Similarly, the growth inhibitory response of PBZ observed in the study are in line with earlier findings of Sarkar and Rahim (2012) and Nafeez *et al.* (2010) in mango and could be consequences of modification in photosynthesis rate (Gonzalez and Blaikie, 2003) and carbohydrates (Upreti *et al.,* 2014) besides reductions in gibberellins (Upreti *et al.,* 2013).Theseresults indicated that the combined treatments of pruning and PBZ was relatively more effective in the regulation of tree vigour as compared to pruning or PBZ treatments alone.

Flowering characters

Effects of pruning and PBZ were significant with respect to percentage flowering shoots and number of days for 50% flowering (Table 3). However their interaction effect was non-significant. T_1 and T_5 treatments were at par with respect to%

Table 4: Combined effects of pruning and paclobutrazol on yield attributes in different cultivars of mango

Treatments	Number of fruits/ plant			Yield /plant (kg)			Yield /ha (tonnes)		
	Raspuri	Dashehari	Amrapali	Raspuri	Dashehari	Amrapali	Raspuri	Dashehari	Amrapali
T_1	103.66	119.33	154.33	21.33	22.08	22.6	4.35	4.50	4.61
T_2	29.33	25.16	87.83	5.4	4.50	13.5	1.10	0.91	2.75
T_3	78.0	84.00	70.66	15.66	12.83	19.5	3.19	2.61	3.97
T_4	9.33	6.66	58.66	1.86	1.19	14.5	0.37	0.24	2.95
T_5	146.66	135.5	149.16	28.08	24.00	20.6	5.72	4.89	4.20
T_6	57.5	96.66	98.33	16.83	15.30	14.0	3.43	3.12	2.85
SEM									
Pruning	16.96	19.87	20.51	3.33	3.33	3.12	0.68	0.68	0.63
PBZ	13.85	16.22	16.74	2.72	2.72	2.55	0.55	0.55	0.52
Pruning X PBZ	23.98	28.10	29.00	4.71	4.71	4.41	0.96	0.96	0.90
CD at 5%									
Pruning	76.01	62.59	64.61	10.50	10.50	9.84	2.14	2.14	2.00
PBZ	62.06	51.11	52.76	8.58	8.58	8.03	1.75	1.75	1.63
Pruning X PBZ	107.49	88.52	91.38	14.86	14.86	13.02	3.03	3.03	2.83
Significance at 5 %									
Pruning	NS	NS	NS	NS	NS	NS	NS	NS	NS
PBZ	15.61	9.33	NS	15.15	15.15	6.7	15.15	9.64	4.98
Pruning X PBZ	9.73	NS	NS	NS	NS	NS	NS	NS	NS

*PBZ- paclobutrazol; T_1 – pruning of current season's growth + soil application of PBZ @ 3 ml/m canopy diameter; T_2 – pruning of current season's growth; T_3 – pruning of previous season's growth + soil application of PBZ @ 3 ml/m canopy diameter; T_4 – pruning of previous season's growth; T_5 – no pruning + soil application of PBZ @ 3 ml/m canopy diameter; T_6 – no pruning + no PBZ (control)

Table 5: Combined effects of pruning and paclobutrazol on hormones in different cultivars of mango (ng/g)

Treatments	GA_3						ABA					
	Raspuri		Dashehari		Amrapali		Raspuri		Dashehari		Amrapali	
	45 days After PBZ	75 days After PBZ	45 days After PBZ	75 days After PBZ	45 days After PBZ	75 days After PBZ	45 days After PBZ	75 days After PBZ	45 days After PBZ	75 days After PBZ	45 days After PBZ	75 days After PBZ
T1	80.77	47.42	135.55	124.25	251.43	78.94	31.4	41.84	3.78	108.62	11.74	26.72
T2	198.65	768.09	190.62	156.73	508.43	521.07	11.6	9.02	1.91	47.26	7.17	19.08
T3	461.32	335.97	150.14	130.25	626.74	332.35	28.76	36.72	2.37	67.48	10.84	19.63
T4	900.07	699.59	212.72	173.99	691.92	588.04	4.16	7.77	2.45	40.06	8.82	12.17
T5	352.47	267.87	150.14	126.82	477.35	298.33	30.91	41.69	3.93	96.23	11.2	25.12
T6	578.61	467.4	185.77	150.14	580.13	531.26	11.74	14.17	2.05	39.43	4.89	16.29
SEM												
Pruning	4.92	7.55	2.39	2.36	7	6.85	0.315	0.33	0.17	1.01	0.23	0.67
PBZ	4.01	6.16	1.95	1.93	5.71	5.59	0.25	0.26	0.13	0.82	0.19	0.54
Pruning X PBZ	6.96	10.68	3.39	3.35	9.9	9.68	0.44	0.46	0.24	1.43	0.33	0.95
CD at 5%												
Pruning	15.5	23.79	7.55	7.46	22.05	21.58	0.99	1.04	0.53	3.19	0.74	2.11
PBZ	12.66	19.42	6.17	6.09	18	17.62	0.81	0.84	0.43	2.61	0.6	1.73
Pruning X PBZ	21.93	33.64	10.68	10.55	31.19	30.51	1.4	1.47	0.76	4.52	1.05	2.99
Significance at 5%												
P	30.6	105.9	41.78	46.02	700.57	19.35	24.38	114.5	11.74	243.38	161.6	51.05
PBZ	21.06	240.9	104.63	283.87	606.92	102.1	82.3	157.5	NS	228.5	482.15	18.3
Pruning X PBZ	27.4	311.2	5.43	60.1	204.79	12.12	58.08	413.3	9.21	465.85	140.03	35.62

*PBZ- paclobutrazol; T_1 – pruning of current season's growth + soil application of PBZ @ 3 ml/m canopy diameter; T_2 – pruning of current season's growth; T_3 – pruning of previous season's growth + soil application of PBZ @ 3 ml/m canopy diameter; T_4 – pruning of previous season's growth; T_5 – no pruning + soil application of PBZ @ 3 ml/m canopy diameter; T_6 – no pruning + no PBZ (control)

flowering shoots and number of days for 50% flowering besides flowering percentage. T_1 advanced the number of days for 50% flowering by 17, 21.3 and 19 days followed by T_5 with 14.3, 20.3 and 18.4 days in the cvs Raspuri, Dashehari and Amrapali, respectively. Among the pruning levels, 50% removal of current season growth induced early flowering than the trees pruned to 50% of the previous season growth. More number of days taken for 50% flowering in severly pruned trees might be because of greater utilization of available carbohydrates for vegetative growth at the expense of flowering and longer time taken to replensih the carbohydrates lost in pruning. Our results are in agreement with Balamohan and Gopu (2014) and Jannoyer (2009), who reported that severe pruning delayed the flowering in mango. Early and intense flowering induced by PBZ may be the consequence of early shoot maturity, increased photosynthetic rate (Singh and Singh 2009), carbohydrate accumulation (Upreti *et al.,* 2014) and declined gibberellin contents (Upreti *et al.,* 2013).

Number of days from flowering to harvest ranged between 128.3-149.3, 138-159 and 149-165.3 days in the cvs.

Rasapuri, Dashehari and Amrapali, respectively under the varied treatments (Table 5), thereby revealing the maintenance of early bearing character of cv. Raspuri and late bearing character of cv. Amrapali under pruning and PBZ treatments. Pruning did not have much influence on number of days from flowering to harvest, however, PBZ significantly reduced the number of days from flowering to harvest in all the cultivars. Besides, the interaction effects of pruning and PBZ were non-sigificant. Such reductions in the number of days from flowering to harvest resulted of early flowering, as witnessed from the observed results. The early flowering advanced the harvesting of fruits by 20.4, 13 and 14.7 days in T_1 followed by 20.7, 16.0 and 16.3 days in T_5 in the cvs Raspuri, Dashehari and Amrapali, respectively when compared with control (T_6). The PBZ induced early flowering and eraly harvesting has been reported by Upreti *et al.* (2013), Abdel Rahim *et al.* (2011), Nafeez *et al.* (2010) and Sarkar and Rahim (2012) in different varieties of mango.

Yield attributes

The PBZ effects were siginificant with respect to fruit number per tree, yield per tree and yield per hectare. However, effects of pruning and interaction of pruning and PBZ were found significant only in Raspuri (Table 4). There were cultivar differences with respect to changes in yield parameters under different treatments. The treatment T_5 recorded 66.8 and 56.9% higher fruit yield followed by T_1 (26.7 and 31.2%) in the cvs Raspuri and Dashehari, respectively. The trees of cvs Raspuri and Dashehari under T_4 treatment recorded lower yields as compared to control. Amrapali recorded 61.4 and 47.1% higher yields under T_1 and T_5 treatments, respectively. The higher yields in the PBZ treated trees is ascribed due to high flowering intensity which resulted from higher fruit number. The higher yields in the PBZ treated trees is ascribed due to high flowering intensity, more number of hermaphrodite flowers, increased fruit set which resulted in higher fruit number. PBZ is reported to exert influence on overall tree physiology through improved nutrient uptake, partitioning photosynthates to the sites of flowering and fruiting, modifying the plant water balance and altering hormonal balance (Sarkar and Rahim, 2012; Upreti *et al.,* 2013). More number of fruits per plant and higher yields with PBZ application has been reported in different mango varieties (Singh and Singh, 2003; Sarkar and Rahim, 2012; Upreti *et al.,* 2013; Reddy *et al.,* 2014).

Hormonal factors

Pruning, PBZ and their interaction effects on GA_3 and ABA contents were significant at 45 and 75 days after PBZ application (Table 3). GA_3 content showed declining trends from 45 to 75 days after PBZ application. T_1 treatment recorded 86%, 26.7% and 86.3% decline by 45 days and 89.8%, 17.3% and 86.3% decline by 75 days followed by T_5 with 60.8%, 19.1% and 17.7% decline by 45 days and 49.6%, 16.% and 43.8 % decline by 75 days after PBZ application in Rasapuri, Dashehari and Amrapali cultivars, respectively when compared with control. PBZ is well documented for its antigibberellin activity (Nafeez *et al.,* 2010). Thus reduction in GA_3 is expected to favour growth reduction as evident from the results. Similar PBZ induced reduction in gibberellins have been reported earlier (Hauser *et al.,* 1990; Abdel Rahim *et al.,* 2011; Upreti *et al.,* 2013) in mango. However we witnessed that the extent gibberellin reduction by PBZ depends upon cultivars and bearing with early bearing variety Raspuri responding greater. Significant increase in ABA content was recorded with PBZ at 45 and 75 days after PBZ application (Table 5). Following PBZ application, ABA levels were increased by 181.8%, 84.3% and 140.8% at 45 days and 196.4%, 176.9% and 64.8 % at 75 days after PBZ application in T_1 followed by 164.1%, 91.7% and 133.3% at 45 days and 192.8%, 146.1% and 54.9% at 75 days after PBZ application in T_5 respectively in the cvs Rasapuri, Dashehari and Amrapali when compared with control. The role of ABA in the induction of floral bud formation has been reported by Chacko (1986). As gibberellins and ABA share common intermediate for their biosynthesis in the isoprenoid pathway, the PBZ induced increase in ABA may be consequence of diversion of biosyntheic intermediate to ABA synthesis in the event of PBZ mediated declined gibberellin synthesis (Abdel Rahim *et al.,* 2011, Upreti *et al.,* 2013). Similar to gibberellins, ABA increase by PBZ depended upon cultivar and bearing habit with maximum response observed in cv. Rasapuri and Dashehari.

From the study, it was concluded that the pruning of trees to current season's growth and PBZ application were vital for regulating tree size, early flowering and advancing fruit harvest in mango and such beneficial effects of treatments were mediated through increases in ABA and decreases in GA_3 contents. It was also observed that the treatment effects have strong dependence on cultivar growth and bearing habit, with early and regular bearing cultivar, Raspuri showing the best response.

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REFERENCES

Abdel Rahim, A. O. S., Osman, M. E. and Fritz, K. B. 2011. Effect of paclobutrazol (PBZ) on floral induction and associated hormonal and metabolic changes of biennially bearing mango (*Mangifera indica* L.) cultivars during off year. *ARPN. J. Agri. Bio. Sci.* **6(2):** 55-67.

Anonymous. 2013. Indian horticulture database. p. 95.

Aron, Y., Monselise, S. P., Goren, R. and Costo, J. 1985. Chemical control of vegetative growth in citrus trees by paclobutrazol. *Hort. Sci.* **20:** 96-98.

Balamohan, T. and Gopu, B. 2014. Canopy management in mango (*Mangifera indica L.*) cv. Alphonso under high density planting system. *National conference on value chain management in mango.* pp. 29-37.

Chacko, E. K.1986. Physiology of vegetative and reproductive growth in mango (*Mangifera indica* L.) trees in: Proceedings of first Australian mango research workshop, CSIRO, Australia, Melbourne. pp. 54-70.

Erez, A. 1984. Dwarfing peaches by pruning and by paclobutrazol. *Acta Hort.* **146:** 235-241.

Gonzalez, A. and Blaikie, S. J. 2003. Seasonal variation in carbon assimilation in mango (cv. Kensington Pride): Effect of flowering treatments. *Australian J. Agric. Res.* **54:** 309-321.

Gurung, N., Swamy, G. S. K., Sarkar, S. K. and Ubale, N. B. 2014. Effect of chemicals and growth regulators on germination, vigour and

growth of passion fruit (*Passiflora edulis* Sims). *The Bioscan*. **9(1):** 155-157.

Hauser, C., Kwiatkowski, J., Rade macher, W. and Gossman, K. 1990. Regulation of endogenous abscissic acid levels and transpirtation in oilseed rape by plant growth retardants. *J. Plant Physiol*. **137:** 201-207.

Jannoyer, M. and Lauri, P. E. 2009. Young flush thinning in mango cv. Cogshall controls canopy density and production. *Acta. Hort*. **820:** 395-402.

Kelen, M., Demiralay, E. C., Sen, S. and Ozkan, G. 2004. Separation of abscisic acid, indole acetic acid and gibberellic acid in 99R (*Vitis berlandieri* x *Vitis rupestris*) and rose oil (*Rosa domascena* Mill) by reverse phase liquid chromatography. *Turkish J. Chemistry*. **28:** 603-610.

Muralidhara, B. M., Reddy, Y. T. N., Shiva Prasad, M. K., Akshitha, H. J. and Kishore Kumar, M. 2014. Studies on foliar application of growth regulators and chemicals on seedling growth of mango varieties. *The Bioscan*. **9(1):** 203-205.

Nafeez, M., Faqueer, M., Ahmad, S., Alam Khan, M., Jamil, M. and Naveed Aslam, M. 2010. Paclobutrazol soil drenching upresses vegetative growth, reduces malformation and increases production in mango. *Int. J. fruit sci.* **10:** 431-440.

Panse, V. G. and Sukhatma, P. V. 1985. *Statistical Methods for Agricultural Workers*. ICAR, New Delhi, pp.145-55.

Reddy, Y. T. N., Upreti, K. K. and Shivu Prasad, S. R. 2014. Response of paclobutrazol treatment on flowering, fruit maturity, yield and quality of mango (*Mangifera indica* L.) cv. Totapuri. *Indian J. Agic. Sci.* **84(10):** 1231-1235.

Sarkar, C. B. and Rahim, M. A. 2012. Vegetative growth, harvesting time, yield and quality of mango *(Mangifera indica L.)* as influenced by soil drench application of paclobutrazol. *Bangladesh J. Agri*. **37(2):** 335-348.

Singh, S. K., Sharma, R. R, Srivastav, M. and Patel, V. B. 2009. Effect of pruning on morpho-physiological parameters and microclimate under high density planting of mango (*Mangofera indica* L.). *Indian J. Agr. Sci*. **79(8):** 632-635.

Singh, V. K. and Singh, A. 2003. Effect of paclobutrazol on regularity of bearing in mango (*Mangifera indica* L.). *Physiol. Mol. Biol. Plants*. **9:** 239-248.

Upreti, K. K., Reddy, Y. T. N., Shivu Prasad, S. R. Bindu, G. V. Jayaram, H. L. and Rajan, S. 2013. Hormonal changes in response to paclobutrazol induced early flowering in mango cv. *Totapuri. Sci. Hort*. **150:** 414-418.

Upreti, K. K., Shivu Prasad, S. R., Reddy, Y. T. N. and Rajeswara, A. N. 2014. Paclobitrazol induced changes in carbohydrates and some associated enzymes during floral initiation in mango (*Mangiferaindica* L.) cv. Totapuri. *Indian J. Plant Physiol*. **19:** 317-323.