Impact of paclobutrazol in flowering, fruiting and quality parameters of mangosteen (*Garcinia mangostana* L.)

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Received on 27 February 2024; received in revised form 30 November 2024, accepted 06 December 2024.

Abstract

Mangosteen (*Garcinia mangostana* L.) known as the queen of fruit, is gaining importance in States, particularly in Kerala. Long juvenile period and irregular bearing are the major problems of mangosteen. Hence a field experiment was undertaken at the College orchard of the Kerala Agricultural University, Vellanikkara during 2021-22 to study the effect of paclobutrazol (PBZ) on induction of flowering and fruiting in mangosteen. The study was conducted in 15 year old mangosteen trees. The design of the experiment was completely randomized design with five treatments and three replications. Four doses of paclobutrazol (viz., T_1: 2.3 g; T_2: 4.6g, T_3: 6.9 g, and T_4: 9.2 g a.i) dissolved in 10 litres of water per tree and control (T_5: water alone) were applied by soil drenching in the tree basins. Observations on various growth, flowering, yield and fruit quality parameters were assessed. It was observed that PBZ application @ 9.2 g ai /tree ie., 40 ml Cultar/tree (T_4) gave the earliest flowering and maximum yield. Other treatments were also effective in induction of early flowering. From the results it was concluded that application of paclobutrazol @ 4.6 g ai /tree (20ml Cultar 23% ai) can be recommended in mangosteen considering the early flowering, yield, and quality attributes of fruit.

Keywords: Flowering, Kerala,Mangosteen,Paclobutrazol, Yield

Introduction

Mangosteen (*Garcinia mangostana*), known as the "Queen of tropical fruits" is a tropical evergreen tree native to Southeast Asia. The fruits are known for its juicy, flavourful flesh. Mangosteen cultivation is increasing in Kerala due to ideal weather conditions and increasing market demand and its health benefits. In Kerala, mangosteen is mainly grown in the districts of Pathnamthitta, Ernakulam, Thrissur and Wayanad districts. However, irregular bearing is experienced in mangosteen. Various plant growth regulators like placobutrazol were found effective to induce early and regular flowering d fruiting in mango (Singh, 2000; and Rane et al., 2005). Hence an experiment was taken up to evaluate the effectiveness of paclobutrazol in mangosteen to induce flowering and fruit set, and to standardize its optimum dose.

Materials and Methods

A field experiment was conducted at the College orchard of the Kerala Agricultural University,

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Vellanikkara during 2021-22 to study the effect of paclobutrazol on induction of flowering and fruiting in mangosteen. The study was carried out in 15 year old mangosteen trees in a completely randomized design with five treatments and three replications. The treatments consisted of four doses of paclobutrazol viz., (T_1: 2.3 g; T_2: 4.6g, T_3: 6.9 g, and T_4: 9.2 g a.i.; dissolved in 10 litres of water per tree) and control (T_5: water alone) applied by soil drenching in the tree basins during October 2021.

The vegetative characters of plants after application of paclobutrazol were observed at monthly interval. The days taken for flowering after PBZ application, number of flowers per cluster and days taken for harvest were recorded. Observations on fruit characters like days to fruit setting, number of days from fruit set to fruit maturity, fruit size (cm), number of seeds per fruit, edible portion/aril content in fruit (%), average fruit weight (g), yield per tree (kg), number of fruits per tree, shelf life of fruits, gamboge infected fruits (%), marketable fruits (%); and quality parameters of fruits were recorded.

Results and discussion

Mean of growth, yield and quality parameters observed along with results of statistical analysis are furnished in tables 1 to 4.

Effect of PBZ on vegetative characters:

Monthly increase in trunk circumference (cm) of trees in the control plants was statistically superior than the PBZ treated trees. Maximum days (94 days) taken for bud break was observed in T_5 (control) whereas the PBZ treated plants shown early bud break (74.70 days, 74.30 days, 72.73days and 70.86 days in T_1, T_2, T_3 and T_4 respectively). Days taken for flushing also differed significantly among the treatments. Minimum days taken for flushing was observed in T_4 (167.33 days) and it was statistically on par with the treatments T_3 (174.33) and T_5 (174.33). The maximum days taken for flushing was observed in T_2 (187.16 days) and it was on par with treatment T_1 (186.50 days) (Table 1).

Monthly increase in shoot growth (cm) from December 2021 to June 2022 (Table 1) shown significant difference among the treatments. Highest rate of shoot growth was observed in untreated control T_5 (2.01 cm) and the lowest rate in plants applied with the highest PBZ dose T_4 (1.11 cm). These results support observations made in mango by Singh (2000), which revealed that paclobutrazol was effective in reducing tree vigour and enhancing blooming, fruit set and production. Inhibiting the oxidation of kaurene to kaurenoic acid in the GA biosynthesis pathway was found to be the primary cause of vegetative growth and the relative concentration of gibberellin and cytokinin determines the fate of the shoot. The GA3 in the shoots of PBZ-treated mango trees significantly decreased after two months, according to Protacio et al. (2000).

Effect of PBZ on flowering characters:

Days to first flowering after PBZ application shown significant differences among treatments when compared to untreated control T_5 (127.33 days). The earliest flowering was observed in plants applied

Table 1. Mean days to bud break and flushing and growth of shoots (cm)

Treatment	Days to bud break	Days taken for flushing	Growth of shoot (cm)						
			Dec 2021	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022
T_1	74.70^{b}	186.50^{a}	0.31^{cd}	0.45^{b}	0.60^{b}	0.66^{c}	0.82^{c}	0.96^{b}	1.24^{c}
T_2	74.30^{b}	187.16^{a}	0.41^{bc}	0.46^{b}	0.85^{ab}	1.13^{ab}	1.22^{ab}	1.25^{ab}	1.61^{b}
T_3	72.73^{b}	174.33^{b}	0.26^{d}	0.69^{a}	0.91^{ab}	0.95^{bc}	1.09^{bc}	1.31^{ab}	1.29^{c}
T_4	70.86^{b}	167.33^{b}	0.56^{a}	0.67^{a}	0.73^{b}	0.84^{bc}	0.91^{bc}	0.98^{b}	1.11^{c}
T_5	94.00^{a}	174.33^{b}	0.55^{ab}	0.68^{a}	1.22^{a}	1.42^{a}	1.54^{a}	1.61^{a}	2.01^{a}
CD (0.05)	7.99	9.22	0.14	0.13	0.37	0.42	0.37	0.37	0.31
CV%	5.68	2.85	18.75	12.22	24.09	0.34	18.40	16.98	12.05
SE(m) +	2.53	2.92	0.04	0.04	0.12	19.01	0.11	0.11	0.10

with the highest doze of PBZ (T_4, 100.66 days) and the rest three viz., T_3 (107.33 days), T_1 (112.66 days) and T_2 (112 days) treatments were on par. Days taken to complete the flowering phase from PBZ application also differed significantly. The maximum duration for flowering phase was observed in T_5 (untreated control, 168.33 days). The flowering phase was completed with minimum of 151.66 days in T_4 which was significantly the lowest when compared to all other treatments. Total duration of flowering phase did not show statistical difference. The flowers per cluster also differed significantly among the treatments. Maximum number of flowers per cluster was observed in T_4 (2.63) and all other treatments were on par with each other. In general, it was observed that the PBZ application significantly retarded vegetative growth, induced early flowering, reduced the duration of flowering phase and increased flowers per cluster (Table 2).

Mabvongwe (2016) reported that the plant growth regulator paclobutrazol has the ability to shorten new shoots,' distances between nodes, accelerate the development of terminal buds, and trigger flowering. In addition to flower induction, PBZ was also successful in inducing early and off-season flowering in mango (Christov et al., 1995; Burondkar et al., 2013). It was reported that early flowering by application of paclobutrazol was due to increase in C:N ratio (Upreti et al., 2013). This was due to increase in ABA and cytokinins and decline in gibberellins GA1, GA3, GA4 and GA7 in buds. The results of the present study are also in agreement with observations of Patel et al. (2016), where PBZ reduced the vegetative growth of mango by antagonizing the gibberellin action and it may be the reason for reduction in duration of flowering phase.

Table 2. Mean of flowering characters after application of PBZ

Treatment	Days taken for first flowering	Days taken for last flowering	Duration of flowering	Flowers/ cluster
T_1	112.66^{b}	160.00^{bc}	47.33	1.60^{b}
T_2	112.00^{bc}	165.16^{ab}	53.16	1.74^{b}
T_3	107.33^{bc}	155.50^{cd}	48.16	1.34^{b}
T_4	100.66^{c}	151.66^{d}	53.66	2.63^{a}
T_5	127.33^{a}	168.33^{a}	41.00	1.46^{b}
SDP-0.05	11.85	7.82	NS	0.55
CV%	5.81	2.58	17.41	17.49
SE(m) +	3.76	2.38	4.89	0.17

Effect of PBZ on fruit characters of mangosteen

Effect of PBZ treatments on fruit characters are presented in Table 3. Days taken for fruit set was significantly maximum in untreated control T_5 (132.66 days) whereas all other treatments applied with PBZ took lesser time and were statistically at par with each other. Days taken for fruit set in PBZ treated plants varied from 113 days (T_4), 117 days (T_3) and 118 days (T_1, T_2).

All PBZ treated trees were statistically on par and early for fruit harvest (189 days in T_4 to 191.33 days in T_1 and T_3) and the control plants (T_5) were significantly late for harvest (198.33 days). Days taken from fruit set to maturity did not vary statistically. Fruit size in terms of diameter was maximum in T_3 (6.27 cm). Fruit diameter in T_1 (5.39 cm) and T_2 (5.47cm) were on par; and that of T_4

Table 3. Effect of PBZ on fruit characters for different treatments

Treatment	Days@ taken for fruit set	Days@ taken for harvesting	No. of days from fruit set to fruit maturity	Fruit size (mm)	Average fruit weight (g)	No. of arils/ fruit	Number of seeds/ fruit	Shelf life of fruits	Number of fruits per tree	Yield per tree (kg)
T_1	118.16^{b}	191.33^{b}	73.16	53.97^{bc}	84.60^{b}	5.93	1.58^{bc}	16.77^{bc}	189.33^{b}	14.19^{bc}
T_2	118.33^{b}	190.66^{b}	72.33	54.7^{b}	88.12^{b}	5.99	2.03^{a}	16.72^{bc}	203.50^{a}	16.81^{ab}
T_3	117.00^{b}	191.33^{b}	74.33	62.8^{a}	104.84^{a}	6.04	1.78^{ab}	21.05^{ab}	171.50^{c}	16.79^{ab}
T_4	113.00^{b}	189.00^{b}	76.00	50.8^{d}	89.11^{b}	5.78	1.41^{bc}	21.82^{a}	203.70^{a}	19.27^{a}
T_5	132.66^{a}	198.33^{a}	65.66	51.7^{cd}	80.69^{b}	5.80	1.35^{c}	13.71^{c}	143.67^{d}	11.93^{c}
LSD0.05	11.74	5.29	NS	2.66	8.56	NS	0.43	4.80	6.86	2.88
CV%	5.38	1.51	8.97	2.66	5.26	2.08	14.57	14.64	2.06	10.03
SE(m) +	3.72	1.68	3.74	0.84	2.71	0.07	0.13	1.52	2.17	0.91

Figure 1. Fruits from different treatments

and T_5 were also on par with each other (5.07cm and 5.17 cm). Average fruit weight differed significantly among the treatments and was maximum in T_3 (104.84 g) and all other treatments were on par (varying from 80.69g T_5 to 89.11g in T_4). Fruits of all treatments had uniform deep purple color at time of harvest maturity. Number of arils per fruit varied from 5.80 to 6.04 in different treatments and it did not vary significantly. Number of seeds per fruit also differed significantly- T_2 and T_3 had significantly higher number of seeds (2.03 and 1.78 respectively) whereas the lowest was in control T_5 (1.35) which was on par with T_4 (1.41) and T_1 (1.58). Percentage of edible portion (aril content) of fruits varied significantly among the treatments- T_2 and T_3 had maximum percentage of arils (35.17 and 32.85) and they were significantly superior and on par with each other. The minimum aril content was observed in T_1 (25.26%) (Fig. 1 and 2). Shelf life of fruits indicated that T_3 and T_4 had the highest shelf life of 21.05 and 21.82 days respectively. Shelf life of fruits in T_5 control (13.71 days) was the lowest and it was at par with lower doses of PBZ, T_1 and T_2 (16.77 and 16.72 days). Total number of fruits per tree was maximum in T_2 (203.50) and T_4 (203.70 fruits) the untreated control trees (T_5) had the minimum number of fruits (143.66). These results were in accordance with that of Omran and Semiah, (2006). In comparison to the control, they found that foliar treatments of potassium nitrate or bicomine promoted mangosteen flowering and fruiting. The treatments had no discernible variations in total yield. Compared to the other treatments, the fruit size from foliar PBZ

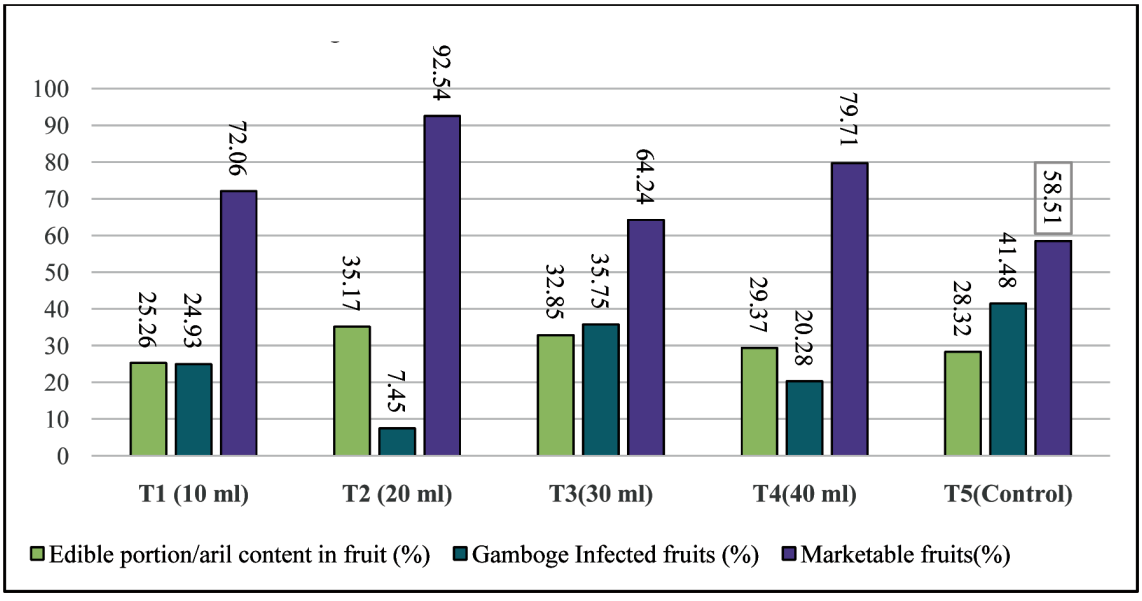

Figure 2. Effect of PBZ on fruit characters

+ Bicomine treated trees was noticeably smaller. This decrease in average fruit weight may be due to the greater quantity of fruits produced by each tree. Total yield of fruits was maximum for T_4 (19.27 kg) and the lowest was for control T_5 (11.93). Yield of T_4, T_3, T_2 (19.27, 16.79, 16.80) were on par with each other. Percentage of gamboge infected fruits (Fig. 1) also varied significantly among the treatments. The lowest gamboge infection was observed in T_2 (7.45%) and significantly maximum in T_3 and T_5 (35.75%, 41.48%) and they were on par with each other. The maximum percentage of marketable fruits (Fig. 1) was obtained from T_2 (92.5%) and the lowest from control T_5 (58.51%). Increase in flower bud differentiation and fruit set in mango by application of cultar was reported earlier by Singh, (2000). It was found that foliar spray and soil drenching of cultar on mango cv. Dushehari promoted flowering and fruit set, and increased yield. Rane et al. (2005) reported that the application of paclobutrazol to mango trees resulted in higher fruit yield and these trees started bearing fruits every year.

Quality parameters of fruits:

Qualitative characteristics of fruits are presented in Table 4. The lowest TSS was observed in T_3 (13.67) and all other treatments were on par (14.31 for T_5 to 14.61 for T_1). The lowest level of acidity was observed in T_2 (0.5%) and the highest in T_3 (0.73%). Acidity of T_1 (0.6 %), T_4 (0.57%) and T_5 (0.63%) were on par with each other. These results were consistent with results from Jain et al. (2002) and Burondkar et al. (2013) that paclobutrazol treatment improved the fruit quality of mango and lemon by increasing TSS and acid content. In contrast, paclobutrazol did not demonstrate any improvement in fruit quality in grapes (Intrieri et al. 1986) or citrus (Monselise 1986). This indicated the effectiveness of PBZ on fruit quality is very specific on the dosage and the crop. Reducing sugar of fruit pulp was not significantly influenced by the treatments and it ranged from 3.04 % in T_3 to 3.54% in T_4. Non reducing sugar of fruit pulp differed significantly among the treatments, and was the lowest in T_4 (8.7%) and in T_5 (9.11%) and these treatments were on par with each other. The highest content of non-reducing sugars was obtained in T_2 (10.07%) and T_1 (9.88%) and they were on par with each other. This showed the superiority of fruit quality parameters with application of PBZ. Research conducted by Kumar et al., (2019) indicated that PBZ doses has positive effect on total sugars but non-reducing sugar was non-significant among the treatments of paclobutrazol. In the current investigation, there were substantial differences in the total sugar concentration of fruit pulp- T_2 (14.23%) and T_1 (13.16%), had the highest total sugar content, and they were on par with each other. Vitamin C content of fruit pulp among the treatments showed significant difference. The maximum vitamin C was observed in T_4 (17.55 mg/100g) followed by T_5 (17.32 mg/100g) and they were on par. The T_1 showed the lowest (13.71 mg/100g) value. T_2 and T_3 had vitamin C content of 16 mg/ 100g. This finding was in accordance with report by Kumar et al. (2019)- the maximum vitamin C (16.56 mg/100g) content was found in treatment of PBZ with dosage of 30 ml/ tree and 35 ml/ tree (T_5) and minimum (14.43 mg/100g) in control.

Table 4. Qualitative characters of fruits

Treatment	TSS (° Brix)	Acidity (%)	Reducing sugar (%)	Non- reducing sugar (%)	Total sugar	Vitamin C (mg/ 100g)
T_1	14.61^{a}	0.60^{bc}	3.34	9.88^{ab}	13.16^{ab}	13.71^{c}
T_2	14.42^{a}	0.50^{c}	3.31	10.92^{a}	14.23^{a}	16.00^{b}
T_3	13.67^{b}	0.73^{a}	3.04	10.07^{ab}	13.10^{ab}	16.00^{b}
T_4	14.35^{a}	0.57^{bc}	3.54	8.70^{c}	12.26^{b}	17.55^{a}
T_5	14.31^{a}	0.63^{b}	3.37	9.11^{bc}	12.49^{b}	17.32^{a}
LSD	0.59	0.1	NS	1.14	1.19	1.31
CV%	2.28	9.21	13.37	6.47	5.02	4.49
SE(m) +	0.18	0.03	0.25	0.36	0.37	0.41

Conclusion

Results of the study in mangosteen indicated that paclobutrazol application had a suppressing action on vegetative characters, while it induced early flowering, fruit set and fruit maturity, higher yield and fruit quality parameters. PBZ application @ 9.2 g ai /tree (40ml Cultar 23.00% w/w ai ie., T_4) was effective to induce early flowering and high yield. PBZ dose of 4.6 g ai /tree (20 ml Cultar 23.00% w/w applied in T_2) was the most superior considering the early flowering, yield and quality attributes of fruits in mangosteen and also considering the cost economics.

Acknowledgement

Facilities and financial assistance provided by the Kerala Agricultural University for conducting this research work as a part of M.Sc. research programme of the first author at College of Agriculture , Vellanikkara is acknowledged.

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