Original Research Article

Influence of paclobutrazol and potassium nitrate on vegetative growth, leaf nutrient status, flowering and yield of mango (*Mangifera indica* L.) cv. Amrapali planted under different spacing

ABSTRACT

A field experiment was conducted to study the effect of paclobutrazol and potassium nitrate on the vegetative growth, nutrient mobilisation to leaves, flowering and fruit yield of Amrapali mango (*Mangifera indica* L.) plants grown under different plant spacings at Horticultural Research Station, OUAT, Bhubaneswar during 2018-19 and 2019-20**.** The experiment was laid out in a Factorial Randomized Block Design with 24 treatment combinations and 2 replications. The treatment combinations consist of four levels of spacings (2.0 x 2.0 m, 4.0 x 2.0 m, 4.0 x 4.0 m, 8.0 x 2.0 m) and 6 levels of chemical treatments (Paclobutrazol@0.25, 0.50 and 0.75 g a.i. per meter of canopy spread and KNO_3@ 2% and 4%) and a control with water application. The results of the study revealed that the plants spaced at 2.0 x 2.0 m recorded minimum vegetative growth except plant height and maximum yield (t/ha) in comparison to the plant spacing of 4.0 x 2.0 m, 4.0 x 4.0 m, 8.0 x 2.0 m. Among chemical treatments paclobutrazol irrespective of its concentration significantly reduced vegetative growth, increase flowering intensity and yield. There was a reduction in leaf N, P and K contents and increase in total leaf chlorophyll content in the plants treated with Paclobutrazol. Higher concentration of Paclobutrazol (0.75 g a.i.) reduced the yield. Whereas KNO_3 increase the vegetative growth, leaf biochemical status, flowering intensity and yield. But the increase in yield of mango plant due to Paclobutrazol treatment @ 0.50 g a.i. and 0.25 g a.i. was significantly higher than KNO_3 at both the applied concentration. Hence, soil drenching of paclobutrazol at 0.50 g a.i. per meter of canopy spread irrespective of plant spacing during September seems recommendable for regulating tree size and enhancing yield in mango cv. Amrapali planted under higher densities.

Key words: Mango, planting density, paclobutrazol. potassium nitrate, growth, leaf nutrient content and yield

1. INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most important commercial fruits of India. It belongs to the family Anacardiaceae and originated in Indo-Myanmar region. It is grown in an area of 2.317 million ha with a production of 20.386 million tons [1]. Although, India is still by and large the major producing country and accounts for more than 60 per cent of world production, the highest production in India is by virtue of large area but not due to high productivity. The productivity of mango in India is 6.8 tonnes/ha which is very less compared to Israel's productivity (30 tonnes/ha) [1].

To overcome low productivity due to alternate bearing, a distinctly dwarf and regular bearing variety 'Amrapali' was introduced in 1971. In mango, the concept of high-density planting has gained momentum after the development of cultivar Amrapali. Further, mango under tropical conditions like Odisha is bound to grow vegetatively and can affect the reproductive phase particularly in high density planting systems if not regulated properly. So, in the high-density plantation of fruit crops, controlling tree vigour and canopy size are important for enhancing the orchard efficiency and productivity without causing injury to plants.

Chemically induced manipulations in vegetative growth have been attempted in many fruit crops [2, 3]. Among the chemicals suggested, paclobutrazol is considered as one of the important plant growth retardants which restrict vegetative growth and induce flowering in many fruit species including mango [4]. Paclobutrazol (PBZ) is a cell elongation and internode extension inhibitor that retards plant growth by inhibition of gibberellins biosynthesis. Gibberellins have the ability to mobilize carbohydrate thereby preventing starch accumulation. Once GA level falls below a threshold, starch can start to accumulate allowing the tree's competence to flower to be expressed.

In mango temperature plays an important role in floral induction. Temperatures below 15°C readily promote floral induction, whereas vegetative growth is generally promoted by warmer temperatures [5]. Decrease in temperature below 20^0 C, which is common in sub-tropical regions but seldom occurs in many tropical ones. So, an alternative to dependence on the environmental stimulus for flower initiation is evolving management strategies substitute for these signals. Among different strategies evolved to induce flowering in mango crop as a substitute to environment signals, potassium nitrate application is effective not only in flower induction but also in early and offseason flower induction in mango [6, 7]. The influence of Paclobutrazol (PBZ) and potassium nitrate on growth, flowering and fruiting on mango cv. Amrapali has not been studied under Odisha condition.

Keeping the above facts in view the present investigation was conducted to study the influence of paclobutrazol and potassium nitrate on vegetative growth parameters, leaf nutrient status, flowering and yield of mango (*Mangifera indica* L.) cv. "Amrapali" planted under different spacing.

2. MATERIALS AND METHODS

The experiment was conducted during 2018-19 and 2019-20 in the Horticulture Research Station, Baramunda, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha. The Horticulture Research Station is about 5 km away from OUAT campus, Bhubaneswar situated at an latitude of 20^0 16' N and longitude of 85^0 47' E with an altitude of 25.5 m above MSL and about 40 km away from Bay of Bengal. The soil was sandy loam, strongly acidic in reaction and had low organic carbon (< 0.5%) and N content (< 200 kg ha^{-1}). The experiment was carried out on a 8-year-old existing bearing mango orchard (cv. Amrapali) planted under different density and uniform in vigour and canopy spread. The experiment was laid out in a Factorial Randomized Block Design with 24 treatment combinations and 2 replications. The treatment combinations consist of four levels of spacings (2.0 x 2.0 m, 4.0 x 2.0 m, 4.0 x 4.0 m, 8.0 x 2.0 m) and 6 levels of chemical treatments (Paclobutrazol @ 0.25, 0.50 and 0.75 g a.i. per meter of canopy spread and KNO_3@ 2% and 4%) and a control with water application.

The quantified amount of PBZ (Lustar- 28% w/w) was dissolved in 20 litres of water and applied around the root zone by making a ring of 20 cm width and 10-15 cm depth with a radius of 1.5 m from the trunk during 1st week of September 2018 and 2019. For preparation of KNO_3 solution @ 2 % and 4 %, 20 g and 40 g KNO_3 dissolved in one litre of water. Foliar spray of prepared solution of KNO_3 as per the treatments were done to the undersides of leaves using tractor operated sprayer because of the high numbers of stomata on the lower surface [8] during1st week of November and again in 1st week of December, 2018 and 2019. The control trees were treated with water. All the trees were provided with standard orchard management practices including nutrient and pest management.

The vegetative growth parameters viz., tree height, trunk girth, canopy spread in both directions of North-South and East-West (cm) were measured after harvest of the fruits in the month of July before initiation of the experiment and after one year of imposition of treatments in four representative plants in each treatment and average was calculated. The height of tree was measured from the graft union to the highest crown level with the help of pre marked bamboo pole and expressed in meters. The trunk girth was measured with the help of measuring tape at 30 cm above from the base and expressed in centimeter. Canopy spread was measured by taking horizontal distance from one end of the canopy to the other end in both directions viz. North-South and East- West with the help of pre marked bamboo pole and expressed in meters. The increase in tree height, girth and canopy spread within an experimental year was expressed as percentage of increase over each year.

The chlorophyll contents (total chlorophyll) of the leaves were analysed before floral bud initiation i.e., 1st week of December, following the method as suggested by Barnes *et al.* [9]. Number of panicles produced per square meter of canopy area was measured by placing a bamboo square block of one meter area on the tree at four different points and the number of inflorescences present within each block was counted during January and the average worked out. From the data of yield per plant, the average yield per hectare in tons was worked out.

Leaf samples collected before flowering from each treatment were used for the study of nutrient status of mango plant. Four to seven months old leaves with petiole from middle of shoots were collected for analysis of foliar nutrient composition of mango [10]. After collection, the leaves were washed in 0.2% teepol, followed by 0.1 N HCl, distilled water and finally in double distilled water to remove dust. The samples were oven dried at 68 ± 2 ^{0}C and grounded in a plant sample grinder to a fine powder and kept in polythene packets for analysis of the nutrients. For the analysis of total N, the samples were digested at 200 ^{0}C (after pre-digestion) in concentrated H_2SO_4 with a mixture of K_2SO_4 + catalyst. The leaf nitrogen was estimated by using Kjeldahl digestion and distillation method [11]. For the analysis of leaf P, the samples were digested in di-acid mixture of HNO_3 and $HClO_4$ in the ratio of 3:2 followed by spectrophotometric determination [11]. The leaf potassium was estimated digestion with di-acid mixture of HNO_3 and $HClO_4$ in the ratio of 3:2 followed by flame- photometric determination [11]. The statistical analysis was carried out as per Factorial Randomized Block Design suggested by [12]. The level of significance was tested for different variables at 5 per cent level of significance.

3. RESULTS AND DISCUUSSION

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3.1 Effect of different plant spacing and chemical treatment on vegetative parameters

The pooled data presented in Table 1 revealed that the percentage increase in plant height of mango was significantly influenced by the different plant spacing. The maximum percentage increase in plant height was recorded in plants spaced at 2.0 x 2.0 m (9.46%) and the minimum was recorded in 4.0 x 4.0 m (6.97%). The present results are in conformity with the findings of Nath *et al.* [13]. Among the different chemical treatments, maximum percentage increase in plant height was recorded in KNO_3 4% spray (10.83 %) which was significantly superior to rest of the treatments and the minimum percentage increase in plant height was recorded with application of paclobutrazol at 0.75 g a.i. (5.56%). Similar results were earlier obtained by Kurian *et al.* [14], Yeshitela *et al.* [15] and Hegazi *et al.* [16].

Table 1. Influence of PBZ and KNO_3 on vegetative growth parameters of mango cv. Amrapali planted under different spacing (Pooled mean of 2018-19 and 2019-2020)

Treatments	Percentage increase in plant height	Percentage increase in trunk girth	Percentage increase in canopy spread (E-W)	Percentage increase in canopy spread (N-S)
Spacing (S)				

S_1: 2m x 2 m	9.46	5.50	9.65	10.01
S_2: 4m x 2m	8.82	6.18	12.02	9.36
S_3: 4m x 4m	6.97	6.91	13.95	14.46
S_4: 8m x 2m	8.03	6.71	12.62	9.30
S.E m±	0.06	0.02	0.08	0.09
C.D. at 5%	**0.18**	**0.07**	**0.23**	**0.26**
Chemical(C)				
C_1: (PBZ @ 0.25 g a.i./m of canopy area)	7.67	5.79	11.03	9.86
C_2: (PBZ @ 0.50 g a.i./m of canopy area)	6.46	5.47	10.10	9.03
C_3: (PBZ @ 0.75 g a.i./m of canopy area)	5.56	5.04	9.12	8.15
C_4: (2% KNO_3)	10.37	7.44	14.59	13.05
C_5: (4% KNO_3)	10.83	7.67	15.21	13.60
C_6: (Control - water application)	9.02	6.50	12.31	11.02
S.E m±	0.05	0.03	0.10	0.11
C.D. at 5%	**0.13**	**0.08**	**0.28**	**0.32**
Interaction: Spacing (S) x Chemical (C)				
S_1C_1: (2m×2m & 0.25 g a.i. PBZ)	8.73	5.03	8.82	9.15
S_1C_2: (2m×2m & 0.50 g a.i. PBZ)	7.34	4.75	8.09	8.39
S_1C_3: (2m×2m & 0.75 g a.i. PBZ)	6.32	4.39	7.30	7.57
S_1C_4: (2m×2m & 2% KNO_3)	11.79	6.50	11.67	12.12
S_1C_5: (2m×2m & 4% KNO_3)	12.30	6.67	12.17	12.63
S_1C_6: (2m×2m & water application)	10.25	5.65	9.85	10.23
S_2C_1: (4m×2m & 0.25 g a.i. PBZ)	8.12	5.66	10.99	8.55
S_2C_2: (4m×2m & 0.50 g a.i. PBZ)	6.84	5.34	10.07	7.84
S_2C_3: (4m×2m & 0.75 g a.i. PBZ)	5.88	4.91	9.09	7.08
S_2C_4: (4m×2m & 2% KNO_3)	11.01	7.31	14.55	11.32
S_2C_5: (4m×2m & 4% KNO_3)	11.48	7.50	15.16	11.79
S_2C_6: (4m×2m & water application)	9.57	6.35	12.28	9.56
S_3C_1: (4m×4m & 0.25 g a.i. PBZ)	6.43	6.32	12.75	13.22
S_3C_2: (4m×4m & 0.50 g a.i. PBZ)	5.42	5.97	11.68	12.11
S_3C_3: (4m×4m & 0.75 g a.i. PBZ)	4.67	5.51	10.54	10.93
S_3C_4: (4m×4m & 2% KNO_3)	8.68	8.16	16.88	17.51
S_3C_5: (4m×4m & 4% KNO_3)	9.06	8.38	17.59	18.25
S_3C_6: (4m×4m & water application)	7.55	7.10	14.24	14.77
S_4C_1: (8m×2m & 0.25 g a.i. PBZ)	7.41	6.15	11.54	8.50
S_4C_2: (8m×2m & 0.50 g a.i. PBZ)	6.24	5.80	10.58	7.79
S_4C_3: (8m×2m & 0.75 g a.i. PBZ)	5.37	5.35	9.54	7.02
S_4C_4: (8m×2m & 2% KNO_3)	10.02	7.93	15.27	11.26
S_4C_5: (8m×2m & 4% KNO_3)	10.45	8.15	15.93	11.74
S_4C_6: (8m×2m & water application)	8.71	6.90	12.89	9.50
S.E m±	0.09	0.06	0.18	0.22
C.D. at 5%	**0.26**	**0.18**	**0.55**	**0.64**

The interaction effect of spacing and chemical treatment showed that there was significant difference among various treatment combinations. The maximum percentage increase in plant height was recorded in the plants planted at a spacing of 2m×2m and treated with 4% KNO_3 (12.30%) and the minimum was recorded in the plants planted at 4m×4m and treated with 0.75 g a.i. PBZ (4.67%). Sagar *et al.* [17] also observed lowest increase in plant height at higher dose of PBZ and in lower plant density.

Highest percentage increase in trunk girth of the plant was observed in the plants planted at a spacing of 4.0 x 4.0 m (6.91%) and the minimum percentage increase in trunk girth was noticed in 2.0 x 2.0 m (5.50 %). These results are in line with Kumar and Singh [18] in Allahabad Safeda guava. Among the different concentrations of chemical treatment, the maximum percentage increase in trunk girth was recorded in the plants applied with KNO_3 @ 4% (7.67%) and the minimum percentage increase in trunk girth was recorded in the plants treated with paclobutrazol at 0.75 g a.i. (5.04%). Nafees *et al*. [19] found that paclobutrazol was effective in suppressing trunk growth compared to control trees of mango. The interaction effect of spacing and chemical treatment showed significant effect on the above parameter. The maximum percentage increase in trunk girth was recorded in the plants planted at a spacing of 4m×4m and treated with 4% KNO_3 (8.38%).

The plant spread was also influenced by the spacing and chemical treatments. The highest percentage increase in plant spread in the East-West (13.95%) and North-South (14.46%) direction was noticed in the plants spaced at 4.0 x 4.0 m and the minimum plant spread in E-W direction was recorded in 2.0 x 2.0 m (9.65%) and in N-S direction was recorded in 8.0 x 2.0 m (9.30%). Similar results were earlier obtained by Bharad *et al*. [20] and Singh *et al*. [21]. Among the treatments of different chemicals, the maximum percentage increase in plant spread was noticed in plants applied with KNO_3 @ 4% (15.21% E-W and 13.60% N-S) and the minimum was recorded in the plants applied with paclobutrazol @ 0.75 g a.i. (9.12% E-W and 8.15% N-S). Interaction data revealed that the maximum percentage increase in canopy spread was recorded in the plants planted at a spacing of 4m×4m and treated with 4% KNO_3 (17.59% E-W and 18.25% N-S), The results are in conformity with the findings of Hegazi *et al*. [16].

It is generally expected that in closer spacing, plants will have tendency to grow tall, lower trunk girth and canopy spread. Increase in height might be due to competition for light because of insufficient space. Increase in vegetative growth by KNO_3 might be due to the fact that potassium is involved in protein and carbohydrate metabolism which leads to cell enlargement and trigger the growth of meristematic tissue Mengel *et al*. [22]. Paclobutrazol minimize the plant height, trunk girth, canopy spread. This might be due to gibberellic acid

Table 2. Influence of PBZ and KNO_3 on leaf nutrient content of mango cv. Amrapali planted under different spacings (Pooled mean of 2018-19 and 2019-20)

Treatments	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Spacing (S)			
S_1: 2m x 2 m	1.36	0.12	0.54
S_2: 4m x 2m	1.52	0.15	0.61

S_3: 4m x 4m	1.68	0.19	0.81
S_4: 8m x 2m	1.66	0.17	0.78
S.E m±	0.04	0.003	0.014
C.D. at 5%	**0.10**	**0.010**	**0.041**
Chemical(C)			
C_1: (PBZ @ 0.25 g a.i./m of canopy area)	1.50	0.15	0.63
C_2: (PBZ @ 0.50 g a.i./m of canopy area)	1.39	0.14	0.58
C_3:(PBZ @ 0.75 g a.i./m of canopy area)	1.33	0.12	0.56
C_4: (2% KNO_3)	1.71	0.18	0.81
C_5: (4% KNO_3)	1.78	0.19	0.82
C_6: (Control - water application)	1.60	0.17	0.72
S.E m±	0.04	0.004	0.018
C.D. at 5%	**0.13**	**0.012**	**0.050**
Interaction: Spacing (S) x Chemical (C)			
S_1C_1: (2m×2m & 0.25 g a.i. PBZ)	1.32	0.11	0.50
S_1C_2: (2m×2m & 0.50 g a.i. PBZ)	1.22	0.10	0.46
S_1C_3: (2m×2m & 0.75 g a.i. PBZ)	1.17	0.09	0.44
S_1C_4: (2m×2m & 2% KNO_3)	1.49	0.14	0.64
S_1C_5: (2m×2m & 4% KNO_3)	1.54	0.15	0.65
S_1C_6: (2m×2m & water application)	1.40	0.13	0.57
S_2C_1: (4m×2m & 0.25 g a.i. PBZ)	1.47	0.14	0.56
S_2C_2: (4m×2m & 0.50 g a.i. PBZ)	1.36	0.13	0.52
S_2C_3: (4m×2m & 0.75 g a.i. PBZ)	1.30	0.11	0.49
S_2C_4: (4m×2m & 2% KNO_3)	1.67	0.17	0.72
S_2C_5: (4m×2m & 4% KNO_3)	1.75	0.18	0.73
S_2C_6: (4m×2m & water application)	1.56	0.16	0.64
S_3C_1: (4m×4m & 0.25 g a.i. PBZ)	1.62	0.17	0.74
S_3C_2: (4m×4m & 0.50 g a.i. PBZ)	1.50	0.17	0.69
S_3C_3: (4m×4m & 0.75 g a.i. PBZ)	1.43	0.14	0.66
S_3C_4: (4m×4m & 2% KNO_3)	1.85	0.21	0.95
S_3C_5: (4m×4m & 4% KNO_3)	1.94	0.22	0.97
S_3C_6: (4m×4m & water application)	1.73	0.20	0.85
S_4C_1: (8m×2m & 0.25 g a.i. PBZ)	1.60	0.16	0.72
S_4C_2: (8m×2m & 0.50 g a.i. PBZ)	1.48	0.15	0.66
S_4C_3: (8m×2m & 0.75 g a.i. PBZ)	1.43	0.13	0.64
S_4C_4: (8m×2m & 2% KNO_3)	1.82	0.19	0.92
S_4C_5: (8m×2m & 4% KNO_3)	1.90	0.20	0.94
S_4C_6: (8m×2m & water application)	1.70	0.18	0.82
S.E m±	0.09	0.009	0.035
C.D. at 5%	**NS**	**NS**	**NS**

suppressing nature of paclobutrazol. It is known that gibberellins promote cell division and cell elongation Murti *et al*. [23].

3.2 Effect of different plant spacing and chemical treatment on leaf nutrient status

Plant spacing and chemical treatment (PBZ and KNO_3) had significant influence on leaf nutrient content. The maximum leaf N, P, K was found in plants spaced at 4.0 x 4.0 m (1.66 % N, 0.19 % P and 0.81% K) and the minimum leaf nutrient content was recorded in

2.0 x 2.0 m (1.36% N, 0.12 % P and 0.54% K). Nautiyal *et al*. [24] also observed that, among plant spacing nitrogen content of leaves increase with increase in plant density in guava cv Pant Prabhat. Kumar *et al.* [25] also observed that, maximum leaf phosphorus and potassium content (0.149% P and1.69% K) was recorded in wider spacing and minimum in the closer spacing of Apricot.

Among the different chemical treatments, maximum leaf N, P, K was recorded in plants treated with KNO_3 @ 4% spray (1.78% N, 0.19% P, 0.82% K). Whereas minimum leaf N, P, K content was recorded in PBZ application @ 0.75 g a.i. (1.33% N, 0.12% P and 0.56% K) which was at par with PBZ @ 0.50 g a.i. (1.39% N, 0.14% P and 0.58% K). Kishore *et al*. [26] noticed that PBZ had inverse relationship with N and K contents of leaves. Chater *et al*. [27] also revealed that application of 2% and 3% KNO_3 resulted in significantly higher leaf N, P and K concentrations than the control. Whereas interaction effect between spacing and chemical treatment found to be non significant for leaf nutrient.

The wider spacing might be responsible for higher uptake and translocation of nutrient from soil to aerial part of the plants that results in higher leaf nutrient content in leaf of plants planted at lower density. Reduction in the leaf N, P and K contents in PBZ treated trees could be due to reduced root hydraulic conductivity and root length, which in turn reduces water flux responsible for passive uptake of mobile nutrients like N and K, Reiger *et al.* [28]. The influence of paclobutrazol on leaf nutrient status lacks consistency as the level of nutrient varies differently with the application rate and soil conditions.

3.3 Influence of PBZ and KNO_3 on leaf chlorophyll content, flowering and fruiting

The data presented in Table 3 suggests that total chlorophyll content in leaves was not influenced by the plant spacing. However, the chemical treatment alone had significantly affected the chlorophyll content and highest chlorophyll content was noticed in the plants treated with PBZ @ 0.75 g a. i. (1.93 mg g^{-1}) which was at par with PBZ @ 0.50 g a. i. (1.85 mg g^{-1}) and lowest was recorded in control (1.61 mg g^{-1}). Interaction effect between spacing and chemical treatment did not have significant influence on the total leaf chlorophyll content

Table 3. Influence of PBZ and KNO_3 on total leaf chlorophyll content, flowering and yield of mango cv. Amrapali planted under different spacings (Pooled mean of 2018-19 and 2019-20)

Treatments	Total leaf chlorophyll (mg g^{-1})	Panicle produced per square meter of canopy area	Fruit yield (t/ha)
Spacing (S)			
S_1: 2m x 2 m	1.48	18.00	10.40
S_2: 4m x 2m	1.72	21.92	8.66

S_3: 4m x 4m	2.02	30.42	5.85
S_4: 8m x 2m	1.90	29.33	5.28
S.E m±	0.028	0.65	0.07
C.D. at 5%	**0.080**	**1.86**	**0.19**
Chemical(C)			
C_1: (PBZ @ 0.25 g a.i./m of canopy area)	1.77	24.22	8.09
C_2: (PBZ @ 0.50 g a.i./m of canopy area)	1.85	29.20	9.00
C_3:(PBZ @ 0.75 g a.i./m of canopy area)	1.93	27.78	7.58
C_4: (2% KNO_3)	1.73	23.15	7.15
C_5: (4% KNO_3)	1.78	25.38	7.63
C_6: (Control - water application)	1.61	19.78	5.85
S.E m±	0.034	0.80	0.08
C.D. at 5%	**0.097**	**2.28**	**0.24**
Interaction: Spacing (S) x Chemical (C)			
S_1C_1: (2m×2m & 0.25 g a.i. PBZ)	1.46	17.50	11.33
S_1C_2: (2m×2m & 0.50 g a.i. PBZ)	1.53	21.08	12.43
S_1C_3: (2m×2m & 0.75 g a.i. PBZ)	1.61	20.06	10.41
S_1C_4: (2m×2m & 2% KNO_3)	1.44	16.73	9.91
S_1C_5: (2m×2m & 4% KNO_3)	1.48	18.33	10.47
S_1C_6: (2m×2m & water application)	1.36	14.31	7.86
S_2C_1: (4m×2m & 0.25 g a.i. PBZ)	1.70	21.30	9.23
S_2C_2: (4m×2m & 0.50 g a.i. PBZ)	1.78	25.73	10.31
S_2C_3: (4m×2m & 0.75 g a.i. PBZ)	1.87	24.47	8.75
S_2C_4: (4m×2m & 2% KNO_3)	1.67	20.34	8.15
S_2C_5: (4m×2m & 4% KNO_3)	1.72	22.33	8.80
S_2C_6: (4m×2m & water application)	1.58	17.34	6.71
S_3C_1: (4m×4m & 0.25 g a.i. PBZ)	2.01	29.57	6.18
S_3C_2: (4m×4m & 0.50 g a.i. PBZ)	2.09	35.63	6.95
S_3C3: (4m×4m & 0.75 g a.i. PBZ)	2.20	33.91	5.87
S_3C_4: (4m×4m & 2% KNO_3)	1.97	28.27	5.53
S_3C_5: (4m×4m & 4% KNO_3)	2.02	30.98	5.91
S_3C_6: (4m×4m & water application)	1.86	24.16	4.69
S_4C_1: (8m×2m & 0.25 g a.i. PBZ)	1.89	28.51	5.60
S_4C_2: (8m×2m & 0.50 g a.i. PBZ)	1.94	34.34	6.31
S_4C_3: (8m×2m & 0.75 g a.i. PBZ)	2.06	32.67	5.30
S_4C_4: (8m×2m & 2% KNO_3)	1.85	27.26	4.99
S_4C_5: (8m×2m & 4% KNO_3)	1.90	29.86	5.35
S_4C_6: (8m×2m & water application)	1.75	23.31	4.15
S.E m±	0.608	1.04	0.17
C.D. at 5%	**NS**	**2.97**	**0.47**

of plants. The greening effect caused by plant treatments with growth regulators can be explained by an increase in chlorophyll content and/or more densely packed chloroplasts per unit leaf area due to a reduction in leaf area, Khalil *et al.* [29]. The report of Nivedithadevi *et al.* [30] showed that plants treated with PBZ synthesized more cytokinin, which in turn enhanced chloroplast differentiation and chlorophyll biosynthesis, and prevented chlorophyll degradation.

The maximum panicles per m^2 canopy area was observed in Amrapali mango planted at a spacing of 4.0 x 4.0 m (30.42) and was at par with spacing of 8.0 x 2.0 m (29.33). The least number of panicles per m^2 of canopy area (18.00) was recorded in 2.0 x 2.0 m planting density. These findings are in consonance with the findings reported by Singh *et al.* [21] in high density planting system of 'Amrapali' mango. In chemical treatment, highest no. of produced /m^2 was observed to be in PBZ @ 0.50 g a. i. (29.20) which was closely followed by PBZ @ 0.75 g a. i. (27.78). The interaction effect of plant spacing and chemical treatment had significantly affected the no. of panicles per square meter. The highest no. of panicles per square meter was observed in plant spaced at of 4.0 x 4.0 m and treated with PBZ @ 0.50 g a.i. (35.63) and the minimum was recorded in plant spaced at of 2.0 x 2.0 m and control treatment (14.31).

Results similar to present findings are reported earlier by Yeshitela *et al.* [15]. The interaction effect of planting density and chemical treatment (Table 3) had significantly affected no. of panicle produced/ m^2 of canopy area. Highest no. of panicles produced per m^2 of canopy area was recorded in the plants spaced at 4m×4m and applied with 0.50 g a.i. PBZ (35.63).

The minimum percentage of flowering shoots was observed in high density planting which is mainly because of the facts that the smaller the area available to plants, the higher the tendency to decrease the number as reported by Singh *et al.* [21]. Application of paclobutrazol compounds enhance flowering by inhibiting synthesis of kaurene oxidase in the gibberellin-synthesis pathway which stimulates production of flowering shoots in weakly inductive conditions thereby increase flowering intensity and yield, Yeshitela *et al.* [15].

The fruit yield (t/ha) significantly differed due to plant spacing. The highest yield per ha (10.40t/ha) was obtained in plant spacing in 2.0 x 2.0 m. Whereas lowest yield (5.28 t/ha) was recorded in 8.0 x 2.0 m. Among chemical treatment significantly highest yield was recorded in PBZ @ 0.50 g a.i. (9 t/ha) followed by 8.09 t/ha in PBZ treatment @ 0.75 g a.i. Whereas lowest yield (5.85 t/ha) was recorded in control. The above finding is similar to those noted by Yeshitela *et al.* [15] and Kishore *et al.* [26]. Interaction effect is significant and maximum yield (12.43 t/ha) was recorded in the plants planted at a spacing of 2m×2m and applied with 0.50 g a.i. PBZ followed by 2m×2m spacing and applied with 0.25 g a.i. PBZ (11.33 t/ha).

On the basis of productivity per unit area basis the highest yield was recorded in higher density plantation. This was due to higher plant population per unit area as reported by Nath *et al.* [13] and Kumawat *et al.* [31]. Paclobutrazol is also known to alter the source-sink relations in the plant and directly or indirectly reallocates carbohydrate resources, suppressing vegetative growth and increasing yield. However, the highest concentration of paclobutrazol, 10.0 g a.i. per tree, considerably decreased yield in both years, probably due to its phytotoxic effects and reduction in leaf area Kurian and Iyer a [32] and fruit retention Kurian and Iyer b [33].

4. CONCLUSION

Paclobutrazol was efficacious in restricting vegetative growth and increasing flowering and fruit yield. Leaf N, P and K contents were affected negatively, whereas leaf total chlorophyll content increased in all doses of paclobutrazol. It has been observed that high rate of application (0.75 g ai m^{-1} canopy spread) not only promoted shoot and panicle compaction but also lower the yield due to its phytotoxicity effect on pollen germination and fertilization required for fruit set. Foliar spray of potassium nitrate @ 4% resulted increase in leaf N, P, K, total chlorophyll content, and no. of panicle per square meter of canopy area but fruit yield obtained from this treatment is significantly lower than PBZ @ 0.25 g a.i. and at par with PBZ @ 0.75 g a.i. per meter of canopy spread. Among different planting densities plant spaced at 2.0 x 2.0. m recorded highest yield per hectare due to accommodation of more no. of plants in comparison to other spacing. It can be concluded from the current investigation that soil drench application of 0.50 g a.i. PBZ in the month of September may be sufficient to suppress vegetative growth that will in turn have an impact in encouraging reproductive growth.

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