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Assessment of Residual Effect of Paclobutrazol on the Growth, Flowering, Yield and Quality of Litchi

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A B S T R A C T

This study focuses on the residual effect of paclobutrazol on the vegetative growth, flowering, yield, and quality of litchi grown at the Horticulture Research Centre, Patharchatta, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar during the period 2016– 2019. A total of 45 litchi trees were included in this experiment. The treatments consisted of four doses of paclobutrazol at 1.0 g a.i. (20 ml/tree), 2.0 g a.i. (40 ml/tree), 3.0 g a.i. (60 ml/tree), and 4.0 g a.i (80 ml/tree) per meter canopy diameter. The doses were applied on three dates, September 15, October 15, and November 15, through soil drenching in the years 2016 and 2017, subsequently. Plain irrigation water was applied in the basins of trees which served as control. The results show that application of paclobutrazol at 3.0 g and 4.0 g a.i. Per meter canopy diameter during 2016 and 2017 were the most effective in suppressing vegetative growth as compared to control. Higher doses of paclobutrazol persisted in the soil for longer duration and consequently affected flowering and fruiting during 2019. The trees treated with higher doses of paclobutrazol displayed more residual effects on flowering, fruiting, yield, and quality parameters during 2019.

Introduction

Litchi occupies an eminent place among fruit crops because of its sweetness, fragrance, and richness in many nutrients. A litchi tree exhibits wide variation in flowering and fruiting due to its strong dependency on the environment for flowering (Crops, 2014). Several reasons can contribute to low production in litchi, but the dominance of the vegetative phase over there productive phase (Hu *et al.*, 2018) is the major one. The vegetative flushing habit of litchi varieties is related with irregular bearing (Pandey *et al.*, 2017).This problem is generally due to the failure of flower initiation, which encourages vegetative growth prior to panicle emergence and flowering and thus eliminates the crop completely (Pandey *et al.*, 2017). The enhancement of flowering and fruiting in modern agricultural systems is increasingly dependent on the manipulation of a crop's physiological activities by chemical means (Subbaiah *et al.,* 2017). Several chemicals and practices have been suggested to overcome these problems. Among them, paclobutrazol is the most effective plant growth retardant and restricts the vegetative growth of a plant efficiently (Menzel and Simpson, 1990). The current study was conducted in order to better understand the residual effect of paclobutrazol on the vegetative growth and reproductive growth of litchi. Paclobutrazol is an environmentally stable compound and persists in soil for a long time after its (Kishore *et al.,* 2019). The half life of paclobutrazol is about 450–950 days in orchard soils, indicating its poor degradation rate (Kishore *et al.,* 2015). The residual effects of paclobutrazol have been observed through its routine application across consecutive years, and researchers have recommended discontinuing its application or lowering its doses depending on the desired outcome (Reddy and Kurian, 2008). To build on the existing literature, this study on the residual effect of paclobutrazol on the vegetative growth, flowering, yielding, and quality of litchi was carried out in a litchi orchard with trees which had received different doses of paclobutrazol across two years.

Materials and Methods

Area description

The experiment was conducted during the period 2016–19 at the Horticulture Research Centre, Patharchatta, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand. The center is located in the *terai* region of Uttarakhand, which lies at latitude 29◦ north, longitude 79.3◦ east, and an altitude of 243.84 m above the mean sea level.

Plant material

Twenty-two-year-old litchi trees of cultivar Rose Scented were selected for this study. Paclobutrazol was applied to the selected trees across two years, in 2016 and 2017, respectively. Rose Scented is a prominent variety of India and is extensively grown in this region (Pant *et al.,* 2020).The fruits of this cultivar have distinct rose aroma (Menzel and Waite, 2005). The tuberculate pericarp has an attractive red color. All the treated trees were care for following standard orchard management practices. Water was supplied by drip irrigation around the basins of the trees.

Design, method, rate, and time of paclobutrazol application

The experiment followed a randomized block design with three replications, and each replication had a unit of one plant in a treatment. The treatments had two factors (doses and time of application) that varied. There were four different doses of paclobutrazol: 1.0 g a.i. (20 ml/tree), 2.0 g a.i. (40 ml/tree), 3.0 g a.i. (60 ml/tree), and 4.0 g a.i. (80 ml/tree) per meter canopy diameter, respectively. The doses were applied on September 15, October 15, and November 15 through soil drenching in 2016 and 2017. The required quantity of paclobutrazol was dissolved in a bucket with 10 L of clean water by thoroughly stirring the mixture, and then it was applied through soil drenching using trenches formed around the tree trunks. Each trench was 30cm wide and 15cm deep. The base strength of the paclobutrazol was 25 percent; therefore, the quantity of paclobutrazol was increased 4 times to reach 100 percent and supply an accurate concentration in each treatment.

Data recorded

Vegetative growth

The vegetative growth parameters like tree height, shoot length, and internodal length were measured in February 2019 before flowering began. Tree height was measured using a graduated measuring poles panning from the collar region of the trunk to the highest crown level. Tagged shoots were evaluated using a measuring scale and the average shoot length was calculated based on the data. The average internodal length of tagged shoots was also determined using a measuring scale.

Flowering parameters

The panicle initiation was recorded from February to March 2019 through visual observation based on daily visits. The duration of flowering was de- fined as the number of days from initiation of flowering to the last date of flowering in all the tagged panicles. The average length and width of a tagged panicle was deter- mined using a measuring scale, and the total number of functional female flowers in a tagged panicle was counted manually.

Fruiting parameters

Ten tagged panicles per tree were used to record fruit set and fruit drop. The total numbers of pea-sized fruits were counted to calculate the fruit set percentage using the following formula:

$$\text{Fruit set (\%)} = \frac{\text{Average number of fruits initially set per panicle}}{\text{Average number of female flowers per panicle}} \times 100$$

Fruit drop was calculated using the following formula:

$$\text{Fruit drop (\%)} = \frac{\text{Average number of fruits initially set} - \text{Average number of fruits harvested}}{\text{Average number of fruits initially set per panicle}} \times 100$$

Yielding parameters

Ten fruits per replication per treatment were randomly selected from the tagged panicles to determine fruit yielding parameters. Fruit weight, peel weight, pulp weight, and seed weight were measured using a physical balance. Fruit volume was measured through a water displacement method.

Quality parameters

The total soluble solids (TSS) of fruit was measured using a hand refractometer (MCP, modelno.KM-ITZR-4KR1). Titratable acidity was estimated through the acid base titration method proposed by (C, 1970) A.O.A.C (1970). Ascorbic acid content was determined based on the reduction of 2, 6-Di chloro phenol indophenol dye by ascorbic acid (Rangnna, 2007).

Total sugars, reducing sugars, and non reducing sugars were assessed using the Lane and Eynon method (Rangnna, 2007).

Anthocyanin content was estimated using the method proposed by (Rangnna, 2007), which features ethanolic HCl (85:15) prepared by mixing 85 parts reagent A (ethanol, 95% in distilled water) and 15 parts reagent B (1.5 N hydrochloric acid) by volume.

Leaf nutrient content

Before the initiation of panicle emergence, a leaves sample was collected in February 2019. Approximately 30–35 uniform, healthy, and disease-free leaves from the third position of the shoots of autumn flush were collected from all four directions of a tree.

The samples were oven dried at a temperature of 55°C for two hours and then ground up. Nitrogen level was estimated using the micro-Kjeldahl method (Jackson, 2005). Meanwhile, phosphorus and potassium levels were measured using a flame photometer, and the levels of calcium, magnesium, and sulfur were collected using an atomic absorption spectrophotometer.

Statistical analysis

The differences between the treatments were determined through an analysis of variance using a statistical software package for agricultural research workers (OPSTAT) developed by (Sheoran *et al.,* 1998). An *F* test was used to calculate the mean differences at 5 percent level of significance. Critical differences at 5 percent level of probability were used to compare the data.

Results and Discussion

Residual effect of paclobutrazol on vegetative growth

The various levels of paclobutrazol application caused significant differences with respect to tree height, shoot length, and internodal length. Trees treated with 4 g a.i. per tree canopy diameter showed a minimum tree height of 3.48 m, a minimum shoot length of 16.33 cm, and a minimum internodal length of 3.73 cm. The time of application was found to yield non significant differences. Paclobutrazol, at 4 g a.i. per tree canopy diameter, reduced the tree height by 22.83, shoot length by16.42 and internodal length by 15.22 per cent as compared to control.

Residual effect of paclobutrazol on flowering parameters

Paclobutrazol treatment advanced panicle emergence after application even in 2019. Treatment T_{14} showed the earliest panicle emergence on February 3, 2019, which was 14 days earlier than the control treatments. The maximum duration of flowering (13.33 days) was recorded from paclobutrazol applied at 4 g a.i. per canopy diameter (80 ml/tree).The flowering duration in the treatment where paclobutrazol was applied @ 4 g a.i. per canopy diameter was extended 37.85 per cent when compared to the control. The shortest panicle length (21.63 cm) and width (17.24 cm) in the subsequent year of application of PBZ were also observed in the same treatment. There was maximum reduction in panicle length (15.83 %) and width (13.84 %) with respect to control. The time of application of PBZ however, had no significant effect on these characters in the following year of application.

Residual effect of paclobutrazol on fruiting parameters

Paclobutrazol-treated trees showed higher fruit set percentage. Maximum fruit set (67.79%) was observed in the trees applied with paclobutrazol @ 4 g a.i. per canopy diameter while in trees takes as control, there was minimum fruit set (59.69%). The trees of this treatment recorded 13.57 per cent higher fruit set as compared to control. Thus, the paclobutrazol doses had a significant residual effect on the fruit set percentage. The effect of time of application, was again found to be non significant. Similarly, lowest fruit drop (84.21%) was also observed in the same treatment. Time of application did not show any remarkable effect on fruit drop. Paclobutrazol application at 4 g a.i. per tree canopy diameter decreased the fruit drop of trees by 6.57% with respect to control.

Residual effect of paclobutrazol on yielding parameters

The paclobutrazol doses had significant residual effects on all the yielding parameters, but the time of application showed a non significant effect. The maximum fruit weight (21.94 g), volume (21.36 ml), peel weight (1.97 g), pulp weight (16.45 g), and yield (52.92 kg/tree) and the minimum seed weight (3.21 g) were recorded under the paclobutrazol application of 4 g a.i. per canopy diameter as compared to the control. The application of paclobutrazol @ 4 g a.i. per canopy diameter increased the fruit weight by 23.81per cent, volume by 30.00per cent, peel weight by 11.29per cent, pulp weight by34.39per cent, and yield by 34.69 per cent. The seed weight in the above mentioned treatment was reduced by 13.94per cent with respect to control.

Residual effect of paclobutrazol on quality parameters

Paclobutrazol significantly affected all the quality parameters. On the other hand, time of application yielded a non significant difference. The highest TSS (19.24°Brix), ascorbic acid (27.42 mg/100 g), total sugars (13.79%), reducing sugars (8.78%), non reducing sugars (5.25%) and anthocyanin content (56.01 mg/100g) were found from the application of paclobutrazol at 4 g a.i. per tree canopy diameter (80 ml/tree), which was at par with the application of 3 g a.i. per tree canopy diameter. The per cent increase in quality parameters under residual effect of various doses of paclobutrazol showed that application of paclobutrazol @ 4 g a.i. per canopy diameter resulted in maximum increase in TSS (17.74%), ascorbic acid (8.20%), total sugars (14.43%), reducing sugars (20.60%), non reducing sugars(15.38%) and anthocyanin content (42.04%) with respect to control. Minimum titratable acidity (0.49%) was also recorded in the fruit of above treatment. The fruits of trees taken as control, however recorded highest titratable acidity (0.55%) in the following year of application of PBZ.

Residual effect of paclobutrazol on leaf nutrient content

The study's results reveal that paclobutrazol had a significant effect with respect to the leaf nutrient N, P, K, Ca, Mg, and S content. The highest rates of N (1.64%), P (0.30%), K (0.82%), Ca (0.64%), Mg (0.35%), and S (0.16%) came from the paclobutrazol application of 4 g a.i. per tree canopy diameter, while the minimum was observed under the control treatment. In the trees supplied with 4 g a.i. paclobutrazol in the previous years, it was found that there was 9.33per cent more N, 30.43per cent more P, 9.33per cent more K, 16.36 per cent more Ca, 34.61more Mg and 45.45per cent more S with respect to control.

In the present investigation, higher doses of paclobutrazol (4 g and 3 g a.i. per tree canopy diameter) applied in 2016 and 2017 resulted in maximum stunting of vegetative growth. Higher doses of paclobutrazol probably persisted for longer duration in the soil than the lower doses in the subsequent years of application. In general, an inverse relationship between doses of paclobutrazol and vegetative growth was observed. The higher doses of paclobutrazol might have had a stronger inhibiting effect on the biosynthesis of gibberellins by blocking the conversion of kaurene to kaurenoic acid. Even after discontinuation, the anti gibberellin nature of paclobutrazol continued to suppress vegetative growth of the trees. Wani *et al.,* (2011) also reported that the increase in plant height was inversely proportional to increasing doses of paclobutrazol. The results are consistent with the findings of Shaban and Ibrahim (2009), who found that higher doses of paclobutrazol resulted in a greater decrease in vegetative development. In addition, Werner (1993) reported that paclobutrazol persists in soil for a very long time when applied through the soil and can effectively suppress plant height in the subsequent years following its application. Charnvichit *et al.,* (1991), however, observed that in mango, the residual effect of paclobutrazol persisted for only one year of its application, after which normal growth resumed. Reddy and Kurian (2008) discovered that the inhibitory effect of paclobutrazol on vegetative growth was greater in the initial years after application and then dissipated slowly in successive years, with soil application achieving a more marked effect than foliar spray. Lehman *et al.,* (2019) also found that soil drench application of paclobutrazol decreased the length of shoots for up to two years of its application in the lower canopy.

Flowering growth parameters such as date of panicle emergence, duration of flowering, length and width of panicle, and number of functional female flowers responded positively with respect to residual effect of paclobutrazol. The earliest panicle emergence was observed from application of higher doses of paclobutrazol, so paclobutrazol applied to the soil may have induced physiological activities and improved the flowering duration.

The observations suggest that paclobutrazol application might have stimulated the compound responsible for the production of the flowering hormone and nonstructural carbohydrates. The persistence of paclobutrazol residue in soil and its eventual absorption by plants facilitates early reduction of endogenous gibberellin levels within the shoots which eventually results in their early maturity (Sarker and Rahim, 2012 and Burondkar and Gunjate, 1991). In the present investigation it was found that paclobutrazol significantly enhanced the amount of flowering probably due to fact that the shoots gained enough maturity under the residual effect of paclobutrazol and profuse flowering was observed. Kulkarni, (1988) also concluded that soil application of paclobutrazol significantly increased the amount of flowering in Dashehari and Banganpalli mangoes.

Table.1 Residual effect of paclobutrazol doses and time of application on vegetative growth in litchi cv. Rose Scented

Treatments	Tree height (m)	Shoot length (cm)	Internodal length (cm)
Paclobutrazol doses (P)	**Mean**	**Mean**	**Mean**
P_0 (Control)	4.51	19.54	4.40
P_1 (Paclobutrazol @ 20 ml / tree)	4.10	18.68	4.06
P_2 (Paclobutrazol @ 40 ml / tree)	3.80	16.88	3.93
P_3 (Paclobutrazol @ 60 ml / tree)	3.63	16.59	3.84
P_4 (Paclobutrazol @ 80 ml / tree)	3.48	16.33	3.73
SEM	0.155	0.533	0.151
C.D. at 5%	0.45	1.543	0.44
Time of application (D)	**Mean**	**Mean**	**Mean**
D_1 (15th September)	4.05	17.56	3.90
D_2 (15th October)	3.85	17.52	3.79
D_3 (15th November)	3.86	17.73	4.28
SEM	0.120	0.413	0.117
C.D. at 5%	NS	NS	NS

Table.2 Residual effect of paclobutrazol doses and time of application on date of panicle emergence in litchi cv. Rose Scented

S. No.	Treatments	Symbols	Year (2019)
1	$P_0 D_1$	T_1	15 February
2	$P_0 D_2$	T_2	16 February
3	$P_0 D_3$	T_3	15 February
4	$P_1 D_1$	T_4	14 February
5	$P_1 D_2$	cT_5	13 February
6	$P_1 D_3$	T_6	15 February
7	$P_2 D_1$	T_7	14 February
8	$P_2 D_2$	T_8	14 February
9	$P_2 D_3$	.T_9	13 February
10	$P_3 D_1$	T_{10}	09 February
11	$P_3 D_2$	T_{11}	08 February
12	$P_3 D_3$	T_{12}	08 February
13	$P_4 D_1$	T_{13}	05 February
14	$P_4 D_2$	T_{14}	03 February
15	$P_4 D_3$	T_{15}	04 February

Table.3 Residual effect of paclobutrazol doses and time of application on flowering parameters in litchi cv. Rose Scented

Treatments	Duration of flowering (days)	Panicle length (cm)	Panicle width (cm)	Number of functional female flowers per panicle
Paclobutrazol doses (P)	**Mean**	**Mean**	**Mean**	**Mean**
P_0 (Control)	9.67	25.70	20.01	123.54
P_1 (Paclobutrazol @ 20 ml / tree)	11.00	23.06	19.68	128.38
P_2 (Paclobutrazol @ 40 ml / tree)	11.67	22.93	19.12	132.67
P_3 (Paclobutrazol @ 60 ml / tree)	11.33	21.89	18.77	148.91
P_4 (Paclobutrazol @ 80 ml / tree)	13.33	21.63	17.24	151.66
SEM	0.513	0.608	0.613	4.283
C.D. at 5%	1.48	1.761	1.77	12.40
Time of application (D)	**Mean**	**Mean**	**Mean**	**Mean**
D_1 (15^{th} September)	11.00	22.91	18.58	136.82
D_2 (15^{th} October)	11.40	22.88	19.83	138.25
D_3 (15^{th} November)	11.80	23.34	18.48	136.02
SEM	0.398	0.471	0.475	3.318
C.D. at 5%	NS	NS	NS	NS

Table.4 Residual effect of paclobutrazol doses and time of application on yielding parameters in litchi cv. Rose Scented

Treatments	Fruit weight (g)	Fruit volume (ml)	Seed weight (g)	Peel weight (g)	Pulp weight (g)	Fruit yield (kg/tree)
Paclobutrazol doses (P)	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
P_0 (Control)	17.72	16.43	3.73	1.77	12.24	39.29
P_1 (Paclobutrazol @ 20 ml / tree)	18.38	17.28	3.69	1.80	12.89	41.93
P_2 (Paclobutrazol @ 40 ml / tree)	20.38	19.29	3.53	1.87	14.71	47.56
P_3 (Paclobutrazol @ 60 ml / tree)	20.71	20.44	3.44	1.91	15.31	51.53
P_4 (Paclobutrazol @ 80 ml / tree)	21.94	21.36	3.21	1.97	16.45	52.92
SEM	0.475	0.582	0.059	0.032	0.480	2.220
C.D. at 5%	1.37	1.68	0.17	0.09	1.39	6.43
Time of application (D)	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
D_1 (15^{th} September)	19.80	18.80	3.50	1.84	14.32	46.29
D_2 (15^{th} October)	19.90	18.99	3.52	1.86	14.39	47.04
D_3 (15^{th} November)	19.78	19.08	3.55	1.89	14.25	46.61
SEM	0.368	0.451	0.046	0.025	0.372	1.720
C.D. at 5%	NS	NS	NS	NS	NS	NS

Table.5 Residual effect of paclobutrazol doses and time of application on leaf nutrient contents in litchi cv. Rose Scented

Treatments	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	Magnesium (%)	Sulphur (%)
Paclobutrazol doses (P)	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
P_0 (Control)	1.50	0.23	0.75	0.55	0.26	0.11
P_1 (Paclobutrazol @ 20 ml / tree)	1.53	0.24	0.77	0.57	0.28	0.12
P_2 (Paclobutrazol @ 40 ml / tree)	1.55	0.26	0.78	0.62	0.32	0.14
P_3 (Paclobutrazol @ 60 ml / tree)	1.63	0.29	0.81	0.63	0.34	0.15
P_4 (Paclobutrazol @ 80 ml / tree)	1.64	0.30	0.82	0.64	0.35	0.16
SEM	0.027	0.005	0.014	0.010	0.008	0.003
C.D. at 5%	0.078	0.01	0.03	0.03	0.02	0.01
Time of application (D)	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
D_1 (15^{th} September)	1.54	0.26	0.77	0.60	0.30	0.13
D_2 (15^{th} October)	1.56	0.26	0.79	0.61	0.31	0.14
D_3 (15^{th} November)	1.61	0.27	0.79	0.60	0.32	0.13
SEM	0.021	0.004	0.011	0.008	0.006	0.005
C.D. at 5%	NS	NS	NS	NS	NS	NS

Fig.1 Residual effect of paclobutrazol doses and time of application on fruiting parameters in litchi cv. Rose Scented

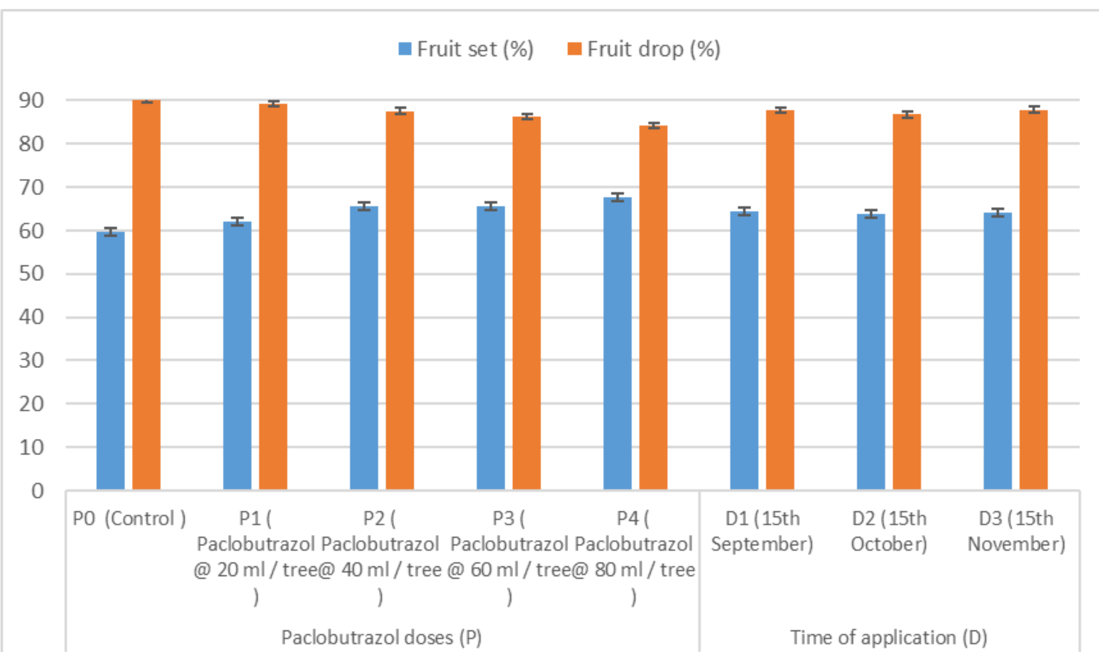
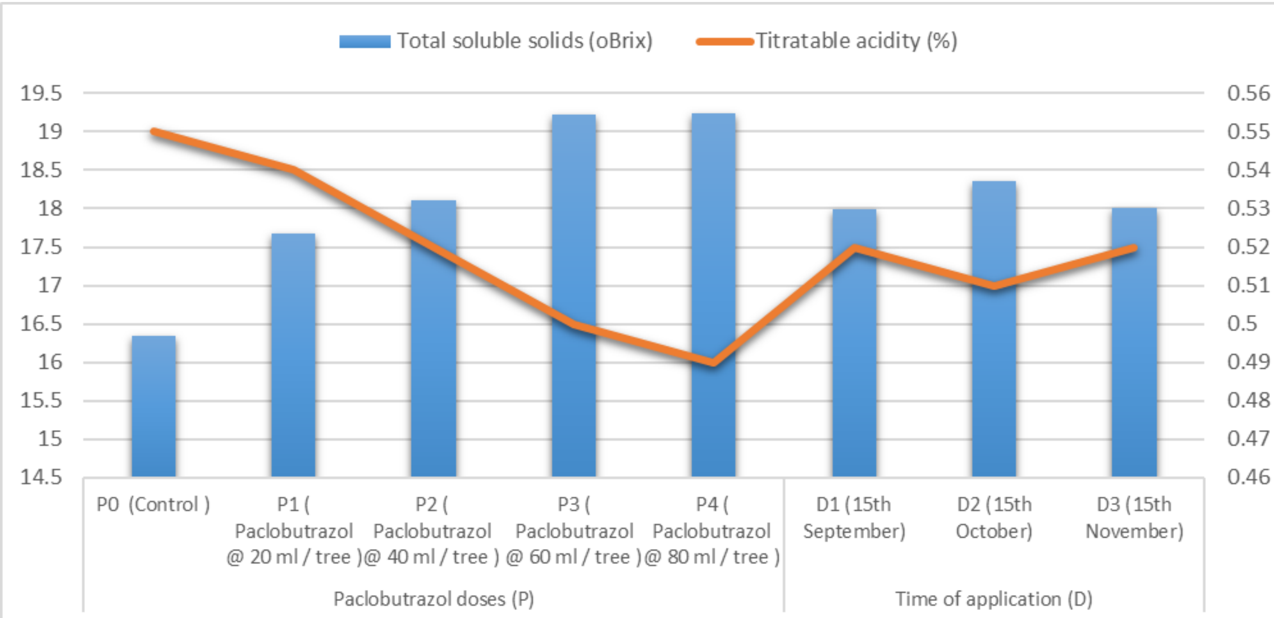
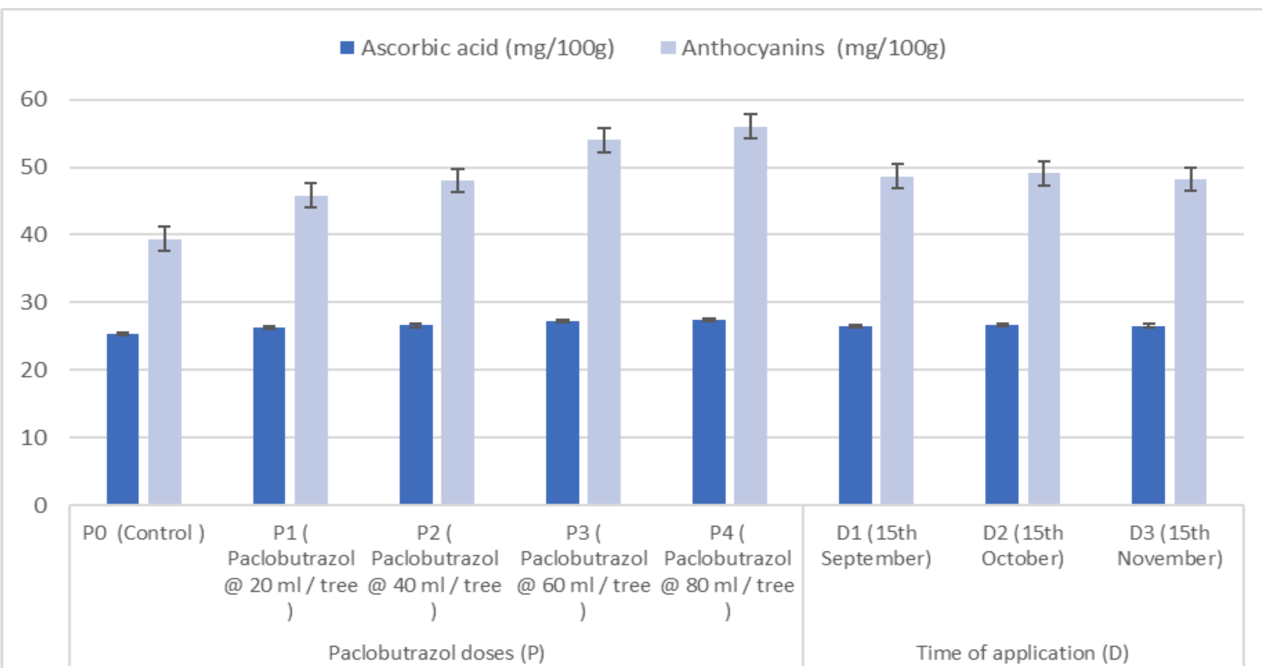


Fig.2 Residual effect of paclobutrazol doses and time of application on quality parameters in litchi cv. Rose Scented





The residual effect of Paclobutrazol was also noticed on the fruiting parameters, like fruit set and fruit retention. The encouraging effect on flowering parameters ultimately enhanced the fruit set percentage. Burondkar *et al.*, (2000) reported that there was carryover effect of paclobutrazol across successive years. They discovered that the fruit set per panicle substantially increased during two cropping seasons after application of PBZ was discontinued and paclobutrazol had a positive effect on increasing the number of fruits in mango. In the current study, better fruit retention in paclobutrazol treated trees was noted as compared to control. Paclobutrazol helps plants to overcome abiotic stresses better thus resulting in better performance (Soumya *et al.,* 2017). Although the residual effect of paclobutrazol on fruit drop was non significant, however, it was observed that the trees applied with 4g a.i. paclobutrazol per metre canopy diameter showed minimum fruit drop. The use of paclobutrazol in fruit plants decreases the level of gibberellins and raises the level of auxin which prevents fruit drop. Ather and Kumar (2001) also reported that paclobutrazol application considerably decreased fruit drop in litchi.

The residual effect of paclobutrazol effectively enhanced the yield parameters such as weight, volume, peel weight, pulp weight, and so on. The increase in fruit size in the year 2019 might be due to earlier blooming and fruit set. There was less competition from vegetative organs due to the inhibition of vegetative flush, internodal length, shoot length, and tree height. Therefore, it could be concluded that paclobutrazol's main contribution was decreasing vegetative growth, while a secondary effect was observed on the enhancement of fruit development parameters such as fruit size (fruit length, width, weight, and volume). There might have been changes in the source-sink relationship, with movement of photosynthates towards the sink or development of fruit. These results mirror the findings of Pandey *et al.,* (2017), who discovered that paclobutrazol had a substantial impact on the length and diameter of the fruit of cashew nuts and that the chemical had a greater effect with higher doses. Lurie *et al.,* (1997) also reported that paclobutrazol application decreased vegetative growth and enhanced fruit growth development during the year following application. In our study, the treated trees showed increased fruit yields due to the increased fruit set percentage and fruit development. Ray and Rani (2004) reported that there was negligible residual effect of paclobutrazol on the fruit yield of litchi in the first year of application but a 52% increment in yield after one year of paclobutrazol application in the second year was discovered.

The present research has shown that the use of paclobutrazol significantly increased the TSS, ascorbic acid, total sugars, reducing sugars and anthocyanin content in fruit. The extended effect of paclobutrazol could be related to the increased metabolic activity of the trees. Paclobutrazol application inhibit the catabolism of ABA and plays a major role in raising the osmotic pressure of cells will ultimately increase the accumulation of ions and sugars in them, thus enhancing the level of TSS and sugars in fruit. It was also found that residual effect of paclobutrazol decreased the levels of titratable acidity in litchi fruits. This might be due to increased levels of sugars and TSS and the reduction in the conversion of sugars into acid. Paclobutrazol enhanced the anthocyanin contents in the fruit of treated trees, and this likely happened because of the higher production of the compounds and secondary metabolites, which are responsible for anthocyanin formation. The leaf nutrient content of the paclobutrazol-treated trees significantly increased in comparison to the control group in 2019 after two years of application. These results indicate that paclobutrazol had a positive effect on the leaf nutrient content of the litchi trees. Paclobutrazol remained in the soil one year after application and might have increased the root density, likely by reducing vegetative growth and supplying carbohydrates that moved toward root development. After absorbing more water and nutrients, the trees were able to increase their root density, which ultimately enhanced the levels of leaf nutrients. Anusuya and Selvarajan (2014) discovered that the application of paclobutrazol increased the content of leaf nutrients at all stages of mango tree development. These results are in agreement with the findings of Atkinson and Crisp (1983) in apple rootstocks, Wang *et al.,* (1985) in pears, and Pequerul *et al.,* (1997) in peaches. Moreover, Singh *et al.,* (2005)observed that soil application of paclobutrazol over two consecutive years increased the levels of P, K, and Ca in mango.

From the present study, it was clearly observed that there was significant residual effect of paclobutrazol on the litchi trees. The effect of higher doses of paclobutrazol was more pronounce as there was maximum restriction of vegetative growth with enhanced flowering, fruiting, yield, quality parameters and leaf nutrient contents. It was found that Paclobutrazol when applied through soil across two consecutive years had significant residual influence on growth, yiels and quality of litchi. This indicates that there is possibility to skip application of paclobutrazol or taper its doses in subsequent years to obtain sustainable production in litchi with least possible damage to the environment.

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