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Impact of Different Doses and Methods of Application of Paclobutrazol on Leaf Area and Flush Length of Litchi Cultivars

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Abstract
Litchi (*Litchi chinensis* Sonn.) an important subtropical evergreen fruit crop is highly specific to climatic requirements. Initiation and development of litchi floral buds occurs in the winter, leading to anthesis in early to late spring. The effects of either ring basin (RB) or trunk soil line pore (TSLP) method of application of paclobutrazol (1.00-4.00 g per m canopy diameter) during September, for Leaf area and Flush length of 2 cultivars of Litchi were investigated during 2016-17. In India, litchi produces two growth flushes i.e., first during August followed by the second one during November apart from the initial flushing just after fruit harvest. The flushing habit of litchi varieties was intimately connected with irregular bearing and due to vegetative growth prior to panicle emergence and flowering eliminating the crop completely. One method to manipulate flowering is to use the plant growth regulators particularly the growth retardants like, paclobutrazol. The post-flushing application of a small amount of paclobutrazol to the soil significantly promotes flowering and fruiting in the following year. Typically, leaves that formed after paclobutrazol treatment were smaller and darker green than leaves that developed before treatment or on control plants. Leaf area, we found to be non-significant due to method of application of Paclobutrazol. The first flush emerged during July measured between 11.11 cm to 15.33 cm in various treatments. After treatment in September, the flush length in different experimental plant of China was between 11.33 to 13.24 cm in China. Before emergence of panicle during November the flush length showed reducing growth trends.

Keywords: Different Doses, Flush Length, Leaf Area, Methods, Paclobutrazol

Introduction
Litchi (*Litchi chinensis* Sonn.) an important subtropical evergreen fruit crop belonging to family Sapindaceae, is believed to be originated in Southern China. It is highly specific to climatic requirements and probably due to this reason its cultivation is restricted to few countries in the world. India and China account for 91 per cent of the world litchi production. At global level, litchi production is confined to few countries like China, India, Thailand, Taiwan, Madagascar, South Africa and Australia. Litchi crop is gaining importance in other parts of the world also like Israel and Spain. In its region of origin the winter is cool and almost rainless and day length is short, reaching a minimum of about 10 h (Groff, 1921 Batten, 1986). Litchi flowering is indeed promoted by cool and dry winters, but not short day length. Litchi is a day-neutral plant, extremely short (8 h) or long (16 h) days do not affect it's flowering at all (Nakata and Watanabe 1966 and Stern 1992) [10, 15]. Flower bud formation usually occurs in mature terminal shoots. A cool winter is generally considered a pre-requisite for adequate litchi flowering (Groff 1921 and Groff 1943) [6]. There is great variation among litchi cultivars in their need for a cool winter to induce flowering. All studies on litchi flowering have been conducted with subtropical litchi cultivars, which need a cool winter to initiate flower buds. A dry autumn and winter are considered favourable for flowering in litchi, via the induction of vegetative dormancy (Chapman 1984, Galan- Sauco 1989 and Menzel and Simpson 1994).

In India, litchi produces two growth flushes i.e., first during August followed by the second one during November apart from the initial flushing just after fruit harvest. In view of this, the vegetative flush/excessive shoot growth during winter should be controlled chemically or manually flush pruning (Ravishankar *et al.*, 2012) [12]. The consideration of canopy management in litchi is based on the premise that it is of multi flushing nature (3-5/year), responsive to pruning and useful to post pruning chemical application, endowed with potentially productive lower middle canopy and has potential for rejuvenation. It is important to note that the lower 2/3rd of the canopy contributes for the maximum economic yield. Empirical studies have shown that foliar application of high doses of thiourea and potassium nitrate helps in defoliation of pruned tree and in quick emergence of flush and shoot pruning of bearing branches to 20 cm improved over all plant yield.

The plant generally produces 3-4 flushes annually:

1stflush: Mid of July (30 days after pruning)

2ndflush: 3-4th week of August

3rdflush: November

4thflush: Mixed flush during January.

Floral induction is considered to be the result of elevated levels of up-regulated florigenic promoter (FP) and down-regulated vegetative promoter (VP), primarily gibberellins, whereas the reverse condition promotes vegetative growth (Nartvaranant *et al.* 2000 and Davenport, 2007). The production of vegetative shoots in place of reproductive shoots is due to the elevated level of gibberellin which is considered as a vegetative promoter (Núñez-Eliséa and Davenport 1995). Paclobutrazol, a gibberellin inhibitor, reduces VP level and thereby increases FP/VP ratio which stimulates flowering shoots in weakly inductive shoots of fruit crops (Voon *et al*., 1991, Yeshitela *et al*., 2004, Adil *et al*., 2011 and Iglesius *et al*., 2007) [16].

The flushing habit of litchi varieties was intimately connected with irregular bearing. Problem is generally due to failure of flower initiation which puts forth vegetative growth prior to panicle emergence and flowering eliminating the crop completely. Observations on young as well as old 'Calcuttia' litchi trees showed that vegetative growth after September was at the expense of fruiting in the following year (Mustard and Lynch, 1959) [9]. Several research workers advocated the use of various growth retardants as an alternate approach in litchi to restrict vegetative growth before panicle emergence (Chapman *et al*., 1980) [5].

Paclobutrazol (PBZ), a triazole derivative, has been effectively used to induce and manipulate flowering, fruiting and tree vigour in several perennial fruit crops. However, its use in mango is quite common but not in litchi. Soil application of paclobutrazol has been efficacious in promoting flowering and increasing yield in many fruit crops. However, there are some conflicting reports on its impact on fruit quality parameters. Besides reducing gibberellins level, PBZ increases cytokinin contents, root activity and C: N ratio, whereas its influence on nutrient uptake lacks consistency. PBZ also affects microbial population and dehydrogenase activity in soil. Thus, paclobutazol holds considerable promise in manipulation of flowering, yield and vigour in fruit crops (Kishor *et al*., 2014) [8].

Paclobutrazol has demonstrated its usefulness by regulating traits of agronomic interest in various crops including cereal, vegetables, fruits and ornamentals (Rademacher and Bucci 2002) [11]. It has been effectively used for flower regulation, yield and quality improvement in various perennial fruit crops (Nartvaranant *et al.,* 2000, Koukourikou-Petridou, 1996 and Adato, 1990).

Flower initiation is very important process it is the first step towards attaining fruit of the tree. Recent trials have clearly shown that the extent (quantity) of flowering affects yields; time of flower emergence has a significant influence on time of fruit maturity. Early flowering clearly resulted in early fruit maturity. Unfortunately, our commercial litchi variety China flowers late and does not flower regularly year after year. Flowering is also staggered, leading to considerable variation in fruit maturity. The induction of regular, profuse, early and uniform flowering will undoubtedly ensure higher yields and better returns to the growers.

One method to manipulate flowering is to use the plant growth regulators particularly the growth retardants like, paclobutrazol. The post-flushing application of a small amount of paclobutrazol to the soil significantly promotes flowering and fruiting in the following year.

There were few or no trials that correlate the effect of PBZ on litchi flowering with metabolic and hormonal changes under tropical conditions. If the trees are made to flower earlier and can be harvested at 3-4 weeks ahead of the normal harvest, growers can benefit higher income.

Accordingly, the current study has been carried out with a broad objective of investigating the role of plant growth retardants *i. e*. paclobutrazol on floral induction of irregular bearing litchi cv. China with standardised methods and different dose of application.

Material and methods

The experiment was conducted during 2016- 2017 at Experimental Farm of ICAR-National Research Centre on Litchi, Mushahari, Muzaffarpur, Bihar. The experimental site is situated at $26^0$5'87" N latitude, $85^0$26'64" E *longitude* at an elevation of 210 m above the mean sea level having a sub-tropical climate. The experimental soil was alluvial with sandy loam texture and are calcareous having pH 7.5 - 8.0. The chosen design was 2 factors Randomized Block Design (RBD) with spacing of the trees at 8.0 m x 8.0 m with 12 numbers of treatments viz. Two methods of application [(M_1: Ring basin (1.5-2.0 m away from the trunk) and, M_2: Trunk Soil Line Pore (TSLP) method (near collar region, 2.5 feet away from the tree trunk)] with 5 doses of paclobutrazol [(i.e. T_1: 1.0 g a.i. per m^2 canopy diameter, T_2: 2.0 g, T_3: 3.0 g, T_4: 4.0 g, T_5: 0.0 g (China) and, T_6: 0.0 g (Shahi)].

A shallow circular trench (about 10-cm-deep) was dug at a radius of 1 m from the base of each tree. Paclobutrazol in the water soluble form ''Cultar'' was obtained from ICI (Indonesian Operations, Jakarta). The Burondkar and Gunjate (1993) [4] method of soil drenching was followed, in which 10 small holes (10–15 cm depth) may be made in the soil around the collar region (2.5 feet away from the tree trunk). A homogeneous solution of PBZ was prepared by dissolving it in 5 litters of tap water and 500 ml of this solution will be drenched in each hole. Control trees were drenched with tap water. Drenching was practiced during the first week of September month of first year of experiment. Ten, 12- 15 year old uniform sized litchi cv. China and two trees of Shahi trees were randomly selected for the experiment. Each treatment was replicated thrice with a single tree as a treatment unit.All the experimental trees were given uniform cultural practices as recommended by NRCL, Muzaffarpur, Bihar.

For measurement of average leaf area (cm^2) forty mature leaves were collected from four sides of each tree and leave were scanned (3 replicates) using a scanner (Epson Perfection, V 700 Photo, Scanner, Seiko Epson Corporation, Japan). And Flush length (cm) emergence was measures at frequent interval (July, September and November). The length of flushes was measured in all the four directions of plant and mean value were expressed as the length of flushes.

The mean was computed for the data on various attributes, whereas a two-factor analysis of variance (ANOVA) using a randomized block design (RBD) was conducted with SAS® 9.2 statistical software for the data on quality parameters. The least significant differences (LSDs) between means at $P_{0.05}$ and the standard error (SE) of means were computed.

Results and discussion

The data pertaining to Leaf area recorded during August and February has been presented Table-1.1 and results indicated that the effect of different doses of paclobutrazol (PBZ) was observed to be significant for typically, leaves that formed after paclobutrazol treatment were smaller and darker green than leaves that developed before treatment or on control plants. Leaf area, we found (Table 1.1) to be non-significant due to method of application of Paclobutrazol but dose of PBZ significantly affected leaf area and it was found that higher the doses, lesser the leaf area. 4.0 g PBZ applied through TLSP reduced leaf area up to 39.62 cm^2 and 3.0 g PBZ applied through RB method reduced leaf area up to 38.81 cm^2. They also exhibited a downward curling of leaf margins and a thickened appearance. Hunter and Proctor (1992) [7] also observed reduced leaf area in potted grapes from the axillary shoot by increasing paclobutrazol dosages, the number of leaves harvested from this component was reduced only at 1000 μg paclobutrazol/g soil. Roseli *et al*., (2012) [13] also found significantly reduced plant height and leaf area but increased leaf area index in jamun due to Paclobutrazol. The data pertaining to the length of flush in different treated and control plants were recorded during July, September and November (Table 1.2).The first flush emerged during July measured between 11.11 cm to 15.33 cm in various treatments. After treatment in September the flush in different experimental plant of China were between 11.33 to 13.24 cm in China. Before emergence of panicle during November the flush length showed reducing growth trends being minimum (9.21 cm) in TSLP methods with PBZ@ 3.0 g PBZ followed by 9.47 cm in TSLP method with 2 g PBZ and 9.83 cm in TSLP with 4.0 g PBZ where as in control the November flush length range between 12.16 to 12.3 cm in China. The data clearly indicate that PBZ irrespective of method application was effective to reduce the pre bloom flush length which might help in inducing flower panicle emergence. The length of flushes emerges in July got reduced to September and the slight increase in November. Length of flushes was 10% more in control tree over treated tree in November.

While paclobutrazol was effective in controlling Leaf area and vast Flush, conflicting evidence on paclobutrazol induced changes in leaf area and Flush length attributes in litchi suggests that further investigation is required.

Table 1.1: Impact of Different doses and methods of application of Paclobutrazol on Leaf area of litchi cultivars

Methods	Dose of PBZ	Leaf area (cm^2)	
		August	February
Ring Basin Methods	1.0	46.14	38.18
	2.0.	42.75	36.78
	3.0	46.19	37.60
	4.0	38.81	39.94
	Control (China)	46.15	36.50
	Control (Shahi)	40.95	37.49
TSLP	1.0	53.41	36.18
	2.0.	40.39	36.06
	3.0	39.62	36.53
	4.0	51.88	38.44
	Control (China)	55.06	40.61
	Control (Shahi)	41.92	32.61
$CD_{0.05}$	A	NS	NS
	B	7.12	NS
	A x B	NS	NS
SEM±	A	1.39	1.05
	B	2.41	1.81
	A x B	3.41	2.57

Table 1.2: Impact of Different doses and methods of application of Paclobutrazol on Length of Flushes emerged of litchi cultivars

Methods	Dose of PBZ	Length of Flushes emerged (cm)		
		July	September	November
Ring Basin Methods	1.0	13.63	11.33	12.33
	2.0.	15.33	12.38	12.00
	3.0	12.84	11.73	12.02
	4.0	12.45	11.48	12.01
	Control (China)	13.23	13.11	12.16
	Control (Shahi)	12.71	12.57	13.05
TSLP	1.0	13.20	13.24	12.38
	2.0.	12.49	12.58	12.74
	3.0	11.73	12.10	11.21
	4.0	11.11	12.40	12.82
	Control (China)	11.90	12.16	11.33
	Control (Shahi)	11.50	11.67	15.15
$CD_{0.05}$	A	0.45	NS	NS
	B	0.77	0.50	0.83
	A x B	NS	0.71	1.18
SEM±	A	0.15	0.10	0.16
	B	0.26	0.17	0.28
	A x B	0.37	0.24	0.40

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