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Effect of Brassinosteroid on Flowering and Fruiting Behavior of Litchi (Litchi chinensis Sonn.) cv. Purbi

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ABSTRACT

This trial was conducted at Bihar Agricultural University, Sabour, Bhagalpur with thirteen treatments and three replications. Different concentrations of brassinisteroids (0.2 mg/l, 0.4 mg/l, 0.6 mg/l and 0.8 mg/l) were used alone and in combination, just before anthesis and after colour break stage. The result showed that the date of initiation of flowers varied from 15th March among the treatments. The maximum total number of flowers per panicle, number of fruits per panicle, fruit weight and yield (637.67, 12.33, 19.42 g and 59.53 kg/tree respectively) was recorded with the treatment of brassinosteroid sprayed with T_{12} (0.8 mg/l just before anthesis + at after colour break stage). Among four different concentration (0.2, 0.4, 0.6 and 0.8mg/l) of brassinosteroid as foliar spray, all yield attributing and biochemical parameters showed the best results with 0.8 mg/l applied at just before anthesis and after colour break stage.

Keywords: Litchi, Brassinosteroid, Flowering behavior, Fruiting behavior, Yield

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INTRODUCTION

Litchi (*Litchi chinensis* Sonn.), an important fruit of Southern Chinese native, belongs to family Sapindaceae. It is one of the most important evergreen and subtropical fruit crops of Bihar, India. Litchi is crowned as the "Queen of the fruit" due to its attractive deep pinkish to reddish fruit peel colour and perfect blend of sweet, sour and juicy and fragrant aril. Its flavored, translucent aril is very much popular in India as well as all over world. A major problem of this attractive fruit is very less time availability so it is very important to enhance the maturity period of litchi and thus increase the availability period in the market. Among the various constraints in its production, less time occurrence hampers the availability of yield and quality of the fruits that need to be managed to achieve its potential towards a more prosperous litchi economy. There are several well established low cost strategies reported throughout the world to enhance the quality and productivity of different agri-horticultural crops. Among all techniques, exogenous application of various plant growth regulators has been found effective for stimulation of fruit growth and maturity. Higher yield with improved fruit quality by the use of plant growth regulators has been reported in mango (Wahdan *et al.*, 2011), citrus (Gonzales *et al.*, 1987), apple (Turk *et al.*, 2010) and other fruits. Exogenous application of PGRs has also been reported to improve the endogenous levels of phytohormones (Al-Duljaili *et al.*, 1987), mineral nutrients (Bist 1990) which stimulate the growth, flowering and fruiting of different fruit crops (Al-Duljaili *et al.*, 1987; Randhawa *et al.*, 1959). Therefore, to improve the productivity of litchi fruits in the country, it is the urgent need to study the performance of PGRs on growth, yield and quality of litchi. Among different PGRs, brassinosteroid plays an important role in various aspects of plant physiological responses including cell division, cell elongation, vascular differentiation, flowering, pollen growth and photomorphogenesis (Clouse 2011).

According to Nolan *et al.* (2020), brassinolides (BRs) ranked sixth position among phytohormones and are widely used in all kinds of plants and take part in growth and development. Schrick *et al.* (2002) stated that the production of BRs is a complex process and mainly of two routes: the first one is the synthesis of campesterol from acetyl coenzyme A, and second is the direct synthesis of BRs from campesterol. During synthesis of BRs it needs many steps of oxidation, deoxygenation, hydrogenation, hydroxylation and isomerization and finally synthesis of castasterone (CS) which in due course changed to brassinolide (BL), the last product which is the most biologically dynamic product. BRs can help in cell division and expansion, balance plant vegetative and reproductive growth, encourage photosynthesis, promote resistance in plants against biotic and abiotic stress, fruit ripening and finally increase yield Ghosh *et al*., (2022). BRs not only improve the size, colour, flavor and quality of fruits but also regulate fruit ripening process by interacting with other factors.

Fruit ripening is a complex and synchronized developmental practices with irreversible changes in texture, flavor, aroma,

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color and nutritional components (Giovannoni *et al*., 2017). Market competition and its commercial value depends on the quality of the produce which act as an indicator or demand in the market. Most of the previous studies were focused on improving the nutritional status of the produce, appearance and storability of fruits (Fenn and Giovannoni, 2021). As discussed earlier, BRs are much more concerned in the course of fruit ripening and may also enhance the fruit storage quality, which making it reasonably valuable. Several reports on brassinosteroids showed that it implicated in fleshy fruit development and ripening of tomato fruit (Vardhini and Rao 2002, Lisso *et al.*, 2006) and grape (Symons *et al.*, 2006).

MATERIALS AND METHODS

The present investigation was carried out under the experimental area of Horticulture Garden, Department of Horticulture (Fruit & Fruit Technology), Bihar Agricultural College, Sabour. Total thirteen treatments were selected with three replications in a randomized block design. All the trees were maintained under uniform cultural schedule during the entire course of investigation. Treatments details before anthesis [T_1:(0.2 mg/l),T_2:(0.4 mg/l), T_3:(0.6 mg/l) and T_4: (0.8 mg/l)], after colour break stage [T_5: (0.2 mg/l), T_6: (0.4 mg/l), T_7: (0.6 mg/l), T_8: (0.8 mg/l) and T_9: (0.2+0.2mg/l)] and beforeanthesis + after colour break stage [T_{10}:(0.4+0.4mg/l), T_{11}: (0.6+0.6mg/l), T_{12}:(0.8+0.8mg/l) and T_{13}: (control)]. Sabour is about 10 km east of Bhagalpur town in the state of Bihar, India. Bihar Agricultural College, Sabour is situated at co-ordinates 25.23'76" °N, 87.05'07" °E and at an altitude of 52.73 m above mean sea level in alluvial Gangetic plains of North India, South to River Ganga. The climate of this place is sub-tropical to tropical with semi-arid in nature and characterized by hot summer, moderate rainfall and cold frostless winter which are favourable condition for litchi cultivation. The data pertaining the weather condition during the period of research experimentation were collected from the meteorological observatory unit of the Bihar Agricultural College, Sabour, Bhagalpur.

Preparation of working solution

Brassinosteroid (2,4-Epibrassinolide) is not water soluble. Therefore, it was first dissolved in DMSO and then poured it in the required amount of water to prepare the working solution. DMSO is taken @ 3ml/mg of brassinosteroid. After preparation of solution sprayed over the experimental litchi trees during before anthesis and colour break stage as per the treatment details. The date of anthesis during experiment was recorded by daily visiting the field. Based on the date of panicle emergence in previously tagged branches in all direction, date of fruit set, duration of fruit set, duration of 50% flowering was recorded. From the beginning of flowering to date of fruit set, the number of days was counted as fruiting period. Three panicles of each replication were tagged for counting the total male and female flowers per panicle. The average of the three panicles from each replication was calculated. Male and female flowers per panicle were divided to find the sex ratio. The four panicles from each treatment were selected randomly and tagged for recording fruit set per panicle; average of four panicles from each replication was calculated. The experimental design was randomised block design with three replications. The value of Critical difference (CD) at 5 % level were calculated to show the significance of differences between mean values of treatments.

RESULTS AND DISCUSSION

Flowering characters

Among the treatments the date of start of flowering varied from 15th March in T_{11}, T_{12}, and T_4 to 19th March in T_{13},T_7 and T_5.Thus, initiation of flowering was within 4 days in all treatments (Table 1).

The date of 50 % flowering varied from 24th March in $T_{12}$and $T_{11}$to 29th March in treatment T_5 and T_6. The data regarding duration of flowering under different treatments were found

Table 1: Meteorological data at Sabour, Bhagalpur, Bihar during 2019-20

Year	Month	Temperature		Relative humidity		Rainfall (mm)	Sunshine hrs.	EP	Wind speed (km/hr)
		Max.	Min.	7 AM	2 PM				
2019	**Oct**	30.8	21.7	89.4	78.5	23.4	4.2	1.2	2.7
	Nov	28.9	16.2	87.6	76.1	0.0	3.3	1.1	2.1
	Dec	21.2	9.3	91.4	75.9	2.5	3.5	0.6	3.9
2020	**Jan**	21.9	8.8	93.0	71.0	6.0	4.5	1.0	4.2
	Feb	24.1	9.7	88.4	66.7	38.4	6.5	1.6	3.6
	Mar	30.5	16.8	86.6	59.1	48.0	6.7	3.5	4.6
	April	33.1	20.2	88.5	65.0	71.4	6.7	5.4	6.8
	May	32.3	22.2	83.9	72.6	103.6	8.1	4.7	5.0

to be at par as there was no significant influence observed due to different doses of brassinosteroids. However, it was varied from 13.33 days in T_{13}(control) to 14.67 days in T_{12}(0.8+0.8 mg/l before anthesis and after colour break stage), T_{11}, and T_4. This might be due to change environmental condition during that period. Number of flowers per panicle was significantly affected due to the spray of different doses of brassinosteroids. The treatment $T_{12}$was found maximum flowers per panicle (667.67) and minimum in control (586.67). Percentage of female flower was significantly affected by the different doses of brassinosteroids and found highest (35.28 %) in T_{12} and lowest (28.13%) in T_{13} (control). The brassinosteroids spray affects significantly on sex ratio of litchi cv Purbi and found highest (2.52) in T_5 while, lowest (1.84) in T_{12}(Table 2).

Table 2: Effect of brassinosteroids on date of anthesis, duration of flowering, no. of flowers per panicle and female flowers per cent

Treatments	Dose	Time of spray	Date of anthesis	Date of 50% flowering	Duration Offlowering (Days)	No. of flowers / panicle	Female flower (%)
T_1	0.2 mg/l	Before anthesis	18-03-2020	27-03-2020	14.33	615.00	32.87
T_2	0.4 mg/l	-do-	17-03-2020	26-03-2020	14.33	617.33	33.88
T_3	0.6 mg/l	-do-	16-03-2020	25-03-2020	14.33	630.67	34.12
T_4	0.8 mg/l	-do-	15-03-2020	25-03-2020	14.67	640.33	35.14
T_5	0.2 mg/l	After colour break stage	19-03-2020	29-03-2020	13.67	581.67	28.55
T_6	0.4 mg/l	-do-	18-03-2020	29-03-2020	14.00	584.33	28.53
T_7	0.6 mg/l	-do-	19-03-2020	28-03-2020	14.00	593.00	28.58
T_8	0.8 mg/l	-do-	18-03-2020	28-03-2020	14.33	595.33	28.73
T_9	0.2+0.2 mg/l	Before anthesis + after colour break stage	17-03-2020	25-03-2020	14.00	595.00	32.98
T_{10}	0.4+0.4 mg/l	-do-	16-03-2020	25-03-2020	14.33	627.67	33.86
T_{11}	0.6+0.6 mg/l	-do-	15-03-2020	24-03-2020	14.67	635.00	34.36
T_{12}	0.8+0.8 mg/l	-do-	15-03-2020	24-03-2020	14.67	667.67	35.28
T_{13}	Control	--	19-03-2020	29-03-2020	13.33	586.67	29.71
CD (P=0.05)	--	--	--	--	NS	42.60	3.47
CV (%)	--	--	--	--	--	4.12	6.43

Date of initiation of fruit set varied from 31st March in T_4(0.8 ppm before anthesis) to 3rd April in T_{13}(control). The difference between initiations of fruit set was recorded 4 days. Duration of fruit set was found non- significant effect. However, it was found increased in all the treatments of brassinosteroids on trees before anthesis and varied from 8.67 days in T_{12}(0.8 ppm before anthesis and after colour break stage) to 6.67days in T_{13} (control). The number of flowers per panicle was highest in plants treated with brassinosteroids at a dose of 0.8 mg/l (T_{12}) before anthesis and after colour break stage. On the other hand, non-significant effect was recorded in duration of flowering. This is possible because the shift from the vegetative to reproductive phases is considered the most significant developmental change in a plant. A number of complicated and inter connected signal transduction mechanisms, control this developmental transition. The expression of genes involved in the initiation and development of floral organs is affected by both endogenous and external stimuli through these signal transduction pathways (Simpson and Dean, 2002). Brassinosteroid exhibitted both additive and synergistic effects on various hormones associated to flowering, according to the findings (Halliday, 2004; Khripach *et al.,* 1999). As a result, using a brassinosteroid before anthesis dramatically increases the quantity of flowers per panicle by hastening the floral initiation process inside the plant system (Yu *et al.,* 2008). In cactus pear (Opuntia *ficus indica*) BRs such as BB-6 and BB-16 helped in the initiation of vegetative buds about 1 week earlier and also increased the growth rate of cladodes (Cortes *et al.,* 2003).However, due to the maximum concentration of brassinosteroid in the treatment when it was sprayed before anthesis, regardless of concentration, the duration of blooming was recorded higher incomparison to the control. Mussig (2005) reported that BRs help in determining the branching and flower formation processes in plants through modulating metabolic pathways and nutrient allocation and/or by interacting with other signaling pathways. Likewise, Papadopoulou and Grumet (2005) reported that exogenous application of epi-brassinosteroids (EBRs) increased precocity in bearing as well as increase in the production of female flowers in cucumber.These findings support previous findings in several fruit crops by (Li *et al.*, 2010), (Clouse 2008), (Domagalska *et al.*, 2007), (Clouse and Sasse 1998), and (Pipattanawong *et al.*, 1996).

Fruiting characters

Number of fruits per panicle was found highly significant and was maximum (12.33 fruits per panicle) in T_{12}(0.8 ppm before anthesis and after colour break stage) whereas T_{13} (control) showed minimum with 7 fruits per panicle (Table 3). (Gomes *et al.*, 2006) reported a better increase in fruit number per panicle by spraying brassinosteroid during their productive growth phase and after fruit set in yellow passion fruit. This could be due to better amassing of photosynthates in the treated plants, which could be stimulated by the application of brassinosteroid. BRs are responsible for enhancement in the absorption efficiency of photosynthetic carbon in fruit trees. For example, in grapevines, the application of 24-epibrassinolide (24-EBL) at 0.01 and 0.1 ppm, improved the number of berries/bunch and total yield by 66.7 and 29.9% over untreated vines (Pozo *et al.*, 1994). Previous research revealed that brassinosteroid is likely to play a role in cell division, cell expansion, reproductive phase development, pollen tube production and fast differentiation of plant tissues, all of which contribute to increased berry output (Bishop *et al.*, 2002, Clouse *et al.* 2002; Sasse, 2003). Other crops that showed an increase in fruit yield when treated with brassinosteroid included yellow passion fruit (Gomes *et al.* 2006), groundnuts (Vardhini *et al.*, 1998), lupins (Kandelinskaya *et al.*, 2007) and grapes (Warusavitharana *et al.*, 2008).

Table 3: Effect of brassinosteroids on date of fruit set, sex ratio, duration of fruit set and number of fruits per panicle

Treatments	Dose	Time of spray	Date of fruit set	Sex ratio	Duration of fruit set (Days)	No. of fruits harvested/ panicle
T_1	0.2 mg/l	Before anthesis	02-04-2020	2.04	7.33	8.38
T_2	0.4 mg/l	-do-	02-04-2020	1.96	7.67	8.67
T_3	0.6 mg/l	-do-	01-04-2020	1.95	8.00	9.65
T_4	0.8 mg/l	-do-	31-03-2020	1.85	8.33	10.62
T_5	0.2 mg/l	After colour break stage	02-04-2020	2.52	7.00	7.67
T_6	0.4 mg/l	-do-	03-04-2020	2.51	7.33	7.83
T_7	0.6 mg/l	-do-	02-04-2020	2.51	7.67	8.33
T_8	0.8 mg/l	-do-	03-04-2020	2.48	7.67	8.70
T_9	0.2+0.2 mg/l	Before anthesis + after colour Break stage	02-04-2020	2.04	7.67	10.10
T_{10}	0.4+0.4 mg/l	-do-	01-04-2020	1.96	8.00	10.67
T_{11}	0.6+0.6 mg/l	-do-	01-04-2020	1.92	8.33	11.25
T_{12}	0.8+0.8 mg/l	-do-	31-03-2020	1.84	8.67	12.33
T_{13}	Control	--	03-04-2020	2.38	6.67	7.00
CD (P=0.05)	--	--	--	0.34	NS	0.46
CV (%)	--	--	--	9.26	--	2.91

CONCLUSION

The present investigation confirmed that the action of brassinosteroid is very quick and it also degrades very quickly. Therefore, repeated application of brassinosteroid reflected its long lasting action for improving physiological growth and maturity of litchi cv. Purbi with increased number of fruits per panicle. Further, among four different concentrations, foliar spray of brassinosteroid at before anthesis and after colour break stage with 0.8 ppm was found the best in respect of early flowering and fruiting and for improving number of fruits per panicle in litchi cv. Purbi.

Conflict of Interest

The Authors declare that there is no conflict of interest among the authors

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