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Effect of Paclobutrazol on Vegetative and Reproductive Phenology of Chickpea (*Cicer arietinum* L.)

Sumanta Panda[1], Subhasis Mondal[1], Suryakant Hembram[2], Kousik Atta[1] and Osman Ali[3]*
[1]*Department of Plant Physiology, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia (West Bengal), India.*
[2]*Assistant Botanist, Field Crop Research Station, Burdwan (West Bengal), India.*
[3]*Department of Agronomy, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia (West Bengal), India.*

(Corresponding author: Sumanta Panda)*
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ABSTRACT: Chickpea (*Cicer arietinum* L.) is the most important pulse crop in India. In spite of the impressive status of India in chickpea cultivation, its national yield is 956.4 Kg ha^{-1} which is poor compared to the corresponding figures for China (5.45 tonnes. ha^{-1}) or Moldova (4.08 tonnes ha^{-1}). Paclobutrazol is a widely used growth retardant that was reported to successfully enhance yield, regularize fruit-bearing, change the fruiting season, fruit quality etc. At the biochemical level, it acts as an inhibitor of gibberellin biosynthesis. The experimental material for the study consisted of chickpea variety *i.e.,* JAKI 92-18 with six treatments; 0 (control), 25, 35, 45, 55, and 65 ml/ ha. Paclobutrazol caused to delay in the appearance of floral bud, flower and pod formation though did not lengthen the attainment of physiological crop maturity. Paclobutrazol caused to reduced plant height, and no primary and secondary branches but enhanced no flower pod setting and pod at maturity though caused to decline in the proportion of the contribution of the secondary branches. The main challenges in this experiment were the concentration of paclobutrazol and the crop growth stage in which the effect could be remarkably distinguishable. The highest yield was obtained in paclobutrazol 35 ml/ha; other treatments with substantially higher yield than control were paclobutrazol 45 ml/ha, and paclobutrazol 25 ml/ha at the vegetative stage.

Keywords: Chickpea, Paclobutrazol, Phenology, Reproductive, Vegetative, Yield.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the most important pulse crop in India. It is the only cultivated species under the genus Cicer. It contains 61-62% carbohydrates, 18-22% proteins, 4-5% fats, 2.80 mg/g calcium, 3.01 mg/g phosphorus and Iron 123 µg with a calorific value of 396 Kcal/100 g. Due to their high nutritional value, chickpeas are a top source of protein and important nutrients like calcium, zinc, and iron for vegetarians (Lekshmy *et al*., 2009). In India, it is grown on more than 11.9 million hectares area, contributing 66% of the global production (11.38 million tonnes) and about 37% of the total pulse production in India (Khan and Mazid, 2018). Globally it is cultivated in 17.81 million ha to produce 17.19 million tonnes with 965 kg per hectare (FAOSTAT, 2018). In spite of the prominent status of India in chickpea cultivation, its national yield is 956.4 Kg/ha which is poor compared to the corresponding figures of China (5.45 tonnes/ha) or Moldova (4.08 tonnes/ha) (FAOSTAT, 2018). Plant growth regulators (PGRs) are known to improve physiological efficiency by improving photosynthetic ability, translocation and favourable partitioning of the assimilates, source-sink relationship and yield attributes and thereby may play a pivotal role in promoting the yield of the crops. Some of the plant growth regulators are physiologically involved in slowing down or arresting the growth processes. Such growth retardants actually limit vegetative growth without affecting photosynthesis and assimilate production. Judicious application of growth retardants was reported to be very effective in appropriately restricting vegetative growth and better partitioning of assimilates towards the economic sink, *i.e.*, yield-forming structures of the plants. According to Solamani *et al*. (2001), growth regulators can improve physiological efficiency, including photosynthetic ability, and the effective partitioning of accumulates from source to sink in field crops. Paclobutrazol is a widely used growth retardant that was reported to successfully enhance yield, regularize fruit-bearing, change the fruiting season, fruit quality etc. According to reports, paclobutrazol has the ability to reduce height. while keeping in mind the potential for synergism in the interaction between these PGRs, which could improve performances in terms of morphology and output (Tekalign and Hammes 2005; Kalyankar *et al*., 2008). At the biochemical level, it acts as an inhibitor of gibberellin biosynthesis. Its use in tropical and sub-tropical fruit crops is very popular and now is being tried with cereals, pulses and oilseed crops. In this background, the experiment was conducted with the objective to study the effect of paclobutrazol on the vegetative and reproductive phenology of chickpeas in relation to yield.

MATERIALS AND METHODS

The experiment was conducted at the district seed farm, A-B Block, B.C.K.V. at Kalyani, Nadia. The selection of the site was neutral alluvial soil, considered based on the suitability of the land for the cultivation of chickpeas. The chickpea variety, JAKI 92-18 was taken as experimental material for the study and as a variety of a rabi season crop, it was sown in the second week of November in the year 2019-20. The seeds of this variety were collected from International Centre for Agricultural Research in Dry Areas (ICARDA) on pulses, Kalyani Centre. The experiment was conducted with six treatments of a formulation of paclobutrazol 40% (0, 25, 35, 45, 55 and 65 ml/ha) each replicated thrice in a randomized block design. The treatments were imposed only once throughout the experiment at 41 days after sowing. The crop was harvested 110 days after sowing to estimate the yield parameters. The mean was computed for the data on various parameters for analyses of variance (ANOVA) using SAS ® 9.2 statistical software.

RESULTS AND DISCUSSION

Reproductive phenological development. The control was earliest in attaining all the reproductive stages like bud appearance, first flowering, 50% flowering, first podding, 50% podding and physiological maturity and the treatment Paclobutrazol 65ml/ha was most delayed in attaining the reproductive developmental stages. Higher the concentration of paclobutrazol in treatment, the more delay in attaining the stages. One interesting aspect of paclobutrazol treatment was, although the early reproductive stage like bud appearance and first flowering was delayed due to the treatments; physiological maturity was attained almost at the same time, similar results have been observed by Zaiter and Barakat (1995). The paclobutrazol treatment appeared to make the reproductive development more synchronous. Due to this synchronizing effect on paclobutrazol-treated crops, the duration between the first flower and physiological maturity declined compared to the control crop.

Table 1: Effect of paclobutrazol on reproductive phenology of chickpea variety JAKI 92-18.

Phonological events→ Treatments ↓	Days to							Yield /ha (Kg)
	Appearance of bud	First flowering	50% flowering	First podding	50% podding	Physiological maturity	Maturity from the First flower ↓	
Control P0	**48.3**	52.3	**61.7**	**65.7**	**75.0**	**110.3**	58	1315
P25	50.0	55.7	63.7	67.3	75.0	110.7	55.0	1692
P35	52.3	59.3	64.3	68.3	75.7	111.0	51.7	2008
P45	53.7	61.7	66.0	69.3	76.3	111.7	50.0	1783
P55	55.3	62.6	67.3	70.0	77.7	111.7	49.0	1304
P65	56.0	63.0	68.7	71.3	79.3	111.7	**48.7**	975
SEm(±)	2.27	3.76	2.69	3.16	3.27	3.80	3.93	181.77
CD	1.56	2.59	1.85	2.18	2.25	2.62	2.74	125.24

Table 2: Effect of paclobutrazol on the vegetative and reproductive structure of chickpea variety JAKI 92-18.

Treatment	Plant height (cm)	Per Plant								
		Primary branches	Secondary branches	Flowers	Pod setting	Pods at maturity	Main stem Pods	Primary branch Pods	Secondary branch Pods	Seed yield
Control	**68.8**	**7.0**	**9.4**	40.8	25.2	21.3	4.2	11.4	**5.7**	2.74
P25	66.3	6.3	7.6	45.7	30.0	28.2	5.2	16.4	5.6	3.07
P35	62.6	6.0	6.8	**50.1**	**36.5**	**35.6**	**8.1**	**22.1**	5.4	3.98
P45	61.2	5.7	6.0	48.4	31.7	29.0	7.4	16.6	5.0	3.53
P55	60.3	5.1	5.5	38.0	20.1	16.9	6.2	8.2	2.5	2.46
P65	**59.6**	**5.0**	**5.2**	**30.9**	**15.7**	**11.2**	**4.1**	**7.1**	**0.8**	1.79
SEm(±)	3.56	0.75	1.09	6.10	5.15	4.72	0.84	2.13	0.89	0.36
CD	2.45	0.52	0.75	4.21	3.55	3.25	0.58	1.47	0.61	0.25

Plant height was highest in the control (68.8 cm) and lowest in the highest dose of paclobutrazol, *i.e.*, paclobutrazol 65 ml/ha (59.5 cm) and it declined with an increase in the concentration of paclobutrazol in the treatment, the result supported by Gimhavanekar *et al.* (2017) in pigeon pea. All the treated chickpea plants were significantly shorter than the untreated control. The number of primary branches per plant was also highest in the control (7.0) and lowest in the highest dose of paclobutrazol, *i.e.,* paclobutrazol 65 ml/ha (5.0) and it declined with an increase in the concentration of paclobutrazol in the treatment. All the treated chickpea plants were significantly lower in the number of primary branches per plant than the untreated control. The same is the result with the number of secondary branches per plant: the highest value was recorded in the control (9.4) and the lowest value in the plants treated with the highest dose of paclobutrazol, i.e., paclobutrazol 65 ml/ha (5.2) and it declined with increase in the concentration of paclobutrazol in the treatment. All the treated chickpea plants were significantly lower in the number of secondary branches per plant than the untreated control. Valle and Dealmedia (1991) also reported that paclobutrazol decreases the diameter, height, leaf number and leaf area in all concentrations.

The plants treated with paclobutrazol 35 ml/ha bore the highest number of flowers (50.1) and those treated with paclobutrazol 65 ml/ha generated the lowest number of flowers. Compared to the control, the treatments paclobutrazol 35 ml/ha (50.1) and paclobutrazol 45 ml/ha (48.4) caused to produce a significantly higher number of flowers per plant whereas the treatment paclobutrazol 65 ml/ha (30.9) caused to reduce the number of flowers per plant. The pod setting was highest in the treatment paclobutrazol 35 ml/ha (36.5) and lowest in the treatment paclobutrazol 65 ml/ha (15.7). Compared to the control, a significantly better pod setting was observed in paclobutrazol 35 ml/ha (36.5), paclobutrazol 45 ml/ha (31.7), paclobutrazol 25 ml/ha (30.0) whereas paclobutrazol 55 ml/ha (20.1) and paclobutrazol 65 ml/ha (15.7) were significantly lower in this respect. The number of pods per plant at maturity was highest in the treatment paclobutrazol 35 ml/ha (35.6) and lowest in the treatment paclobutrazol 65 ml/ha (11.2). Compared to the control, a significantly better number of pods at maturity was observed in paclobutrazol 35 ml/ha (35.6), paclobutrazol 45 ml/ha (29.0), paclobutrazol 25 ml/ha (30.0) whereas paclobutrazol 55 ml/ha (16.9) and paclobutrazol 65 ml/ha (11.2) were significantly lower in this respect.

The pod setting was highest in the treatment paclobutrazol 35 ml/ha (36.5) and lowest in the treatment paclobutrazol 65 ml/ha (15.7). Compared to the control, a significantly better pod setting was observed in paclobutrazol 35 ml/ha (36.5), paclobutrazol 45 ml/ha (31.7), paclobutrazol 25 ml/ha (30.0) whereas paclobutrazol 55 ml/ha (20.1) and paclobutrazol 65 ml/ha (15.7) were significantly lower in this respect. The number of main stem pods per plant was highest in the treatment paclobutrazol 35 ml/ha (8.1) and lowest in the treatment paclobutrazol 65 ml/ha (0.8). Compared to the control, a significantly higher number of main stem pods was observed in paclobutrazol 35 ml/ha (8.1), paclobutrazol 45 ml/ha (7.4), paclobutrazol 55 ml/ha (6.2) and paclobutrazol 25 ml/ha (5.2). The number of primary branch pods per plant was highest in the treatment paclobutrazol 35 ml/ha (22.1) and lowest in the treatment paclobutrazol 65 ml/ha (7.1). Compared to the control, a significantly higher number of primary branch pod was observed in paclobutrazol 35 ml/ha (22.1), paclobutrazol 45 ml/ha (16.6), paclobutrazol 25 ml/ha (16.4) whereas paclobutrazol 55 ml/ha (8.2) and paclobutrazol 65 ml/ha (7.1) significantly lower in this respect. The number of secondary branch pods per plant was highest in the control and its values declined with an increase in the concentration of paclobutrazol in the treatment. Though the number of secondary branch pods in the paclobutrazol 25 ml/ha (5.6), paclobutrazol 35 ml/ha (5.4) and paclobutrazol 45 ml/ha (5.0) was statistically at par with the control, in terms of proportion the contribution of secondary branch pods declined greatly. Seed yield was highest in paclobutrazol 35ml/ha. Compared to the control seed yield was significantly higher in paclobutrazol35ml/ha paclobutrazol45 ml/ha and paclobutrazol 25 ml/ha. Similar results were obtained by Tripathi *et al*. (2009).

The results of an experiment can be summarized as paclobutrazol caused enhanced flowering, pod setting and no. of pods at maturity. The increased no. of pods and seeds per plant was the main contributor to the enhanced yield due to paclobutrazol treatments. Paclobutrazol caused to delay in the appearance of floral bud, flower and pod formation though did not lengthen the attainment of physiological crop maturity. Paclobutrazol caused reduced plant height, no of primary and secondary branches but enhanced no. of flower, pod setting and pod at maturity though caused to decline in the proportion of the contribution of the secondary branches. The highest yield was obtained in paclobutrazol 35 ml/ha; other treatments with substantially higher yields than the control were paclobutrazol 45 ml/ha, and paclobutrazol 25 ml/ha. The application of growth retardants may have improved yield and yield-attributing characters in field crops due to their positive effect on growth, which resulted in the development of higher yield-attributing characters and, ultimately, increased seed yield (Deotale *et al*., 1995; Arora *et al*., 1998; Upadhyaya, 2002; Kiran *et al*., 2005).

CONCLUSIONS

The highest yield was obtained in paclobutrazol 35 ml/ha; other treatments with substantially higher yield than control were paclobutrazol 45 ml/ha, and paclobutrazol 25 ml/ha at the vegetative stage.

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Conflict of Interest. None.

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