International Journal of Economic Plants

https://ojs.pphouse.org/index.php/IJEP

Crossref

IJEP November 2024, 11(4): 431-434

Article IJEP5726d

Full Research

Doi: HTTPS://DOI.ORG/10.23910/2/2024.5726d

Effect of Paclobutrazol on Biochemical and Yield Attributes of Chickpea (*Cicer arietinum* L.)

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Article History

Received on 24th August, 2024
Received in revised form on 29th October, 2024
Accepted in final form on 14th November, 2024

Abstract

The experiment was carried out during the *rabi* (winter) season (2nd week of November to last week of Feburary) of 2019 and 2020 at the District Seed Farm, 'AB' block, Kalyani at Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal to study the effect of paclobutrazol on the biochemical and yield attributes of chickpeas with yield. The experiment was laid down in a randomized block design having six treatments of a formulation of paclobutrazol 40% (0, 25, 35, 45, 55 and 65 ml ha^{-1}) with each replicated four times and the experimental material for the study consisted of chickpea variety was JAKI 92-18. Results revealed that Paclobutrazol caused to decline in the leaf chlorophyll content and enhanced the accumulation of storage carbohydrates particularly starch in the leaf. Leaf soluble sugar content was lowest in the control (2.86) and all the treatments were significantly higher than the control in this respect. It caused to enhance the seed yield by enhancing the number of seeds plants^{-1} and improving the harvest index. The highest yield was obtained in paclobutrazol 35 ml ha^{-1} (2008 kg ha^{-1}); other treatments with substantially higher yields than control were paclobutrazol 45 ml ha^{-1} (1783 kg ha^{-1}), and paclobutrazol 25 ml ha^{-1} (1692 kg ha^{-1}). Hence, foliar application of Paclobutrazol @ 35 ml l^{-1} may be most effective in augmenting the yield attributes and yield of chickpea during *rabi* season.

Keywords: Chickpea, chlorophyll, harvest index, paclobutrazol, sugar, starch, yield

1. Introduction

Chickpea (*Cicer arietinum* L.) is the most important pulse crop mainly grown in semi-arid and arid regions in India and across the globe (Gaur et al., 2012). It is one of the most important food grain legumes in the world after the common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.) (Muehlbauer and Sarker, 2017). Chickpea seed has 9% protein, 38–59% carbohydrate, 3% fibre, 4.8–5.5% oil, 3% ash, 0.2% calcium and 0.3% phosphorus (Nain et al., 2022). . With an average protein content of almost 18–22%, chickpeas have a higher protein content than lentils and field peas (Upadhyaya et al., 2016). It also contains important amino acids along with ß-carotene, as reported by Jukanti et al. (2012) and Thudi et al. (2014). Additionally, compared with animal protein, chickpea is the major and cheap source of protein especially for the vegetarian population (Singh et al., 2016). 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 in more than 11.9 m ha area which contributes 66% of the global production (11.38 mt) and about 37% of total pulse production in India (Khan and Mazid, 2018). Globally it is cultivated in 17.81 m ha to produce 17.19 mt with 965 kg hectare^{-1} (Anonymous, 2018). Despite the prominent status of India in chickpea cultivation, its national yield is 956.4 kg ha^{-1} which is poor compared to the corresponding figures of China (5.45 t ha^{-1}) or Moldova (4.08 t ha^{-1}) (Anonymous, 2018). The average yield productivity of chickpea in the country is very low when we compare it with the world's chickpea productivity (Hidoto et al., 2017). The productivity of chickpeas can be further enhanced by adopting improved high-yielding varieties and scientific crop management practices (Kumar et al., 2016). Growth regulators promote root and shoot growth (Kim et al., 2018, Steffens et al., 2006), improve physiological efficiency, including photosynthetic ability (Solamani et al., 2001), enhance water use efficiency, promote flowering and pod setting (Nagel et al., 2001), increase or decrease chlorophyll content (Sun et al., 2016), improve photosynthetic rate (Travaglia et al., 2009), enhance the translocation of photoassimilates and increase biomass accumulation (Liu et al., 2019) resulting in enhanced growth and yield. The growth-regulating properties of paclobutrazol are mediated by changes in the levels of important plant hormones including gibberellins, abscisic acid and cytokinins (Soumya et al., 2017). When hormone acts upon the plant system, it enters some direct and molecular interactions, eventually manifesting measurable physiological and biochemical effects (Kumar and Purohit, 2011). PBZ has been used to provide plant protection against abiotic stresses viz chilling (Lin et al., 2006), water deficit stress (Zhu et al., 2004), flooding (Lin et al., 2006) and salinity (Kishor et al., 2009). 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 reports, paclobutrazol can 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). 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 to study the effect of paclobutrazol on the biochemical and yield attributes of chickpeas with yield.

2. Materials and Methods

The experiment was sown during the 2nd week of November, 2019 and harvested during the last week of February, 2020 at the district seed farm, A-B Block, B.C.K.V. Kalyani, Nadia, West Bengal, India. The farm is situated at 23.5°N latitude and 89.0°E longitude with an average altitude of 9.75 meters above mean sea level. The land topography is technically known as medium land. 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 the 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^{-1}) each replicated four times in a randomized block design. The treatments were imposed only once throughout the experiment at 41 days after sowing and biochemical parameters were measured after 30 days after treatment were imposed. Seeds of ten randomly selected plants form each plot were collected, dried and weighed and for straw yield, after collection of seeds from the chickpea plant from ten randomly selected plants form each plot, the rest parts of the plants were dried and weighed; the value was then divided by ten for the both cases, expressed in gram and recorded as seed yield plant^{-1}. The chlorophyll content in the leaf sample was estimated as per Arnon, (1949) and extraction and estimation of starch and soluble sugar were done following the method of Yoshida et al. (1973). The crop was harvested 110 days after sowing to estimate the yield attributes. The mean was computed for the data on various parameters for analyses of variance (ANOVA) using SAS ® 9.2 statistical software.

3. Results and Discussion

Chlorophyll-a was highest in control and lowest in paclobutrazol 65 ml ha^{-1}. Compared to the control it was at par with paclobutrazol 25 ml ha^{-1} whereas significantly lower in the rest of the treatments. Chlorophyll-b also was highest in control plants and lowest in paclobutrazol 65 ml ha^{-1}. All the paclobutrazol treatments were significantly lower than the control in this respect. A decline in chlorophyll-b due to paclobutrazol treatment was more severe than chlorophyll-a. Total chlorophyll content was also highest in the control and lowest in paclobutrazol 65 ml ha^{-1}. Compared to control all the treatments were significantly lower than the control. Leaf soluble sugar content was lowest in the control and all the treatments were significantly higher than the control in this respect. Interestingly, the soluble sugar content of all the paclobutrazol-treated plants was at par with each other. Leaf starch was lowest in control and highest in paclobutrazol 65 ml ha^{-1}. The higher the concentration of paclobutrazol in the treatments, the greater the starch content of the chickpea leaves. The same was the pattern in total storage carbohydrates. (Table 1)

Table 1: Effect of paclobutrazol on the biochemical parameters of chickpea variety JAKI 92-18

Treat-ment	Chl a	Chl b	Total Chl	Leaf		
				Sugar	Starch	C'hydrate
Control	2.224	0.755	2.979	2.86	5.16	8.02
P25	2.066	0.654	2.720	3.41	5.61	9.02
P35	1.840	0.524	2.364	3.51	6.52	10.03
P45	1.588	0.403	1.991	3.52	7.48	11.00
P55	1.301	0.281	1.582	3.50	8.59	12.09
P65	1.133	0.203	1.336	3.48	8.92	12.40
SEm±	0.235	0.70	0.335	0.671	1.090	1.424
CD (p=0.05)	0.162	0.048	0.231	0.462	0.751	0.981

The number of seeds plant^{-1} was highest in the treatment of paclobutrazol 35 ml ha^{-1} and the lowest in paclobutrazol 65 ml ha^{-1}. Compared to the control, no of seeds plants^{-1} was significantly higher in paclobutrazol 35, 45, 25 ml ha^{-1}. 100 seed weight was highest in the treatment of paclobutrazol 65 ml ha^{-1} and lowest in the control. 100 seed weight was at par with control in paclobutrazol 35, 25, 45 ml ha^{-1}. Straw yield was highest in the control and lowest in the treatment of paclobutrazol 65 ml ha^{-1}. It was significantly lower than the control in all the treatments of paclobutrazol. Seed yield was highest in paclobutrazol 35 ml ha^{-1}. Compared to the control, seed yield was significantly higher in paclobutrazol 35 ml ha^{-1}, paclobutrazol 45 ml ha^{-1}, and paclobutrazol 25 ml ha^{-1}. Biological yield was at par with control in the treatments 25, 35, 45 ml ha^{-1} but significantly lower in paclobutrazol 55 ml ha^{-1}, and paclobutrazol 65 ml ha^{-1}. The Harvest index was highest in paclobutrazol 35 ml ha^{-1}. Compared to control, higher harvest index was recorded in paclobutrazol 35, 45, 25 ml ha^{-1}. Yield plot^{-1} was highest in paclobutrazol 35 ml ha^{-1}. Compared to the control, it was higher in paclobutrazol 35 ml ha^{-1}, paclobutrazol 45 ml ha^{-1}, and paclobutrazol 25 ml ha^{-1}. Yield meter square^{-1} was derived from yield plot^{-1} and hence pattern was the same. Yield meter^{-1} square was derived from yield plot^{-1} and hence pattern was the same (Table 2).

The results of the experiment can be summarized that paclobutrazol caused to decline in the leaf chlorophyll content out of which chlorophyll-b was more affected and enhances the soluble sugar and starch content as well as total carbohydrate content. As a whole, the results of this experiment may be interpreted that the phenological, and reproductive events were delayed due to the non-availability of the photosynthetic assimilate for metabolic activity, growth and developmental processes as it was stored in their storage form. When the growth inhibitory impact of paclobutrazol gradually got diluted, the storage carbohydrates became available at the stage that coincided with the reproductive stage and caused enhanced yield due to paclobutrazol treatments. The photosynthetic pigment chlorophyll that gradually reduced due to paclobutrazol treatment probably did not interfere with the photosynthetic capacity of the chickpea plant till it got down to a critical value in cases of higher doses of paclobutrazol. Enhancement of leaf storage carbohydrate in cases of paclobutrazol treatments supported the fact of accumulation of photosynthetic assimilates in non-available form. So, from the results of the present experiment following conclusions can be drawn: Paclobutrazol caused a decline in the leaf chlorophyll content and enhanced the accumulation of storage carbohydrates particularly starch in the leaf. It caused to enhance the seed yield by enhancing the number of seeds plants^{-1} and improving the harvest index. The highest yield was obtained in paclobutrazol 35 ml ha^{-1}; other treatments with substantially higher yields than control were paclobutrazol 45 ml ha^{-1}, and paclobutrazol 25 ml ha^{-1}.

Table 2: Effect of Paclobutrazol on yield and yield parameters of chickpea variety JAKI 92–18

Treatment	No. of seeds plant^{-1}	Test weight (100 Seed) (g)	Straw yield plant^{-1} (g)	Seed yield plant^{-1} (g)	Biological yield plant^{-1} (g)	HI (%)	Yield plot^{-1} (kg)	Yield m^{-2} (g)	Yield ha^{-1} (kg)
Control	21.1	19.71	8.01	2.74	10.75	0.25	1.58	131.7	1315
P25	24.5	19.98	7.43	3.07	10.80	0.29	2.03	169.2	1692
P35	30.3	20.01	7.14	3.98	11.12	0.36	2.41	200.8	2008
P45	25.2	20.09	7.68	3.53	11.21	0.31	2.14	178.3	1783
P55	14.6	21.27	7.35	2.46	9.81	0.25	1.57	130.8	1304
P65	13.2	21.90	7.19	1.79	8.98	0.20	1.17	97.5	975
SEm±	3.25	2.21	0.60	0.36	1.04	0.035	0.22	18.14	181.77
CD (p=0.05)	2.24	1.52	0.41	0.25	0.72	0.024	0.15	12.52	125.24

4. Conclusion

Among the different foliar concentrations of paclobutrazol, the highest yield was obtained at paclobutrazol 35 ml ha^{-1}, other treatments also gave substantially higher yields than the control were paclobutrazol 45 ml ha^{-1}, and paclobutrazol 25 ml ha^{-1} and It was resulted due to enhancement of the seed yield by increasing the number of seeds plants^{-1}. Therefore, foliar application of Paclobutrazol 40% @ 35 ml l^{-1} could be more effective in augmenting better yield of chickpea during the rabi season.

5. Acknowledgement

Authors are thankful to the Department of Plant Physiology, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, 741 252, West Bengal and International Centre for Agricultural Research in Dry Areas (ICARDA) on pulses, Kalyani Centre.

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