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Effect of Phosphorus and Boron Levels on Growth and Yield of Chickpea (*Cicer arietinum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) during *Rabi* season of 2021 to study the "Effect of phosphorus and boron levels on growth and yield of chickpea (*Cicer arietinum* L.)". The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1). The experiment was laid out in Randomized Block Design, nine treatments and were replicated thrice. The treatments comprising of different levels of phosphorus and boron whose effect was observed in chickpea. The results showed that application of phosphorus @ 60 kg/ha along with boron @ 3 kg/ha recorded significantly maximum Plant height (53.11 cm), Number of nodules/plant (44.56), Plant dry weight (30.36 g/plant), Number of pods/plant (52.67), Number of seeds/pod (1.80), Test weight (225.67 g), Seed yield (2109.93 kg/ha), Stover yield (3428.07 kg/ha). Therefore, treatment with application of phosphorus @ 60 kg/ha along with boron @ 3 kg/ha was most productive and cost effective.

Keywords: Phosphorus; boron; growth; nodulation; yield.

1. INTRODUCTION

"Chickpea (*Cicer arietinum* L.) belongs to the family Fabaceae, within the tribe Cicerae. It is a self-pollinated, diploid, annual Grain legume crop. Chickpea (*Cicer arietinum* L.) is the largest produced food legume in South Asia and the third largest produced food legume globally, after

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common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.). Chickpea is grown in More than 50 countries (89.7% area in Asia, 4.3% in Africa, 2.6% in Oceania,2.9% in Americas and 0.4% in Europe" [1]. "Its requirement in India is projected to be around 10.22 million tones by the year 2030 that's needs a 4% increase in the annual growth rate" [2]. "The current average global yield of chickpea is 0.9 t ha^{-1}, which is much lower than its estimated potential of 6 t ha^{-1} under the optimum cultivation conditions" [3]. "Chickpea is classified into two types, desi and kabuli. Desi types are small in size, angular in shape with brown seed colour and hard seed coat. Desi chickpea is primarily grown in the semi-arid tropical climates, while kabuli are white seed coat colour and larger in size with smoother seed coat. Kabuli chickpea is primarily grown in the temperate climates. Chickpea also plays an important role in sustaining soil productivity by improving its physical, chemical and biological properties and trapping atmospheric nitrogen in their root nodules" [4]. It is an important source of high quality protein in human nutrition and also provides high quality crop residues for animal feed.

"Sufficient supply of phosphorus to plant, hastens the maturity and increases the rate of nodulation and pod development. Phosphorus also imparts hardline to shoot, improves the quality and regulates the photosynthesis and covers other physico- biochemical process. Most of the phosphorus present in the soil is unavailable to plants which are made available through the activities of efficient micro-organisms like bacteria, fungi and even cyanobactin with production of organic acid and increasing phosphatase enzyme activity" [5]. "Pulses require phosphorus for growth and nitrogen fixation. Since it helps for better root development, phosphorus application is a must for the crops grown under rainfed conditions. Recent researches revealed that there is a good response of chickpea to phosphorus fertilizer" [6].

"Boron is a micronutrient plays an important role in increasing yield of pulse legumes. It is very important in cell division and in pod and seed formation. Boron ranks third places among micronutrients in its concentration in seed and stem as well as its total amount after zinc" [7]. "Boron significantly affected the seed yield of chickpea. Seed yield of chickpea increased with the application of boron @ 1.5- 2.5 kg/ ha" [8]. "The application of boron resulted in a higher production of dry matter, due to an increase of the dry weight of pods including seeds" [9]. The present investigation was therefore carried out to study the effect of phosphorus and boron levels on growth and yield of chickpea. This can increase the production and productivity of the crop.

2. MATERIALS AND METHODS

The experiment was conducted during *Rabi* 2021. The experiment was conducted in Randomized Block Design consisting of nine treatment combinations with three replications and was laid out with the different treatments allocated randomly in each replication. The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low organic carbon (0.36%), available N (171.48 kg/ha), available P (15.2 kg/ha), available K (232.5 kg/ha). The treatment viz. T_1 - Phosphorus 20 kg/ha + Boron 1 kg/ha, T_2 - Phosphorus 20 kg/ha + Boron 2 kg/ha, T_3- Phosphorus 20 kg/ha + Boron 3 kg/ha, T_4- Phosphorus 40 kg/ha + Boron 1 kg/ha, T_5- Phosphorus 40 kg/ha + Boron 2 kg/ha, T_6- Phosphorus 40 kg/ha + Boron 3 kg/ha, T_7- Phosphorus 60 kg/ha + Boron 1 kg/ha, T_8- Phosphorus 60 kg/ha+ Boron 2 kg/ha, T_9- Phosphorus 60 kg/ha + Boron 3 kg/ha. Five random plants were selected from each plot to record observations on plant growth parameters viz., Plant height (cm), Number of nodules per plant, Plant dry weight (g) whereas yield attributes viz., Number of pods per plant, Number of seeds per pod, Test weight (g), Seed yield (kg/ha) and Stover yield (kg/ha) were recorded at harvesting stage from net plot. The seed and Stover yield was taken for the net plot of $1m^2$ and further calculated to 1 hectare. Harvest index is calculated using the formula (economic yield / biological yield) × 100. The experimental data were analyzed statistically by ANOVA technique. Significant difference among the treatment mean was verified against the critical difference at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Crop growth parameters in chickpea were measured in terms of plant height (cm), plant dry weight (g) at harvesting stage and number of nodules/plant at 60 DAS are shown in (Table 1).

During research trail, At harvest significantly higher plant height (53.11 cm) was observed in treatment T_9 with application of phosphorus 60 kg/ha and boron 3 kg/ha and treatment T_8 with application of phosphorus 60 kg/ha and boron 2 kg/ha was statistically at par. Phosphorus application results in increase of plant height, this is possible because phosphorus is the major constituent of ATP, and ATP are used in the Melvin - Calvin cycle to produce glucose molecule, hence phosphorus plays major role in photosynthesis, phosphorus enhances vigour and vitality of the plants. These results are consistent with that achieved from [10]. Significantly higher number of nodules (44.56) was observed at 60 DAS in treatment T_9 with application of phosphorus 60 kg/ha and boron 3 kg/ha and treatment T_8 with application of phosphorus 60 kg/ha and boron 2 kg/ha was statistically at par. Phosphorus is very much needed by the plants, but soil phosphorus gets fixed due to phosphorus fixation, it is made available to plants by phosphorus solubilizing bacteria, exogenous soil application of phosphorus produces growth promoting materials that helps in proliferation of PSB, PSB provide soil phosphorus to plants and also enhances nodulation in roots. These findings are in accordance with [11,12]. At harvest significantly higher dry weight (30.36) was observed in treatment T_9 with application of phosphorus 60 kg/ha and boron 3 kg/ha and treatment T_8 with application of phosphorus 60 kg/ha and boron 2 kg/ha was statistically at par. Maximum dry matter is observed during application of higher doses of phosphorus as it shows significantly effect on equilibrium of nutrients in the soil and due to higher absorption of phosphorus by chickpea and minimum biomass production is observed under lower doses of phosphorus [13].

3.2 Yield Attributes

The observation regarding yield and yield attributes viz., number of pods/plants, number of seeds/pod, test weight, seed yield, Stover yield and harvest index were shown in (Table 2). Significantly higher number of pods/plant (52.67) was observed in treatment T_9 with application of phosphorus 60 kg/ha and boron 3 kg/ha and treatment T_8 with application of phosphorus 60 kg/ha and boron 2 kg/ha was statistically at par. Significantly higher number of seeds/pod (1.80) was observed in treatment T_9 with application of phosphorus 60 kg/ha and boron 3 kg/ha and treatment T_8 with application of phosphorus 60 kg/ha and boron 2 kg/ha and treatment T_6 with application of phosphorus 40 kg/ha and boron 3 kg/ha were statistically at par. Significantly higher test weight (225.67) was observed in treatment T_9 with application of phosphorus 60 kg/ha and boron 3 kg/ha and treatment T_8 with application of phosphorus 60 kg/ha and boron 2 kg/ha was statistically at par. Significantly higher seed yield (2109.93 kg/ha) was observed in treatment T_9 with application of phosphorus 60 kg/ha and boron 3 kg/ha and treatment T_8 with application of phosphorus 60 kg/ha and boron 2 kg/ha was statistically at par. Significantly higher Stover yield (3428.07 kg/ha) was observed in treatment T_9 with application of phosphorus 60 kg/ha and boron 3 kg/ha and treatment T_8 with application of phosphorus 60 kg/ha and boron 2 kg/ha was statistically at par. Seed yield and stover yield that is biological yield of chickpea increases with increase in phosphorus, this increase is due to significant increase in vegetative characters such as no. of pods, seed weight etc. availability of high doses of phosphorus results in higher photosynthetic activity as phosphorus is major constituent of ATP and ATP is utilized in dark reactions of photosynthesis, phosphorus increases production of carbohydrates, sugars, starch, amino acids and proteins, which enhances pod and seed yield these eventually play role in enhancing biological yield. Beneficial effect of phosphorus on yield attributes were also observed by [14-16]. Higher levels of boron resulted in greater uptake of nutrients by seed and stover, boron also enhances chlorophyll content in leaf and there by bio mass and phosynthates production is increased, which are effectively transferred towards the roots for its development and to provide required energy for nutrient uptake this uptake results in higher biological yields. These results are also in close conformity with results of [17,18]. From the (Table 2) the results were observed that increasing levels of phosphorus from 20 kg/ha to 60 kg/ha and boron levels from 1 kg/ha to 3 kg/ha has significant effect on all the yield attributes such as number of pods/plant, number of seeds/pod, test weight (g), seed yield, stover yield, and harvest index.

Table 1. Effect of growth parameters in chickpea as influenced by phosphorus and boron levels

Treatments	Plant height(cm) At harvest	Number of nodulesper plant At 60 DAS	Plant dryweight (g) At harvest
Phosphorus 20 kg/ha + Boron 1 kg/ha	46.69	39.00	25.12
Phosphorus 20 kg/ha + Boron 2 kg/ha	47.93	39.22	25.38
Phosphorus 20 kg/ha + Boron 3 kg/ha	48.01	40.22	25.56
Phosphorus 40 kg/ha + Boron 1 kg/ha	48.49	41.11	25.74
Phosphorus 40 kg/ha + Boron 2 kg/ha	49.41	42.00	26.02
Phosphorus 40 kg/ha + Boron 3 kg/ha	50.83	42.56	28.56
Phosphorus 60 kg/ha + Boron 1 kg/ha	50.64	42.44	27.28
Phosphorus 60 kg/ha + Boron 2 kg/ha	52.04	43.22	29.63
Phosphorus 60 kg/ha + Boron 3 kg/ha	53.11	44.56	30.36
F test	S	S	S
SEm (±)	0.73	0.60	0.54
CD (p=0.05)	2.19	1.81	1.61

Table 2. Effect of Yield attributes in Chickpea as influenced by Phosphorus and Boron levels.

Treatments	Number ofpods per plant	Number of seeds per pod	Test weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
Phosphorus 20 kg/ha + Boron 1 kg/ha	47.93	1.27	186.00	1627.20	2992.00	35.20
Phosphorus 20 kg/ha + Boron 2 kg/ha	48.07	1.33	191.00	1709.07	3023.03	36.12
Phosphorus 20 kg/ha + Boron 3 kg/ha	48.67	1.47	196.33	1763.67	3096.70	36.29
Phosphorus 40 kg/ha + Boron 1 kg/ha	49.40	1.53	201.67	1819.30	3166.37	36.49
Phosphorus 40 kg/ha + Boron 2 kg/ha	49.67	1.53	207.33	1866.53	3209.10	36.77
Phosphorus 40 kg/ha + Boron 3 kg/ha	50.47	1.67	213.67	1981.27	3353.77	37.14
Phosphorus 60 kg/ha + Boron 1 kg/ha	50.67	1.60	212.00	1946.63	3303.67	37.08
Phosphorus 60 kg/ha + Boron 2 kg/ha	52.40	1.73	220.33	2044.10	3408.13	37.49
Phosphorus 60 kg/ha + Boron 3 kg/ha	52.67	1.80	225.67	2109.93	3428.07	38.10
F test	S	S	S	S	S	S
SEm (±)	0.43	0.06	3.86	22.21	17.32	0.31
CD (p=0.05)	1.28	0.19	11.56	66.59	51.93	0.94

4. CONCLUSION

From the above results, Effect of phosphorus and boron levels on chickpea were observed and there by it was concluded that application of phosphorus @ 60 kg/ha along with boron @ 3 kg/ha had performed better in growth parameters and yield attributes. As it was more productive. These findings are based on one season; therefore, further trails need to be conducted for further confirmation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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