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Effect of phosphorus and boron on the growth and yield of cowpea (*Vigna unguiculata* L.)

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Abstract
To study the retaliation performances of Phosphorous and Boron on growth, yield and yield attributes of cowpea (*Vigna unguiculate* Walp.) crop. A field experiment was executed during *Zaid* season of 2021 at crop research farm of SHUATS, Prayagraj to study about the effect of phosphorous and boron on growth and yield of cowpea. The experiment was laid out in most commonly encountered Randomized Block Design (RBD) with three replications of each treatment for all traits. In view of this experiment three phosphorous levels P1 (40 kg/ha), P2 (50 kg/ha), P3 (60 kg/ha) as well as three boron levels B1 (1 kg/ha), B2 (1.5 kg/ha), B3 (2 kg/ha). Result were revealed that maximum Plant height (75.64 cm), number of branches per plant (9.66), number of nodules per plant (16.80), Dry weight (67.24 g/plant), Seed yield (1.26 t/ha) and Straw yield (1.42 t/ha) and Harvest index (47.96 %) were found to be significantly higher with application of Phosphorous 60 kg/ha + Boron 2 kg/ha as compared to the other treatments. This study concluded that the maximum seed yield (1.26 t/ha) were obtained with application of Phosphorus 60 kg/ha + Boron 2.0 kg/ha which was significantly superior over rest of the treatments.

Keywords: Phosphorous, boron, yield and economics

Introduction

Cowpea (*Vigna unguiculata* L.) is one of the most important vegetable crops grown as pulse, vegetable and fodder. It is poor man's protein source and considered one of the most ancient human food sources and has probably been used as a crop plant since Neolithic times (Ng and Marechal 1985) [15]. Cowpea is a vital multipurpose grain legume extensively cultivated in arid and semiarid tropics. It is an important source of nutrients and provides high quality, inexpensive protein diet based on cereal grains and starch foods. Cowpea is a good source of food, fodder, vegetables and certain snakes (Singh *et al*., 2012) [20]. It is a crop that can be used as catch crop, mulch crop, intercrop and green crop. It has ability to fix atmospheric N_2 in the soil 56 kg/ha in association with symbiotic bacteria under favorable conditions (Mandal *et al*. 2009) [12]. The mature cowpea seed contains 24.8% protein, 63.6% carbohydrates, 1.9% fat, 6.3% fiber, 7.4 ppm thiamine, 4.2 ppm riboflavin and 28.1 ppm niacin (Ahlawat and Shivkumar 2005) [2]. The protein concentration ranges from about 3 to 4% in green leaves, 4 to 5% in immature pod and 25 to 30% in mature seeds. The amino acid profile reveals that lysine, leusine and phenylamine contents are relatively high in cowpea. In India pulses are grown nearly in 25.43 m ha with an annual production of 17.28 m t and an average productivity of 679 kg/ha (Anonymous, 2012) [4]. The per capita availability of pulses in India is 35.5 g/day as against the minimum requirement of 7 g/day/capita as advocated by Indian Council of Medical Research. Phosphorus is one of the most important elements required in many tropical soils for crop production. Phosphorus is necessary for growth of Rhizobium bacteria, responsible for nitrogen fixation for nodulation. Phosphorus Application to legume not only benefits the current crop but also has favourable effect on succeeding non- legume crop. It also improves the crop quality and resistance to diseases. It is a part of ADP, ATP, nucleic acid, flavin nucleotides, thiamine phosphate, phospholipids and phosphorylated sugar etc. It acts as energy storage and transformation. It is also essential for cell division, protein synthesis, root development, flowering, fruiting and seed formation. It also provides strength to straw to prevent them from logging. Boron is one of the essential micronutrient required for normal growth of the plants and plays a vital role in promoting growth, yield and nodulation in pea (Bolanos *et al*. 1994) [5]. The most important functions of boron in plants are thought to be its structural role in cell wall development, cell division, seed development and stimulation or inhibition of specific metabolic pathways for sugar transport and hormone development (Ahmed *et al*., 2009).

Furthermore, boron deficiency causes decrease in pollen grain count, pollen germination etc. It also influences growth parameters and filling up of seeds. It is usually accepted that boron availability is decreased under dry soil conditions. Thus, boron deficiency is often associated with dry weather and low soil moisture conditions. This behavior may the related to restricted release of boron from organic complexes which ultimately impaired ability of plants to extract B from soil due to lack of moisture in the rhizosphere. Even of B levels in soil is high, then also low soil moisture impairs transport of B to absorbing root surfaces (Das, 2011) [6].

Material and Methods

A field experiment was conducted during *Zaid* season of 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) which is located at 25 degree 24’41.29” N latitude, 81 degree 50’56” E longitude and 98 m altitude above the sea level. Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj. Having nearly neutral in soil reaction (pH 7.0), organic carbon (0.375 %), available nitrogen (168.75 kg/ha), available phosphorus (17.4 kg/ha) and available potassium (231.7 kg/ha). The climate of the region is semi-arid subtropical. In this experiment a total of ten treatments has been developed and were tested. Treatment comprised of T_1 Phosphorus – 40 kg/ha + Boron – 1 kg/ha, T_2 Phosphorus – 40 kg/ha + Boron – 1.5 kg/ha, T_3 Phosphorus – 40 kg/ha + Boron – 2 kg/ha, T_4 Phosphorus – 50 kg/ha + Boron – 1 kg/ha, T_5 Phosphorus – 50 kg/ha + Boron – 1.5 kg/ha, T_6 Phosphorus – 50 kg/ha + Boron – 2 kg/ha, T_7 Phosphorus – 60 kg/ha + Boron – 1 kg/ha, T_8 Phosphorus – 60 kg/ha + Boron – 1.5 kg/ha, T_9 Phosphorus – 60 kg/ha + Boron – 2 kg/ha, T_{10} Control (RDF). Ten treatments were replicated thrice in Randomized Complete Block Design. The recommended dose of fertilizer (N:P:K) is 20:40:20 kg/ha.

Chemical Analysis of Soil

Composite soil sample are collected before layout of the experiment to determine the initial soil properties. The soil samples are collected from 0-15 cm depth and were dried under shade, powdered with wooden pestle and mortar, passed through 2 mm sieve and were analysed for organic carbon by rapid titration method by Nelson (1975). Soil texture by Bouyoucos Hydrometer Method (Gee and Baudev, 1986) [8]. Available nitrogen was estimated by alkaline permanganate method by Subbiah and Asija (1956) [21], available phosphorus by Olsen *et* al., (1954) [17] and available potash was determined by Flame photometric method, Jackson (1973) [10], available potassium was determined by using the flame photometer normal ammonium acetate solution and estimating by using flame photometer (ELICO Model) as outlined.

Statistical Analysis

The data recorded were different characteristics were subjected to stastical analysis by adopting Fishers the method of analysis of variance (ANOVA) as described by Gomez and Gomez (2010). Critical difference (CD) values were calculated the ‘F’ test was found significantly at 5% level.

Result and Discussion

Effect on plant height (cm)

Observations recorded in respective to the plant height of cowpea were represented in Table 1 there was an increase in crop age and plant height was progressively noticed with the advancement during the experimentation period. The analysis on plant height was significantly higher in all the different growth intervals with the effect of different levels of Phosphorous and Boron. At harvest, maximum plant height (75.64 cm) was recorded with application of Phosphorous 60 kg/ha + Boron 2 kg/ha which was significantly superior over all other treatments except with the application of Phosphorous 60 kg/ha + Boron 1.5 kg/ha (72.60 cm). It might be due to the Increase in plant height with increase in phosphorus level can be attributed to the fact that phosphorus is required in large quantities in shoot and root tips where in metabolism is high and will have favourable effect on cell division and enlargement, which ultimately reflected on plant height. Similar findings were observed with Ndakidemi and Dakora (2007) and Meena and Chand (2014) [14, 13].

Effect of no. of Branches per plant

The optimum result observations were recorded in no. of branches per plant were depicted in Table 1 and was increased with advancement of the crop during the crop growth period. At harvest maximum no of branches per plant (9.66) recorded with the application of Phosphorous 60 kg/ha + Boron 2 kg/ha which was significantly over all the treatments except with the application of Phosphorous 60 kg/ha + Boron 1.5 kg/ha (8.93). Increase in phosphorus levels resulted in greater accumulation of carbohydrates, proteins and their translocation to the different parts of the plant which in turn promoted a greater number of branches. These results were in conformity with the findings of Shekara *et al*. (2010) [18].

Effect of no. of nodules per plant

Recorded observations on no. of nodules per plant were depicted in Table 1. At harvest no. of nodules per plant (16.80) recorded with the application of Phosphorous 60 kg/ha + Boron 2 kg/ha which was significantly over all the treatments except with the application of Phosphorous 60 kg/ha + Boron 1.5 kg/ha (16.63) and Phosphorus – 50 kg/ha + Boron - 2.0 kg/ha (12.73) which were statistically at par with the applications of Phosphorous 60 kg/ha + Boron 2 kg/ha. Increase in the number of nodules plant^{-1} with higher level of phosphorus might be due to favourable effect of phosphorus in promotion of nodulation and enhanced the activity of nitrogen fixing bacteria as it requires phosphorus for growth and development. Similar findings were observed by Kumar *et al*. (2015) and Nkaa *et al*. (2014) [11, 16].

Effect of Dry weight (g/plant)

Observations to be recorded in the dry weight of cowpea were represented in Table 1 the maximum dry weight had given consecutively increased performance from 20 DAS to till harvest. At harvest the maximum dry weight was found in the treatment with application of Phosphorous 60 kg/ha + Boron 2 kg/ha (67.24 g/plant) which was significantly over all the treatments except with the application of Phosphorous 60 kg/ha + Boron 1.5 kg/ha (64.78 g/plant) which were statistically at par with the applications of Phosphorous 60 kg/ha + Boron 2 kg/ha. Dry matter production was highest with the application of 60 kg P_2O_5 ha^{-1} at all the stages of observation due to improvement in growth parameters like plant height, leaf area, number of leaves plant^{-1} and number of branches plant^{-1}. Enhanced dry matter production with increased phosphorus level was also reported by Ram *et al*. (2008).

Effect on Yield, Straw yield and Harvest Index of Cowpea

Observation regarding yield are given in Table 2. Grain yield is an important and considerable trait at all the time. Maximum seed yield (1.26 t/ha) and Straw yield (1.42 t/ha) were recorded with application Phosphorus 60 kg/ha + Boron 2.0 kg/ha which was significantly over all the treatments except with the application of Phosphorous 60 kg/ha + Boron 1.5 kg/ha in grain yield (1.20 t/ha) and straw yield (1.35 t/ha) which was statistically at par with the applications of Phosphorous 60 kg/ha + Boron 2 kg/ha. Similar finding is found in Adkine *et al*. (2011) [1] Boron spray also could enhance the pod yield as evident from the study. This might be due to its positive influence on pod set and mobilization of assimilate reserves to the sink. The increase in Stover yield with highest level of phosphorus might be due to adequate supply of nutrients and efficient utilization through extensive root system developed by phosphorus application which resulted in higher plant height, leaf area, number of leaves plant^{-1} and number of branches plant^{-1}. The results are in conformity with the findings of Tandon and Patel (2009), Shekara *et al*. (2010) [22, 18]. While maximum Harvest index was recorded in the application of Phosphorus 60 kg/ha + Boron 2.0 kg/ha (47.96 %) which was significantly over all the treatments except with the application of Phosphorous 60 kg/ha + Boron 1.5 kg/ha Phosphorus 50 kg/ha + Boron 2.0 kg/ha and Phosphorus 50 kg/ha + Boron 1.5 kg/ha (47.09, 46.97 and 46.64 % respectively). Similar finding is found due to the increase in grain yield and straw yield the harvest index increases IIavarasi *et al*. (2007) [9].

Table 1: Effect of Phosphorus and Boron growth attributes of Cowpea

Treatments		Plant height (cm)				No. of Branches per plant				No. of Nodules per plant				Plant dry weight (g/plant) 15DAS				
	15 DAS	30 DAS	45 DAS	60DAS	At harvest	30 DAS	45 DAS	At harvest	15 DAS	30 DAS	45 DAS	60 DAS	At harvest	15 DAS	30DAS	45 DAS	60 DAS	At harvest
Phosphorus 40kg/ha + Boron 1kg/ha	10.4	27.49	51.48	64.69	66.46	3.26	5.46	8.46	10.33	28.53	20.13	10.61	10.63	1.74	13.46	32.24	57.75	58.20
Phosphorus - 40kg/ha + Boron1.5kg/ha	10.55	27.58	52.28	66.04	67.60	3.46	6.06	8.46	10.88	29.33	21.03	12.92	11.20	1.91	13.60	34.38	58.12	58.63
Phosphorus - 40kg/ha + Boron 2.0kg/ha	10.62	27.73	52.37	66.07	67.92	3.73	6.13	8.46	11.96	30.23	21.26	13.71	11.83	2.03	13.77	34.38	59.12	59.01
Phosphorus - 50kg/ha + Boron 1kg/ha	10.72	27.6	53.12	66.64	69.34	3.80	6.16	8.53	16.99	30.43	21.30	13.84	12.20	2.18	13.78	34.40	59.96	61.20
Phosphorus - 50kg/ha + Boron 1.5kg/ha	10.96	28.28	54.8	67.75	69.46	3.86	6.33	8.63	17.66	32.13	22.50	17.60	12.46	2.51	14.22	36.41	61.02	63.02
Phosphorus - 50kg/ha + Boron 2.0kg/ha	11.09	29.23	58.64	68.33	70.4	4.16	6.46	8.70	19.13	35.90	23.96	18.83	12.73	2.55	14.35	37.13	61.94	63.70
Phosphorus - 60kg/ha + Boron 1kg/ha	10.88	28.04	54.14	67.59	69.45	3.86	6.23	8.60	17.44	32.10	22.06	17.20	12.36	2.46	14.01	35.25	60.61	61.42
Phosphorus - 60kg/ha + Boron 1.5kg/ha	11.34	30.89	59.11	70.65	72.60	4.40	6.60	8.93	19.55	36.10	26.30	19.26	16.63	2.59	14.99	38.31	63.04	64.78
Phosphorus - 60kg/ha + Boron 2.0kg/ha	12.07	32.79	61.54	73.46	75.64	5.06	7.00	9.66	24.22	36.60	27.73	20.63	16.80	2.75	15.06	38.58	65.77	67.24
Control (NPK 20: 40: 20)	10.14	26.02	50.46	63.94	66.12	3.06	5.33	7.86	9.77	25.33	18.98	9.80	9.10	1.47	13.09	32.08	56.44	56.58
SEm (±)	0.25	0.65	1.04	1.24	1.24	0.21	0.24	0.25	4.20	3.72	1.53	2.30	1.44	0.19	0.36	0.84	1.02	1.13
CD (0.05%)	0.74	1.93	3.11	3.71	3.69	0.65	0.73	0.75	-	-	4.56	6.85	4.30	0.59	1.09	2.50	3.03	3.35

Table 2: Effect of Phosphorus and Boron on Yield and Economics of Cowpea

Treatments	Yield		
	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
Phosphorus 40kg/ha + Boron 1kg/ha	0.79	0.94	45.76
Phosphorus - 40kg/ha + Boron1.5kg/ha	0.89	1.03	46.33
Phosphorus - 40kg/ha + Boron 2.0kg/ha	0.90	1.04	46.11
Phosphorus - 50kg/ha + Boron 1kg/ha	0.96	1.11	46.19
Phosphorus - 50kg/ha + Boron 1.5kg/ha	1.09	1.24	46.64
Phosphorus - 50kg/ha + Boron 2.0kg/ha	1.12	1.26	46.97
Phosphorus - 60kg/ha + Boron 1kg/ha	1.08	1.22	45.43
Phosphorus - 60kg/ha + Boron 1.5kg/ha	1.20	1.35	47.09
Phosphorus - 60kg/ha + Boron 2.0kg/ha	1.26	1.42	47.96
Control (NPK 20: 40: 20)	0.72	0.87	45.25
S.Em(±)	0.02	0.02	0.44
CD (p=0.05)	0.07	0.07	1.32

Conclusion

It is concluded that the treatment combination T9 (Phosphorus - 60kg/ha + Boron - 2.0kg/ha) along with recommended doses was found to be the best that recorded highest plant height, number of branches, more number of pods per plant, highest test weight, seed yield, stover yield. It also fetched the maximum gross return, net return, and benefit cost ratio.

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