Original Research Article

Response of phosphorus and zinc on growth and yield of Chickpea (*Cicer arietinum* L.)

Abstract

A field experiment was conducted at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during *Rabi* season 2022 on chickpea crop. The experiment was laid out in randomized block design with ten treatments and three replication. The treatment consisted of soil application of Phosphorus (30 kg/ha, 40 kg/ha and 50 kg/ha), Zinc (10 kg/ha, 15 kg/ha and 20 kg/ha) and zinc and a control (20-40-20 kg NPK/ha). The results of the experiment showed that, plant height (48.81 cm), dry weight (14.88 g) number of nodules/plant (14.67), number of pods/plant (30.07), number of seeds/pod (1.37), seed index (21.36 g), seed yield (2.66 t/ha) and stover yield (4.26 t/ha), harvest index (38.31) were recorded significantly highest with the application Phosphorus 50 kg/ha + Zinc 20 kg/ha. Maximum gross returns (152516.67 INR/ha), net returns (102367.23 INR/ha), and B-C ratio (2.04) were also obtained with the same treatment.

Keywords: Chickpea, Economics, Growth, Phosphorus, Seed Yield, Zinc.

INTRODUCTION

Pulses plays a vital role in Indian agriculture. For Indian vegetarians, they are a crucial source of protein, vitamins, and minerals. Pulses are referred to as "poor man's meat" in popular culture. In contrast to the minimum need recommendation of 80 g day^{-1} by the World Health Organization (WHO) and FAO, the daily per capita availability of pulses has declined from 60 g during the 1960s to a level of less than 40 g in the present. Chickpea hold a significant position among the pulses. Due to its high nutritional value (17-23% protein) and the nation's significant vegetarian population dependency on it. The germinated seeds have a variety of applications, including treating scurvy. Intestinal problems are treated using malic and oxalic acids extracted from green leaves of Chickpea (Balai *et al.* 2016).

India is the single largest producer of chickpea in the world, accounting for 65% (9.075 million tones) of the total production under pulses. During 2020-21, chickpea had a lion's share of 49.3% in the total pulses production. In India, chickpea area is 9.85 million hectare, with 11.99 MT production and 1217 kg/ha productivity in 2020-2021. In India, Uttar Pradesh covers 8.24 million hectare and had a production of 9.97 million tones with the productivity 1.08 t/ha in 2020–2021 (GOI 2020).

The requirement of phosphorus in leguminous crop like chickpea is higher than other crops for their root development and metabolic activities. Phosphorus plays an important role in nodulation, phosphorus fixation, growth and yield of chickpea (Singh *et al.* 2010). Phosphorus stimulates early root development, leaf size, tillering, flowering, grain yield and hastens maturity. It is a constituents of certain nucleic acids i.e. phospholipids, chromosomes and the coenzymes Nicotinamide Adenine Dinucleotide (NAD), Adenosine Triphosphate (ATP) and Nicotinamide Adenine Dinucleotide Phosphate (NADP). Phosphorus is also essential for cell division, seed and fruit development (Ali *et al*. 2010).

In recent years, zinc deficiency has been aggravated in Indian soils due to tremendous increase in cropping intensity and adoption of cultivation of high yielding varieties. Zinc is the major component of several enzymes, influencing the synthesis of proteins, auxins and photosynthetic activity. It also increases plant's resistance to dry and hot weather conditions (Singh *et al*. 2005). The reduction in yield are prominent due to the improper nutrient management practices, to get more yield, it essential to enhance the productivity of crop by management of nutrient application. Keeping above facts in view, the present experiment entitled "Response of phosphorus and zinc on growth and yield of chickpea (*Cicer arietinum* L.)".

MATERIALS AND METHODS

During the *Rabi* season of 2022, a field experiment was conducted in alluvial soil at the Crop Research Farm of the Department of Agronomy, SHUATS, Prayagraj, U.P. The soil of experimental plot was sandy loam, having a nearly neutral soil reaction (pH 7.3), electrical conductivity (0.40 ds/m), medium in available Nitrogen (278.93 kg/ha) and available potassium (244.1 kg/ha), and low in available phosphorous (17.3 kg/ha). The experiment was conducted in a Randomized Block Design consisting of 10 treatment combinations and 3 replications. The treatments consist of 3 levels of Phosphorus (30, 40 and 50 kg/ha) and 3 levels of Zinc (10, 15 and 20 kg/ha). The treatment combinations are as follows, T_1 – 30 kg/ha Phosphorus + 10 kg/ha Zinc, T_2 – 30 kg/ha Phosphorus and 15 kg/ha Zinc, T_3 – 30 kg/ha Phosphorus and 20 kg/h Zinc, T_4 – 40 kg/ha Phosphorus + 10 kg/ha Zinc, T_5 – 40 kg/ha Phosphorus + 15 kg/ha Zinc, T_6 – 40 kg/ha Phosphorus + 20 kg/ha Zinc, T_7 – 50 kg/ha Phosphorus + 10 kg/ha Zinc, T_8 – 50 kg/ha Phosphorus + 15 kg/ha Zinc, T_9 – 50 kg/ha Phosphorus + 20 kg/ha Zinc and T_{10} – (control). The nutrient sources were Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP), applied as per the recommended dose of 20-40-20 kg NPK/ha. As per the treatment, application of phosphorus and zinc were done as basal application. Plant growth parameters, such as plant height (cm), dry weight (g/plant) were measured at a regular intervals from germination till harvest and yield and yield attributes, such as pods/plant, Seeds/pod, seed index (g), seed yield (t/ha), stover yield (t/ha) and harvest index (%) were measured at harvest.

The observed data were statistically analysed using analysis of variance (ANOVA) as applicable to randomized block design (Gomez and Gomez, 1984).

Results and Discussions

Growth parameter

The data pertaining to growth attributes presented in Table 1, has been significantly influenced with the application of phosphorus and zinc. The data revealed that basal application of phosphorus 50 kg/ha along with zinc 20 kg/ha recorded significantly higher plant height (48.81 cm). This might be due to positive effect of phosphorus on nitrogen fixation by rhizobium, that leads to enhanced availability of nitrogen for initial vegetative growth and increases the hardiness of the crop, whereas zinc improves the root proliferation that facilitates diffusion of major nutrients and improves plant height. Similar results were also reported by Singh *et al*. (2010) and Lal *et al*. (2014). Significantly higher number of nodules/plant (32.33) at 60 DAS was recorded with the application of Phosphorus 50 kg/ha + Zinc 20 kg/ha. Around mid-flowering, when the plant needs nitrogen the most, the number of nodules grows frequently, which improves nitrogen fixation when phosphorus is supplied in the right quantities. On the other hand, zinc catalyses oxidation in plant cells, transforms carbohydrates, regulates the consumption of sugar, and increases the source of energy for the production of chlorophyll, which aids in the production of more nodules. These results are in conformity with Gahoonia *et al*. (2006) and Gowthami and Ananda (2017). The significantly higher plant dry weight (14.88 g) and crop growth rate (10.86 g/m ^{2}/day) were recorded with application of phosphorus 50 kg/ha along with zinc 20 kg/ha, might be due to increased availability of phosphorus, which enhances development of new cells, plant vigour and root growth, that fasten leaf development and increase in photosynthetic rate and nitrogen utilization from soil leads to accumulation of dry matter in plants, while application of zinc influence plant vigour through absorption of nutrients at critical stages, that enhance the physiological activity of crop and increases the dry matter accumulation. Kumar *et al*. (2020) reported similar results.

Yield attributes

The data of yield attributes and yield (Table 2), had shown significant increase. The significantly maximum number of pods/plant (30.07) and number of seeds/pod (1.37) were recorded with application of phosphorus 50 kg/ha along with zinc 20 kg/ha. These results might be attributed to increased availability of phosphorus, which leads to manipulation of photosynthesis and remobilization of assimilates in pod formation by stimulating the plant for flowering and fruiting, which leads to the production of more pods. Zinc is involved in synthesis of auxins which favors retention of more flowers and results formation of more pods and enhances protein and carbohydrates synthesis and their transportation to the site of seed formation. Maqsood *et al*. (2000) and Nakum *et al*. (2019) also reported similar results in groundnut. Application of phosphorus 50 kg/ha along with zinc (20 kg/ha) recorded significantly maximum seed index (21.36g), might be due to the positive effect of phosphorus and zinc on cell division and P content of seed as well as formation of fat and albumin. These results are in conformity with Maqsood *et al*. (2000) and Kuldeep (2016). The significantly higher seed yield (2.66 t/ha) recorded with an application of 50 P kg/ha and 20 Zn kg/ha could be due to excess photosynthates stored in the leaves and later translocated to seed at the time of senescence. Also, zinc favours better root growth and the development of sink size, such as the number of pods per plant, resulting in a higher seed yield. The significantly higher stover yield (4.26 t/ha) was recorded with the same treatment, might be due to the ability of phosphorus and zinc to enhance root growth, which promotes plant height and dry matter accumulation, early growth of seedlings, and increases photosynthetic efficiency. Greater accumulation of photosynthates in vegetative parts results in superior vegetative growth and an increase in stover yield. These results are in conformity with Sepat (2005) and Kumawat (2006).

Economics

The data pertaining to the economics of different treatments presented in Table 3 showed that the maximum gross return (₹ 152516.67/ha), net return (₹ 102367.23/ha), and benefit-cost ratio (2.04) were recorded with the application of 50 kg/ha Phosphorus and 20 kg/ha zinc, and the minimum gross return (₹ 108543.33/ha), net return (₹ 61821.89/ha), and lowest benefit-cost ratio (1.32) were recorded in treatment 1.

Conclusion

From the results of the experiment, it can be concluded that application of Phosphorus 50 kg/ha along with Zinc 20 kg/ha (T_9) was found to be more desirable in terms of increasing growth, yield and economics of Chickpea.

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Table 1. Effect of phosphorus and zinc on growth parameters of Chickpea

Sl. No.	Treatments	Plant height (cm) (100 DAS)	Root nodules (No.) (60 DAS)	Dry weight (g/plant) (100 DAS)	Crop Growth Rate (g/cm^2/day) (During 80-100 DAS)
1.	Phosphorus 30 kg/ha + Zinc 10 kg/ha	42.57	25.78	10.81	6.59
2.	Phosphorus 30 kg/ha + Zinc 15 kg/ha	43.23	24.78	11.31	6.93
3.	Phosphorus 30 kg/ha + Zinc 20 kg/ha	44.71	27.89	12.22	8.93
4.	Phosphorus 40 kg/ha + Zinc 10 kg/ha	44.93	28.44	12.79	9.76
5.	Phosphorus 40 kg/ha + Zinc 15 kg/ha	45.05	25.33	12.06	7.76
6.	Phosphorus 40 kg/ha + Zinc 20 kg/ha	46.19	26.11	13.77	10.38
7.	Phosphorus 50 kg/ha + Zinc 10 kg/ha	45.19	29.33	13.07	9.03
8.	Phosphorus 50 kg/ha + Zinc 15 kg/ha	46.84	29.00	14.34	10.46
9.	Phosphorus 50 kg/ha + Zinc 20 kg/ha	48.81	32.33	14.88	10.86
10.	Control (20-40-20 kg/ha NPK)	44.91	25.11	11.79	7.22
	SEm(±)	0.92	1.30	0.352	0.65
	CD (P=0.05)	2.720	3.85	1.048	1.93

Table 2. Effect of Phosphorus and Zinc on yield and yield attributes of Chickpea

Sl.No.	Treatments	Pods/plant (No.)	Seeds/pod (No.)	Seed index (g)	Seed yield (t/ha)	Stover yield (t/ha)
1.	Phosphorus 30 kg/ha + Zinc 10 kg/ha	25.47	1.20	19.02	1.88	3.31
2.	Phosphorus 30 kg/ha + Zinc 15 kg/ha	27.73	1.12	18.31	1.95	3.32
3.	Phosphorus 30 kg/ha + Zinc 20 kg/ha	26.80	1.18	18.94	2.02	3.52
4.	Phosphorus 40 kg/ha + Zinc 10 kg/ha	27.00	1.25	18.94	2.11	3.70
5.	Phosphorus 40 kg/ha + Zinc 15 kg/ha	27.47	1.20	19.86	2.13	3.68
6.	Phosphorus 40 kg/ha + Zinc 20 kg/ha	27.93	1.26	19.29	2.21	3.98
7.	Phosphorus 50 kg/ha + Zinc 10 kg/ha	27.80	1.19	20.22	2.37	4.04
8.	Phosphorus 50 kg/ha + Zinc 15 kg/ha	28.27	1.29	21.04	2.48	4.19
9.	Phosphorus 50 kg/ha + Zinc 20 kg/ha	30.07	1.37	21.36	2.66	4.26
10.	Control (20-40-20 kg/ha NPK)	25.67	1.17	18.07	1.92	3.73
	SEm(±)	0.77	0.04	2.03	0.14	0.16
	CD (P=0.05)	2.30	0.13	0.69	0.43	0.49

Table 3. Effect of phosphorus and zinc on economics of chickpea

Sl. No.	Treatments	Gross returns (INR/ha)	Net returns (INR/ha)	B:C
1.	Phosphorus 30 kg/ha + Zinc 10 kg/ha	108543.33	61821.89	1.32
2.	Phosphorus 30 kg/ha + Zinc 15 kg/ha	112235.00	64301.56	1.34
3.	Phosphorus 30 kg/ha + Zinc 20 kg/ha	116206.67	67061.23	1.36
4.	Phosphorus 40 kg/ha + Zinc 10 kg/ha	121610.00	74384.56	1.58
5.	Phosphorus 40 kg/ha + Zinc 15 kg/ha	122680.00	74242.56	1.53
6.	Phosphorus 40 kg/ha + Zinc 20 kg/ha	127708.33	78058.89	1.57
7.	Phosphorus 50 kg/ha + Zinc 10 kg/ha	136226.67	88501.23	1.85
8.	Phosphorus 50 kg/ha + Zinc 15 kg/ha	142868.33	93930.89	1.92
9.	Phosphorus 50 kg/ha + Zinc 20 kg/ha	152516.67	102367.23	2.04
10.	Control (20-40-20 kg/ha NPK)	111016.67	66215.23	1.48