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Effect of Phosphorus and Zinc Application 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 experimental farm, Department of Agronomy, Faculty of Agriculture and Veterinary Sciences, Mewar University Gangrar, Chittorgarh (Rajasthan) during Rabi season of 2023-24 to effect of phosphorus and zinc application on growth and yield of chick pea, variety "RSG-888" was used in this study. The required quantities of fertilizers as per treatments were applied. The experiment was laid out in randomized block design with three replications consisting of nine treatments. The data recorded maximum growth attributes like, plant height (64.46 cm), number of branches per plant (10.01) and yield attributes such as number of pods per plant (29.15), number of seed per pod (1.92), seed yield (1855 kg/ha), stover yield (3292 kg/ha), biological yield (5147 kg/ha) and maximum net return (89483 Rs/ha) was recorded with

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application of 80 kg phosphorus ha^{-1}. Therefore, it was concluded that application of that phos4phorus and zinc application brought an additive effect in increasing growth, yield, quality and economics of chickpea crop. The highest seed yield (1855 kg ha^{-1}) was obtained under the combined application of 80 kg phosphorus ha^{-1} (T_5) but the highest net returns of gross and net returns (124651 ha^{-1} and 89483 Rs ha^{-1}, respectively) was recorded under the application of 80 kg phosphorus ha^{-1}.

Keywords: Nutrient; boron; production; chick pea.

1. INTRODUCTION

"Chickpea (*Cicer arietinum* L.) is an important grain legume in Asia. Being a rich and cheap source of protein, it can help people to improve the nutritional quality of their diet. Chickpea is relatively of minor importance on the world market but it is extremely important for local trade in numerous tropical and subtropical regions. It is grown and consumed in large quantities from South East Asia to India and in the Middle East and Mediterranean countries. Chickpea is the third most important pulse crop in the world after French bean (*Phaseolus vulgaris* L.) and field peas (*Pisum sativum* L.). Mostly chickpea is grown in South Asia, which accounts for more than 75% of the world chickpea area. It is also the premier food legume crop in India, ranks first among all pulse crops, covering about 9.58 mha area with production of 9.33 mt and productivity of 973 kg ha^{-1}" (Anonymous, 2022-23).

"Amongst the required essential nutrients, phosphorus (P) and zinc (Zn), being crucial element for optimum growth and yield of all crop" (Ryan & Singh, 2012) throughout the world, are most important for our farmers consideration because of the sensitivity of these two nutrients to the existing soil conditions and their mutual interaction. "Phosphorus availability in optimum quantities is needed for early growth stages, development of the reproductive parts, root growth, reduced disease incidence and early maturity. Compared to vegetative growth, P availability in considerable quantities is critically needed for seed formation" (Gidago et al., 2019). "Phosphorus (P) is an essential nutrient both as a part of several key plant structure compounds and as a catalysis in the conversion of numerous key biochemical reactions in plants. P is noted especially for its role in capturing and converting the sun's energy into useful plant compounds; thus, P is essential for the general health and vigor of plants" (Griffith, 2007).

"Zinc are important minerals required for various metabolic functions. It is obvious for both animals and plants. Zinc is responsible for protein synthesis, gene expression, proper growth and immune system. Physically Zn deficiency is manifested as stunting, common health problem in children like diarrhea, low birth weight, high rate of infection, skin lesions and impaired wound healing. This makes body metabolism keep going and healthy" (Gidago et al., 2019). "It causes behavioral disturbances and impairment of both cognitive function and psychomotor development to children. In plant, Zn deficiency reduces the growth, yield, and overall quality of edible part. Soil with low micronutrient concentrations produces grains with low concentration of for example Zn" (Singh, 2009).

2. MATERIALS AND METHODS

A field experiment was conducted during Rabi season of 2023-24 at experimental farm, Department of Agronomy, Faculty of Agriculture and Veterinary Sciences, Mewar University Gangrar, Chittorgarh (Rajasthan). Soil of the experimental field was sandy loam in texture, saline in reaction with a pH value of 7.6, poor in organic carbon (0.16%), deficient in available zinc (0.48 ppm) and iron (1.2 ppm) low in available nitrogen (176 kg/ha) and phosphorus (20.2 kg/ha) but medium in available potassium (320 kg/ha). The experiment was laid out in randomized block design with three replications which treatment nine treatments *viz.,* T_1- Control, T_2-10 kg phosphorus ha^{-1}. T_3-20 kg phosphorus ha^{-1}, T_4-40 kg phosphorus ha^{-1}, T_5-80 kg phosphorus ha^{-1}, T_6-1.5 kg zinc ha^{-1}, T_7-2.5 kg zinc ha^{-1}, T_8-5.0 kg zinc ha^{-1}. T_9-7.5 kg zinc ha^{-1}.

The required quantities of fertilizers as per treatments were applied. The doses of NPK were applied in the form of urea, diammonium phosphate, murate of potash respectively. The half dose of nitrogen gives basal dose and remain two split doses after irrigation and full dose of phosphorus and potassium at basal dose. The yield parameters were calculated from output from the field. The profitability and productivity of mung bean was calculated from cost of field preparation to harvesting and threshing cost and out pot from straw yield and grain yield as per market rate.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

A critical examination of data (Table 1) revealed that phosphorus and zinc application did not bring any significant difference on growth attributes of chickpea at 30 DAS. The maximum mean plant height at 60 DAS (46.68 cm), at harvest (64.46 cm) was recorded with the application of 80 kg phosphorus ha^{-1} which was found at par with T_4 and T_3 and statistically superior over rest of the treatments. Plant height of chickpea was significantly increased due to application of 80 kg phosphorus ha^{-1} was in the tune of 57.78% at 60 DAS, 59.26% at 90 DAS and 58.93% at harvest, respectively over control (T_1). Application of 80 kg phosphorus significantly highest number of branches $plant^{-1}$ (10.01) at harvest of chickpea as compared to rest of the treatment but it was remained at par with treatment T_4 and T_3. The improvement in number of branches $plant^{-1}$ at harvest of due to application of 80 kg phosphorus was 65.40% at harvest, respectively over control (T_1). "Zinc is an important micronutrient (involved in various biochemical processes in plants, including photosynthesis, respiration, chlorophyll biosynthesis, and protein, lipid, carbohydrate and nucleic acid synthesis and degradation" (Auld 2001); as well as pollen functionality and fertilization (Raj et al., 2019 and Singh et al., 2022).

3.2 Yield Attributes and Yield

The data pertaining to yield attributes of chickpea as significantly influenced by different phosphorus and zinc application treatments are presented in Table 2. Application of 80 kg phosphorus ha^{-1} resulted into highest number of pods (29.15) $plant^{-1}$ of chickpea. The enhancement in number of pods $plant^{-1}$ due to application of 80 kg phosphorus ha^{-1}(T_5) was 59.9 as compared to T_1 treatments. Maximum number of seed pod^{-1} (1.92) in chickpea was observed with the application of 80 kg phosphorus ha^{-1} (T_5) treatment which was significantly superior to all other treatments except treatment T_4 which was found statistically at par with each other. The number of seeds pod^{-1} was increased due to application of 80 kg phosphorus ha^{-1} (T_5) in the tune of 76.7% respectively as compared to control (T_1). It is evident from the data that the significantly highest seed yield of chickpea (1855 kg ha^{-1}) was produced by the application of 80 kg phosphorus ha^{-1} (T_5) over rest of the treatments but closely followed by 40 kg phosphorus ha^{-1} (T_4). The magnitude of increase in seed yield of chickpea due to application of 80 kg phosphorus ha^{-1} (T_5) was in the tune of 69.7% as compared to control (T_1). It is evident from the data that the application of 80 kg phosphorus ha^{-1} (T_5) gave significantly highest haulm yield of chickpea (3292 kg ha^{-1}) over control and remained treatments but closely followed by 40 kg phosphorus ha^{-1}(T_4). The corresponding increase in haulm yield of chickpea due to application of 80 kg phosphorus ha^{-1} (T_5) was in the order of 68.1% as compared to control (T_1). The application of 80 kg phosphorus ha^{-1}(T_5) produced significantly maximum biological yield of chickpea (5147 kg ha^{-1}) over T_1, T_2, T_3, T_6, T_7, T_8 and T_9 but closely followed by T_4. "The significant improvement in seed yield under the influence of phosphorus was largely a function of improved growth and the consequent increase in different yield attributes as mentioned above. Significant increase in straw and biological yield due to phosphorus application might be due to increased dry matter production, plant height and profused branching in chickpea. The significant increase in grain and straw yield under the influence of phosphorus was largely a function of improved growth and yield attributes like number of branches, number of pods $plant^{-1}$, and number of seeds $plant^{-1}$ which consequently increased grain and straw yield" as observed by Gudadhe et al. (2015), Kumar et al. (2014), Praveen et al. (2018), Dewangne et al. (2016), Ahmed et al. (2017), Verma et al. (2017), Singh et al. (2017), Kumar et al. (2018) in chickpea crop and Singh et al. (2023).

3.3 Economics

The net returns and BC ratio of chickpea (Table 3) was significantly differed due different phosphorus and zinc application treatment and significantly highest gross and net returns (124651 ha^{-1} and 89843 Rs ha^{-1}, respectively) was recorded under the application of 80 kg phosphorus ha^{-1} (T_5). However; B:C ratio (2.55) of chickpea was obtained by the application of 40 kg phosphorus ha^{-1} (T_4). The increased net returns and B:C ratio could be explained on the basis of increased yield and low cost of treatment. These results are in corroborate the findings of Mustafa et al. (2008), Kumar et al. (2014), Solanki et al. (2014), Dewangne et al. (2016), Ahmed et al. (2017), Singh et al. (2017), Verma et al. (2017) and Kumar et al. (2018) in chickpea crop.

Table 1. Effect of phosphorus and zinc application on growth attributes of chickpea

Treatments		Plant height (cm)			Number of branches plant^{-1}
		30 DAS	60 DAS	Harvest	
T_1	Control	11.24	29.58	6.05	6.05
T_2	10 kg phosphorus ha^{-1}	11.41	36.72	7.90	7.90
T_3	20 kg phosphorus ha^{-1}	11.78	45.64	9.05	9.05
T_4	40 kg phosphorus ha^{-1}	11.89	46.29	9.89	9.89
T_5	80 kg phosphorus ha^{-1}	11.97	46.68	10.01	10.01
T_6	1.5 kg zinc ha^{-1}	11.32	34.27	7.72	7.72
T_7	2.5 kg zinc ha^{-1}	11.36	37.19	7.80	7.80
T_8	5.0 kg zinc ha^{-1}	11.50	37.96	7.91	7.91
T_9	7.5 kg zinc ha^{-1}	11.62	38.56	8.03	8.03
S. Em. $\pm$		0.61	2.09	2.86	0.46
Cd (P = 0.05)		NS	6.46	8.82	1.42
CV (%)		9.02	9.01	9.00	9.41

Table 2. Effect of phosphorus and zinc application on yield attributes and yield of chickpea

Treatments		Number of pods plant^{-1}	Number of seeds pod^{-1}	Test weight (g)	Seed yield (kg/ha)	Haulm yield (kg/ha)	Biological yield (kg/ha)
T_1	Control	18.23	1.09	135.3	1093	1958	3051
T_2	10 kg phosphorus ha^{-1}	21.53	1.32	138.20	1336	2391	3719
T_3	20 kg phosphorus ha^{-1}	25.68	1.62	140.7	1601	2845	4476
T_4	40 kg phosphorus ha^{-1}	28.85	1.89	142.1	1841	3257	5099
T_5	80 kg phosphorus ha^{-1}	29.15	1.92	143.2	1855	3292	5147
T_6	1.5 kg zinc ha^{-1}	19.98	1.29	133.2	1245	2198	3443
T_7	2.5 kg zinc ha^{-1}	21.89	1.34	136.7	1332	2374	3706
T_8	5.0 kg zinc ha^{-1}	25.39	1.55	138.2	1562	2776	4338
T_9	7.5 kg zinc ha^{-1}	25.53	1.58	139.3	1586	2842	4428
S. Em. $\pm$		1.03	0.06	7.25	69	126	153
Cd (P = 0.05)		3.17	0.19	NS	212	389	471
CV (%)		7.15	6.82	9.02	7.66	7.90	6.12

Table 3. Effect of phosphorus and zinc application on economics

Treatments		Economics		
		Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	BC ratio
T_1	Control	73593	46968	1.76
T_2	10 kg phosphorus ha^{-1}	89936	59665	1.97
T_3	20 kg phosphorus ha^{-1}	107613	73695	2.17
T_4	40 kg phosphorus ha^{-1}	123629	88761	2.55
T_5	80 kg phosphorus ha^{-1}	124651	89483	2.54
T_6	1.5 kg zinc ha^{-1}	83569	55748	2.00
T_7	2.5 kg zinc ha^{-1}	89588	60970	2.13
T_8	5.0 kg zinc ha^{-1}	104994	75712	2.59
T_9	7.5 kg zinc ha^{-1}	106794	73176	2.18
SEm$\pm$		5028	3220	0.10
Cd (P = 0.05)		1565	9922	0.29
CV (%)		9,27	8.45	7.90

4. CONCLUSION

Based on one year experimentation it may be concluded that phosphorus and zinc application brought an additive effect in increasing growth, yield and economics of chickpea crop. The highest seed yield (1855 kg ha^{-1}) was obtained under the combined application of 80 kg phosphorus ha^{-1} (T_5) but the highest net returns of gross and net returns (124651 ha^{-1} and 89483 Rs ha^{-1}, respectively) was recorded under the application of 80 kg phosphorus ha^{-1} (T_5). However; B:C ratio (2.55) of chickpea was obtained by the application of 40 kg phosphorus ha^{-1} (T_4). Thus, for growing chickpea crop the application of 40 kg phosphorus ha^{-1} (T_4) were found most suitable. These results are only indicative and require further experimentation to derive credible conclusion.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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