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Effect of levels of phosphorus and zinc on growth and yield of *Kabuli* chickpea (*Cicer kabulium* L.)

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Abstract
A field experiment was conducted during *Rabi* season of 2016-17 at Crop Research Farm, Department of Agronomy, SHUATS, Allahabad, (U.P) to study the effect of levels of phosphorus and zinc on growth and yield of *Kabuli* Chickpea (*Cicer kabulium* L.) var. Pusa-1088. The experiment was laid out in Randomized Block Design with three replications. The experiment consisted of twelve treatment combinations comprising of four levels of Phosphorus (@ 40, 50, 60 and 70 kg P ha^{-1}) along with three levels of Zinc (@ 0, 15 and 20 kg $ZnSO_4$ ha^{-1}) in combination with basal application of Nitrogen and Potassium each @ 20 and 40 kg ha^{-1}. The experimental results revealed that Soil application (Basal) of Phosphorus and Zinc @ 70 kg P, 20 kg $ZnS0_4$ ha^{-1} recorded significantly higher dry weight (35.00 g $plant^{-1}$), more no. of branches (19.5 $plant^{-1}$), pods $plant^{-1}$ (55.99), grains pod^{-1} (1.45) and maximum Seed index (44.86 g)and seed yield (3387 kg ha^{-1}). The interaction of Phosphorus and Zinc was significant for all the major parameters. These results suggested that the application of P and Zn to *Kabuli* Chickpea affect its yield significantly and also found that P fertilizer @ 70 kg ha^{-1} and $ZnSO_4$ @ 20 kg ha^{-1} proved effective for optimum production.

Keywords: Phosphorus, Zinc, yield attributes, *Cicer kabulium*

Introduction
Chickpea (*Cicer kabulium* L.) is the major pulse crop of India. At global level, it ranks third in terms of area and production under legumes. It is grown with less care and less manurial requirement. The earliest record of chickpea in India is from Atranji Khera in Uttar Pradesh and this dates backs to 2000 BC. With an estimated global production of 13.1 million tons in 2013, chickpea is grown in about 50 countries around the world covering an area of 14 million ha with an average global productivity of 968 kg ha^{-1}. Application of phosphorus and zinc are increased the pulse production. Phosphorus plays an important role in nodulation, nitrogen fixation, growth and yield of chickpea (Meena *et al*., 2005) [8]. The response of phosphorus and zinc depends upon many factors like climate, variety and soil type, pH, nutrient availability etc. during the growth. The requirement of phosphorus in leguminous crop like chickpea is higher than other crops for their root development and metabolic activities. 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 essential for promoting certain metabolic reactions. It is necessary for the production of chlorophyll and carbohydrates. Zinc is directly or indirectly required by several enzyme systems, auxin and protein synthesis. Zinc is believed to promote RNA synthesis, which in turn is needed for protein production. Chickpea has an average of 2.2–20 mg of zinc per 100 g edible portion. At several places normal yield of crops could not be achieved despite judicious use of NPK fertilizers due to deficiency of micronutrients in soil, in general, that of Zn in particular. A favourable balance between phosphorus and zinc should be maintained for optimum growth of plant. The information on P and Zn relationship in an important crop like chickpea is not adequate; especially in situations where both the interacting nutrients (P and Zn) are deficient in soil. Hence, the present investigation was conducted to study the effect of phosphorus and zinc on growth and yield of *Kabuli* chickpea crop.

Materials and methods
The experiment was conducted at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology &Sciences, Allahabad (U.P) during *Rabi* 2016-17. Geographically, the experimental site is located between 25°24’42’’ North latitude and 81°50’56’’ East longitude and at an altitude of 98 m above the mean sea level. The soil of experimental field was sandy loam in texture having organic carbon 0.39%, available N (186.9

kg ha^{-1}), available P (22.5 kg ha^{-1}), available K (84kg ha^{-1}), the pH and EC of the soil was recorded as 7.5 and 0.27 dS m^{-1}, respectively. The experiment was laid down in Randomized Block Design comprising of 12 treatments replicated thrice. The treatment comprises four levels of Phosphorus (40, 50, 60 and 70 kg P ha^{-1}) along with three levels of zinc sulphate (0, 15 and 20 kg $ZnSO_4$ ha^{-1}) in combination with basal application of Nitrogen and Potassium each @ 20 and 40 kg ha^{-1}. *Kabuli* Chickpea variety "Pusa-1088" was used for the experiment using a seed rate of 100 kg ha^{-1}. Sowing was carried out on 5th November. Uniform dose of N @ 20 kg ha^{-1} in the of urea and K_2O @ 40 kg ha^{-1} in the form of muriate of potash were applied to all the treatments as a basal dose, P_2O_5 @ 40, 50, 60, 70 kg ha^{-1} in the form of single super phosphate and $ZnSO_4$ @ 0, 15, 20 kg ha^{-1} in the form of zinc sulphate was applied in a single dose according to the treatments. However zinc sulphate is applied after a interval of three days as a basal according to the treatments due to the antagonistic effect of both interacting nutrients like P & Zn. For band placement of the fertilizers furrow of 6cm depth were made and fertilizers and micronutrients were placed in these furrows in a band raising the depth to 4cm. various growth attributes were recorded at different stages of growth. The chickpea crop was harvested at fully maturity stage and yield attributes and yield were recorded following normal standard procedures.

Results and discussion

Plant height

Plant height (cm) as affected by various levels of P_2O_5 and $ZnSO_4$ is shown in Table 1. Statistical analysis revealed that application of P_2O_5 and $ZnSO_4$ significantly (P>0.05) affected plant height (Table 1). Maximum plant height (40.30 cm) was recorded from those plots that had received 70 kg P_2O_5 and 20 kg $ZnSO_4$ ha^{-1}, (Siag, R K 1995 and Ashok, *et al.*, 2005) [3, 6] reported similar findings while minimum plant height (33.55 cm) was recorded from those plots that received 40 kg P_2O_5 and 0 kg $ZnSO_4$ ha^{-1}. The interactive effect of P_2O_5 and $ZnSO_4$ on plant height was significant (Table 1).

Number of branches plant^{-1}

The results presented in (Table 1) have demonstrated that number of branches per plant was influenced by application of P_2O_5 and $ZnSO_4$, significantly (Table 1). Also, interaction effect was significant at 0.05 probability level. Among various treatments, application of 70 kg P_2O_5 and 20kg $ZnSO_4$ ha^{-1} has indicated maximum increase in number of branches per plant (19.5) (Table 1).These results are in close conformity with the findings of (Ashok *et al*., 2005) [6] The highest reduction in branches per plant (12.2) was obtained when 40 kg P_2O_5 $ha^{-1}$was applied alone.

Number of pods plant^{-1}

Data regarding number of pods plant^{-1} as affected by various levels of P_2O_5 and $ZnSO_4$ is presented in (Table 1). Statistical analysis of the data revealed that both P_2O_5 and $ZnSO_4$ application had significantly (p<0.05) affected the number of pods plant^{-1}. Treatments that had received 70 kg P_2O_5and20 kg $ZnSO_4$ ha^{-1} produced maximum (55.99) number of pods plant^{-1}, while minimum (32.21) number of pods plant^{-1} was observed in the plots that received 40 kg P_2O_5 ha^{-1} alone with 0 kg $ZnSO_4$ ha^{-1}. This increase in the number of pods plant^{-1} with the application of might P_2O_5 and $ZnSO_4$ have resulted from more pronounced growth of the plant which in turn had increased number of pods plant^{-1}. The interactive effect of P_2O_5 and $ZnSO_4$ on number of pods plant^{-1} was significant (Table 1). However, maximum (55.99) number of pods plant^{-1} was recorded from those plots that were fertilized with 70 kg P_2O_5 and 20 kg $ZnSO_4$ ha^{-1} while minimum (32.21) number of pods plant^{-1} was produced by plots where no Zinc and P_2O_5 was applied. These results fall in line with the findings of (Siag, 1995 and Enania *et al.,* 1995) [3, 2].

Number of grains pod^{-1}

The number of grains pod^{-1} as affected by various levels of P_2O_5 and $ZnSO_4$ is presented in (Table 1). Analysis of the data indicated that both P_2O_5 and $ZnSO_4$ application as well as their interaction had significant effect (P>0.05) on number of grains pod^{-1} (Table 1). Similar results were reported by (Patel *et al*., 2015) [15].

Hundred grains weight (Seed index)

Data concerning 100-grains weight as affected by various levels of P_2O_5 and $ZnSO_4$ are presented in (Table 1). Statistical revealed that P_2O_5 application and its interaction with $ZnSO_4$ had significant (P>0.05) effect on 100-grains weight (Table 1). However, maximum 100 grains weight (236.8 g) was recorded from plots that had received 70 kg P_2O_5 and 20 kg $ZnSO_4$ ha^{-1}, while minimum 100 grains weight (214.3 g) was noted from the plots that received 40 kg P_2O_5 and 0 kg $ZnSO_4$ ha^{-1}.

Grain yield

Data regarding grain yield ha^{-1} as affected by various levels of P_2O_5 and $ZnSO_4$ are presented in (Table 1). Statistical analysis of the data revealed that the application of P_2O_5 and its interaction with $ZnSO_4$ had a significant (P>0.05) effect (Table 1).Our results showed that on average, the maximum grain yield of 3387 kg ha^{-1} was obtained with the application of 70 kg P_2O_5 ha^{-1} along with 20 kg $ZnSO_4$ ha^{-1}, which was significantly greater than the other treatments; while minimum grains yield (2257 kg ha^{-1}) was produced by those treatments in which no zinc was applied with 40 kg P_2O_5 ha^{-1}. The results confirm the findings of (Pathak, *et al*., 2003) [4] and (Karwasra and Kumar, 2007) [10]. Combined application of P + Zn showed significantly positive influence on seed yield and other yield attributes. Application of P + Zn favoured better root growth and development of sink size (number of pods plant^{-1}) and ultimately higher seed yield. Parihar, (1990) [1] also reported the beneficial effect of phosphorus on the yield attributes.

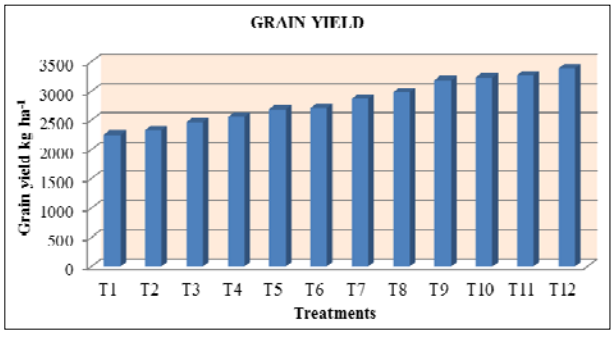

Fig 1: Interaction effects of treatments on grain yield of *Kabuli* Chickpea

Economic analysis

The cost of cultivation (Table 2) was recorded highest ₹45798 ha^{-1} in treatment T_{12} (70 kg P_2O_5 + 20 kg $ZnSO_4$ ha^{-1}) followed by treatment T_{11} (70 kg P_2O_5 + 15 kg $ZnSO_4$ ha^{-1})

which computed ₹45508 ha^{-1} and lowest was in treatment T_1 (40 kg P_2O_5 + 0 kg $ZnSO_4$ ha^{-1}) recorded as ₹43656 ha^{-1}. The gross return was recorded highest in treatment (T_{12}) as ₹203200 ha^{-1} followed by treatment (T_{11}) recorded as ₹196000 ha^{-1}. The lowest gross return was in treatment T_1 ₹135400 ha^{-1}. The net return was recorded highest in treatment (T_{12}) as ₹157402 ha^{-1} followed by treatment (T_{11}) recorded as ₹150492 ha^{-1} and was lowest in treatment (T_1) ₹91744 ha^{-1}. Similar trend was observed for B: C ratio. The result confirms the finding of (Singh, *et al*., 2005) [7]. This gave values as 3.44, 3.34 and 3.31 in treatments T_{12}, T_{10} and T_{11} respectively.

Table 1: Mean values of agronomic traits of *Kabuli* Chickpea as affected by levels of phosphorus and zinc (P × Zn)

Treatments			Plant height (cm)	No. of branches plant^{-1}	Dry matter plant^{-1}	Pods plant^{-1} (No.)	Grains pod^{-1} (No.)	Seed index (g)	Grain yield (kg ha^{-1})	Harvest index (%)
T_1	40 kg P_2O_5 ha^{-1}	+ 0 kg $ZnSO_4$ ha^{-1}	33.55	12.2	12.11	32.21	1.19	34.11	2257	31.63
T_2	40 kg P_2O_5 ha^{-1}	+ 15 kg $ZnSO_4$ ha^{-1}	34.05	12.2	13.33	32.97	1.21	34.34	2327	31.88
T_3	40 kg P_2O_5 ha^{-1}	+ 20 kg $ZnSO_4$ ha^{-1}	35.38	12.8	13.89	34.12	1.20	36.06	2467	33.30
T_4	50 kg P_2O_5 ha^{-1}	+ 0 kg $ZnSO_4$ ha^{-1}	34.71	13.7	14.22	36.08	1.24	36.53	2557	33.90
T_5	50 kg P_2O_5 ha^{-1}	+ 15 kg $ZnSO_4$ ha^{-1}	35.02	14.5	14.78	37.25	1.24	38.10	2687	35.07
T_6	50 kg P_2O_5 ha^{-1}	+ 20 kg $ZnSO_4$ ha^{-1}	35.22	15.2	16.56	38.04	1.26	38.34	2707	35.03
T_7	60 kg P_2O_5 ha^{-1}	+ 0 kg $ZnSO_4$ ha^{-1}	35.26	15.0	17.89	41.08	1.29	39.93	2873	36.78
T_8	60 kg P_2O_5 ha^{-1}	+ 15 kg $ZnSO_4$ ha^{-1}	36.19	16.7	23.56	44.86	1.32	40.59	2987	37.99
T_9	60 kg P_2O_5 ha^{-1}	+ 20 kg $ZnSO_4$ ha^{-1}	37.65	17.7	29.67	48.09	1.36	41.57	3183	39.49
T_{10}	70 kg P_2O_5 ha^{-1}	+ 0 kg $ZnSO_4$ ha^{-1}	38.29	18.2	31.67	51.57	1.39	42.36	3227	39.62
T_{11}	70 kg P_2O_5 ha^{-1}	+ 15 kg $ZnSO_4$ ha^{-1}	39.42	19.1	33.89	54.77	1.41	43.80	3267	39.47
T_{12}	70 kg P_2O_5 ha^{-1}	+ 20 kg $ZnSO_4$ ha^{-1}	40.30	19.5	35.00	55.99	1.45	44.86	3387	40.65
F test			S	S	S	S	S	S	S	S
SEd (±)			0.86	0.55	0.51	0.90	0.02	1.27	90.93	1.19
CD (P=0.05)			1.78	1.14	1.06	1.86	0.03	2.63	188.58	2.46
C.V			2.90	4.31	2.92	2.60	1.45	3.95	3.94	4.01

Nitrogen and Potassium where applied at 20 and 40 kg ha^{-1}

Table 2: Economics of different treatment combinations of *Kabuli* Chickpea

Treatments			Gross Returns ₹ ha^{-1}	Cost of cultivation ₹ ha^{-1}	Net Returns ₹ ha^{-1}	B:C ratio
T_1	40 kg P_2O_5 ha^{-1}	+ 0 kg $ZnSO_4$ ha^{-1}	135400	43656	91744	2.10
T_2	40 kg P_2O_5 ha^{-1}	+ 15 kg $ZnSO_4$ ha^{-1}	139600	44526	95074	2.14
T_3	40 kg P_2O_5 ha^{-1}	+ 20 kg $ZnSO_4$ ha^{-1}	148000	44816	103184	2.30
T_4	50 kg P_2O_5 ha^{-1}	+ 0 kg $ZnSO_4$ ha^{-1}	153400	43983	109417	2.49
T_5	50 kg P_2O_5 ha^{-1}	+ 15 kg $ZnSO_4$ ha^{-1}	161200	44853	116347	2.59
T_6	50 kg P_2O_5 ha^{-1}	+ 20 kg $ZnSO_4$ ha^{-1}	162400	45143	117257	2.60
T_7	60 kg P_2O_5 ha^{-1}	+ 0 kg $ZnSO_4$ ha^{-1}	172400	44311	128089	2.89
T_8	60 kg P_2O_5 ha^{-1}	+ 15 kg $ZnSO_4$ ha^{-1}	179200	45181	134019	2.97
T_9	60 kg P_2O_5 ha^{-1}	+ 20 kg $ZnSO_4$ ha^{-1}	191000	45471	145529	3.20
T_{10}	70 kg P_2O_5 ha^{-1}	+ 0 kg $ZnSO_4$ ha^{-1}	193600	44638	148962	3.34
T_{11}	70 kg P_2O_5 ha^{-1}	+ 15 kg $ZnSO_4$ ha^{-1}	196000	45508	150492	3.31
T_{12}	70 kg P_2O_5 ha^{-1}	+ 20 kg $ZnSO_4$ ha^{-1}	203200	45798	157402	3.44

Sale rate of *Kabuli* Chickpea seed @ ₹ 60 kg^{-1}

Conclusion

It is clear from the present study that application of phosphorus and zinc manipulates the growth of chickpea, resulting in beneficial changes in yield and yield components. The present findings also indicate that soil application (band placement) of phosphorus and zinc sulphate has a great effect in enhancing the uptake of nutrients and also results in less fixation of phosphorus than broadcast application in chickpea crop and resulting in higher growth and yield.

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