Responses of Phosphorus and Zincon growth and yield in chickpea(*Cicerarietinum* L.)

ABSTRACT

The investigation was taken up at Student's Instructional Farm, Nawabganj at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, (U.P.) India, during *Rabi* 2020-21. The 2 factors in sixteen treatment combinations *viz*., P_0Zn_0 (control), $P_0Zn_{2.5}$, P_0Zn_5, P_0Zn_{10}, $P_{30}Zn_0$, $P_{30}Zn_{2.5}$, $P_{30}Zn_5$, $P_{30}Zn_{10}$, $P_{60}Zn_0$. $P_{60}Zn_{2.5}$,$P_{60}Zn_5$,$P_{60}Zn_{10}$, $P_{90}Zn_0$,$P_{90}Zn_{2.5}$,$P_{90}Zn_5$ and $P_{90}Zn_{10}$ were experimented in randomized block design with 3 replications.All the growth and yield parameters increased significantly with increasing levels of phosphorus up to 90 kg ha^{-1}. However, growth and yield parameters of chickpea were increased up to 5 kg Zn ha^{-1} and further increase in the level of Zn does not show significant influence on growth and yield of chickpea. Interaction effect of P and Zn levels on the grain and straw yield of chickpea was significant during study. Thus, it may be concluded that application of phosphorus and zinc proved more beneficial in improving the productivity of chickpea crop. The result showed that application of P and Zn also improved the growth and yield. Phosphorus requirement of chickpea was found more.

Keywords: Chickpea, Growth,Phosphorus, Yieldand Zinc

1. INTRODUCTION

The chickpea (*Cicer arietinum* L.) is a prominent *rabi* crop in pulse-growing regions of India.Chickpeas, which are members of the Fabaceae family, have their origins in south-eastern Asia.In the fourth estimate of 2021-22, India produced 13.750 million tonnes of chickpeas from an average of 10.910 million hectares, with a productivity of 12.60 quintals per hectare (DES 2023, MOAF&W, GoI).Chickpea accounts for almost 50% of India's pulse production.Major chickpea producing states in India are Maharashtra (contributing 25.97% to national production), Madhya Pradesh (18.59%), Rajasthan (20.65%), Gujarat (10.10%), and Uttar Pradesh (5.64%). The chickpea cultivation in Uttar Pradesh spans across an area of 5.73 lakh hectares, yielding a production of 7.09 lakh tons with a productivity rate of 1236 kg ha^{-1} (MOAF&W, GoI 2021).Significant gram cultivation districts in Uttar Pradesh include Chitrakoot, Kanpur, Jhansi, Meerut, Aligarh, and Agra.

Chickpea is a predominantly self-pollinating crop, with cross-pollination occurring only in rare instances, typically accounting for less than 1% of the total pollination events.Pulses are rich in protein and possess unique qualities that can improve soil fertility. Pulses boost protein bioavailability when eaten with cereals. Pulses are the most significant category of food crops in India. Chickpea grains' nutritional profile: Protein is 18–22%, calcium is 280 mgper 100 g, carbohydrate is 61-62%, iron is 12.3 mgper 100 g, fat is 4.5%, phosphorus is 301 mgper 100 g, and calorific value is 396 (as reported by the Directorate of Pulses Development). As a small nitrogen production facility and high-protein source, it helps maintain agriculture by improving soil physical, chemical, and biological properties. The plant's vast root system aerates soil, while leaf drop increases soil organic matter. Symbiosis enables the fixation of approximately 25–30 kg N ha^{-1}, thereby lowering chemical fertilizer use. Therefore, chickpeas play a crucial role in enhancing soil health.(Pandey *et al*., 2021)

Phosphorus is termed as a ‘master key’ element in crop production. It is second most important essential nutrient element next only to nitrogen and classed along with nitrogen and potassium as major plant nutrient.Phosphorus, being a vital plant nutrient, is a significant constraint on crop productivity in modern intensive crop production systems (Heuer *et al*., 2017). The lack of phosphorus in soils is ubiquitous, and crops cultivated in such conditions have strong reactions to phosphorus fertilizer. Nevertheless, in a single cropping season, the crop uptake of P seldom exceeds 20 to 25 % due to various physico-chemical and biological transformations that convent the soluble P in to insoluble forms. As per Motsara's (2001) findings, forty-five % of the samples fall into the low group, 38% fall into the medium category, and 20% fall into the high category. Phosphorus application is necessary in soils that exhibit medium and low levels of accessible phosphorus.

Zinc is crucial for facilitating specific metabolic reactions. Chlorophyll and carbohydrate synthesis require it. Zinc is an essential element for many enzyme systems, auxin and protein synthesis, seed production, and the pace of maturity (Shah *et al*., 2017). Zinc is thought to enhance RNA synthesis, which is essential for protein synthesis. Zinc does not undergo translocation within the plant. Initially, symptoms manifest in the more juvenile foliage and other anatomical components of the plant (Zewide and Sherefu, 2021). The typical symptoms of zinc deficiency include slowed growth and the appearance of light green yellowish patches and chlorotic bands on either side of the midrib in plants. The practice of cultivating high-yielding varieties (HYVs) through intense cropping, which aims to increase food production in our country, leads to a significant reduction in the natural nutrient reserves present in the soil. As a result, shortages of zinc are commonly observed in soils, in addition to N, P, and K. It is advisable to use nutrients to improve their inadequacies (Dhaliwal, *et al*., 2022).The aim of the experiment was the study the effect of phosphorus and zinc on growth and yield parameters of chickpea.

2. MATERIALS AND METHODS

The experiment was conducted at the Student's Instructional Farm, C.S.A. University of Agriculture and Technology, Kanpur, during the *rabi* season of 2020–21. Kanpur Nagar is located between the latitudes of 25.26^0 and 26.58^0 north and the longitudes of 79.31^0 and 80.34^0 east. The location is positioned at an altitude of 124 meters above the mean sea level in the alluvial region of the Gangetic plains in central Uttar Pradesh.

The experimental field's soil originated from alluvial deposits and had a sandy loam texture. It had a slightly alkaline pH of 7.9 (1:2.5 soil: water suspension method by Richards, 1954), EC 0.30 dSm^{-1} (Richards, 1954), low in organic carbon 4.5 gm kg^{-1}(Walkley and Black method, 1934), low in available N 210.0 kg ha^{-1}(Alkaline permanganate method by Subbiah and Asija, 1956), medium in available P 12.80 kg ha^{-1} (Olsen's method, 1954), low in available K 198.0 kg ha^{-1} (Hanwey and Heidel, 1952), low in available S 9.2 kg ha^{-1}(turbidimetrically method by Chesninand Yien, 1951) and low in available Zn 0.55 kg ha^{-1} (Lindsay and Norvell, 1978).

The sixteen treatments *viz*., P_0Zn_0 (control), $P_0Zn_{2.5}$, P_0Zn_5, P_0Zn_{10}, $P_{30}Zn_0$, $P_{30}Zn_{2.5}$, $P_{30}Zn_5$, $P_{30}Zn_{10}$, $P_{60}Zn_0$. $P_{60}Zn_{2.5}$, $P_{60}Zn_5$, $P_{60}Zn_{10}$, $P_{90}Zn_0$, $P_{90}Zn_{2.5}$, $P_{90}Zn_5$ and $P_{90}Zn_{10}$ were experimented in factorial randomized block design with 2 factors and 3 repetitions.

The full doses of phosphorus and zinc as per treatments were supplied through diammonium phosphate and zinc sulphate, respectively at sowing time. Recommended doses of nitrogen and potassium (20 kg N ha^{-1} and 40 kg K_2O ha^{-1}) through urea and muriate of potash were given as basal dressing.

The chickpea variety Uday was sown in rows spaced 30 cm apart, using a seed rate of 100 kg ha^{-1} in October (28-10-2020). The lines were excavated with a sharp spade by manual labour. After the act of sowing, planking was performed to provide coverage for the seeds. The crop was harvested at full maturity on March 21, 2021. The following observations were recorded-

2.1 Growth and development studies

Growth and development observations recorded in chickpea are presented as below:

Two plants were tagged and measured height (in cm) from the ground up to base of uppermost opened leaf at maturity stage of chickpea crop and averaged. The plants already tagged for height study were used for counting branches/plant, number of pods/plant were counted at maturity stage of the cropand two plants/plot were used for Number of grains/pod and averaged.The samples were drawn from net plot produced and 1000-grains were counted and weighed.

2.2 Yield studies

The seed yield of net plot (kg) was noted after threshing the dried pods of crop and then it was converted into seed yield (q ha^{-1}).The straw yield was computed by deducting the grain/seed yield from the crop biomass and then converted into q ha^{-1}.

2.3 Statistical analysis

The data pertaining to yield, chemical composition, and nutrient uptake were subjected to statistical processing and analysis to determine the significance of the impacts of different treatments.The Fisher's 'F' test was utilized for this purpose.The interpretation of the results relies on the statistical significance of the derived 'F' value at a 5% significance level. A critical difference has been determined for examining significant treatments.

3. RESULT AND DISCUSSION

3.1 Growth studies

3.1.1 Plant height

A study of Table-1 reveals that phosphorus fertilization in chickpea @ 30 and 60 kg P_2O_5 ha^{-1}considerably increased the plant height over no phosphorus treatment. The plant height was further increased non-significantly with 90 kg P_2O_5 ha^{-1} over 60 kg P_2O_5 ha^{-1} in crop. The tallest plants were produced by chickpea crop with 90 kg P_2O_5 ha^{-1} application.

Table 1. Influence of zinc and phosphorus levels on chickpea plant height and number of branches per plant

Treatments	Plant height (cm)	No. of primary branches/plant	No. of secondary branches/plant
Phosphorus (kg ha^{-1})			
0	46.19	3.61	6.40

30	48.64	4.62	8.37
60	52.48	5.82	9.61
90	53.71	5.93	10.26
SEm ±	0.55	0.15	0.22
CD (P=0.05)	1.58	0.42	0.61
Zinc (kg ha^{-1})			
0	48.57	4.16	7.73
2.5	50.68	4.92	8.57
5.0	51.95	5.39	9.18
10.0	50.15	5.43	9.26
SEm ±	0.55	0.15	0.22
CD (P=0.05)	1.58	0.42	0.61

The plant height exhibited a significant increase, rising from 46.19 cm under normal conditions to 53.71 cm when subjected to a dosage of 90 kg P_2O_5 ha^{-1}. The use of phosphorus may enhance plant development due to its involvement in the synthesis of proteins, vitamins, and chlorophyll. These results validate the conclusions of Kumar and Puri (2002), Kumar *et al*. (2009), and Sonet *et al*. (2020).

The data in Table-1 demonstrate that applying 2.5 kg of zinc ha^{-1} to chickpea plants resulted in a considerable increase in plant height compared to plants that did not receive any zinc treatment. The plant height exhibited a substantial additional increase when treated with 5 kg of Zn ha^{-1}compared to 2.5 kg of Zn ha^{-1}. Subsequently, there was a decrease in the height of the plants when the Zn application rate was increased from 5 kg ha^{-1} to 10 kg ha^{-1}. It happens due to antagonistic effect of P with increasing Zn. Therefore, the application of 5 kg Zn ha^{-1} resulted in the production of the tallest plants. This could be attributed to its role as a catalyst or stimulant in the majority of physiological and metabolic processes, as well as its ability to activate enzymes, leading to enhanced plant growth and development. Ullah *et al*., (2020) reported comparable findings.

3.1.2 Number of branches per plant

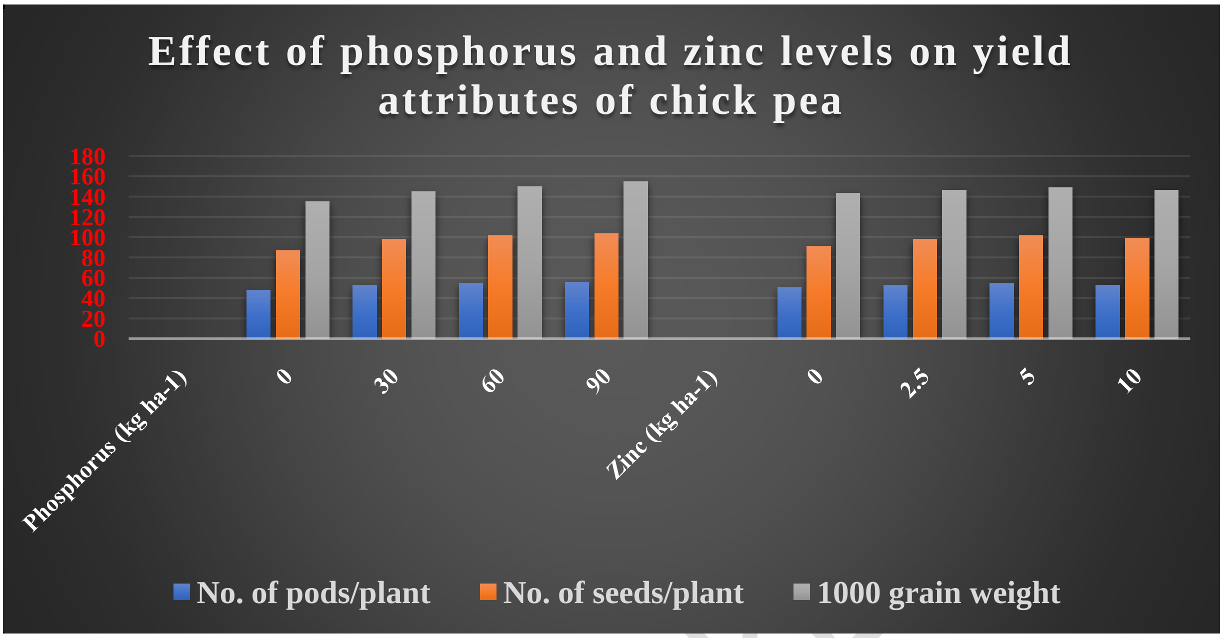
A further study of Table-1 reveals that the elevated phosphorus levels resulted in a considerable increase in the number of primary and secondary branches per plant in the crop, compared to the control group.The application of 90 kg P_2O_5 ha^{-1} resulted in the highest number of main and secondary branches, with values of 5.93 and 10.26, respectively while minimum values in control (3.61 and 6.40, respectively). Kumar *et al*., (2009), and Sonet *et al*., (2020)reported similar results. The data (Table-1) indicate that the number of primary and secondary branches per plant recorded at harvest increased significantly with zinc application in the crop. The maximum numbers of primary and secondary branches per plant were recorded in 10 kg Zn ha^{-1} treatment followed by 5 kg Zn ha^{-1} and control. However, both the higher levels of Zn (5 and 10 kg ha^{-1}) were statistically at par with respect to number of primary and secondary branches per plant. Similar results were reported by Ullah *et al.* (2018).

3.2 Yield attributing characters

Data on yield attributes of chickpea recorded at harvest are presented in fig-1. The number of pods/plant, number of grains/pod, 1000 grains weight of chickpea increased significantly with phosphorus application over control. The maximum values of 56.18 for number of pods/plant, 103.95 for number of seeds/plant and 154.83 for 1000 grains weight respectively were recorded at 90 kg P_2O_5 ha^{-1} during study. The increase in test weight of seed by application of P was up to 60 kg P_2O_5 ha^{-1}. This might be on account of better translocation of nutrients specially P, resulting in to formation of bold seed by increasing the size and weight of seeds. Similar resulted were reported by Kumar *et al.* (2022). The possible region of increase in these yield attributes could be that growth was much influenced by phosphorus application, which, later on, got converted in to reproductive phase. The positive impact of phosphorus (P) addition on yield attributes is likely attributed to phosphorus's well-established role as an "energy currency" and its crucial involvement in energy transformation and numerous metabolic processes. These findings endorse the results of Kumar and Puri (2002), Nehra *et al*. (2006) and Tripathi *et al.* (2013).

Fig - 1. Effect of phosphorus and zinc levels on yield attributes of chick pea

A study of Fig-1. reveals that the use of zinc resulted in a substantial augmentation in the



number of pods/plant, the number of grains/pod, and the weight of 1000 grains compared to the control throughout the duration of the study. The highest values of these yield qualities were seen in the treatment with 5 kg Zn ha^{-1}, followed by the treatment with 2.5 kg Zn ha^{-1} and the control, as recorded during the study. The rise in zinc levels can be attributed to the limited availability of zinc in the soil used for the experiment. Similar results were observed by Gautam *et al.*,(2022).

3.3 Yield Studies

3.3.1 Grain yield

The data about the grain yield of the chickpea crop and how it was influenced by different amounts of phosphorus during the study are given in Table-2. Phosphorus treatment in this study led to a considerable increase in the grain production of chickpea. The crop output showed substantial increases at each level of phosphorus relative to the control group during the trial. The significant effect was limited to phosphorus application up to 60 kg P_2O_5 ha^{-1}, beyond which the response was not significant in yield of the crop. The enhancement in grain yield of chickpea due to 30, 60 and 90 kg P_2O_5 ha^{-1} over control during study were 12.7, 29.3 and 33.5 percent, respectively. The rise in crop production can be attributed to an elevated rate of protein synthesis and improved photosynthetic activity in the plants, resulting from increased chlorophyll synthesis as a result of phosphorus fertilization. The soil used in this study was deficient in available P and, therefore, significant response to chickpea to applied phosphorus is quite understandable. Responses of chickpea to phosphorus application were also reported by Sharma *et al*., (2000), Kumar *et al*., (2004) and Kumar *et al.,* (2009)and Gulpadiya and Chhonkar (2014).

Application of zinc to the soil enhanced the grain yield of chickpea significantly over control during the study. The maximum grain yield was noted under 5 kg Zn ha^{-1}. The percent increase in grain yield over control was 12.1 with 5 kg Zn ha^{-1}. The grain yield of chickpea lowered at 10 kg Zinc ha^{-1} over 5 kg Zinc ha^{-1} during study, indicating an adverse effect 10 kg Zn ha^{-1} on chickpea grain production. The data on soil chemical analysis show that experimental soil fell in the low category of available zinc and as such were expected to show response to zinc application. Due to its role as a metal activator of enzymes and catalysts or stimulants in most physiological and metabolic processes, it enhanced yield by promoting plant growth and development, which in turn increased grain output. Singh *et al*. (1998), Sharma *et al*. (2000) and Balai *et al.* (2017) also observed a noteworthy responseof Legumes to zinc application.

Table 2.Influenceof phosphorus and zinc levels on grain and straw of chickpea

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
Phosphorus (kg ha^{-1})		
0	14.70	18.11
30	16.58	20.42
60	19.02	22.45
90	19.63	23.12
SEm ±	0.38	0.42
CD (P=0.05)	1.08	1.20
Zinc (kg ha^{-1})		
0	16.35	19.68
2.5	17.62	21.39
5.0	18.33	22.12
10.0	17.61	20.90
SEm ±	0.38	0.42
CD (P=0.05)	1.08	1.20

3.3.2 Straw yield

The straw yield of chickpea was considerably influenced by phosphorus levels, similar to grain yield, during the study. The highest straw yield was seen at a phosphorus level of 90 kg P_2O_5 ha^{-1}, as shown in Table-3.During study, the application of 30, 60, and 90 kg P_2O_5ha^{-1} resulted in respective increases of 12.7%, 23.9%, and 27.6% in the straw yield of chickpea compared to the control.The soil chemical analysis findings indicate that the soil in the experimental field had a deficiency of available phosphorus. Consequently, it is highly probable that the addition of P_2O_5would result in a response that aligns with the soil's phosphorus levels. The increase in straw yield of chickpea was mainly due to enhanced rate of photosynthesis and carbohydrate metabolism as influenced by P application. Chickpea being a legume is known to respond to P fertilization as it plays a pivotal role in root and nodule development, energy transformation and metabolic processes of the plant (Mitran*et al*. 2018). Since the soil was low in available P favourable response of chickpea to applied P could be obtained. Sharma *et al*. (2000), Kumar *et al*. (2004) and Kumar *et al*. (2009) also observed similar response of chickpea to P application.

Data presented in Table-3 reveals that the inclusion of zinc led to a significant augmentation in the straw yield of chickpea compared to the control group during the trial. The study observed that the application of 2.5, 5.0, and 10 kg ha^{-1} of zinc resulted in respective increases of 8.7%, 12.4%, and 6.2% in chickpea straw yield compared to the control.The enhanced crop productivity resulting from zinc treatment can be attributed to its involvement in many enzymatic activities, acting as a catalyst in growth processes, hormone production, and protein synthesis. Similar results were also reported by Behera*et al.* (2021).

Table 3. Interaction effect of P and Zn levels on grain and straw yield of chickpea

P levels (kg ha^{-1})	**Zn levels (kg ha^{-1})**			
	0	**2.5**	**5.0**	**10.0**
Grain yield (q ha^{-1})				
0	13.72	14.58	15.35	15.16
30	15.45	16.83	17.54	16.47
60	17.61	19.12	19.89	19.48
90	18.64	19.95	20.60	19.35
SEm ±	0.75			
CD (P=0.05)	2.15			
Straw yield (q ha^{-1})				

0	16.50	18.66	19.34	17.94
30	19.47	20.85	21.39	19.95
60	20.81	22.56	23.47	22.98
90	21.95	23.47	24.32	22.76
SEm ±	0.83			
CD (P=0.05)	2.39			

Interaction effect of P and Zn levels on the grain and straw yield of chickpea was significant during study. It is obvious from the data that the maximum grain and straw yields were obtained under 90 kg P_2O_5 and 5 kg Zn ha^{-1} treatment. Thus, every incremental increase in zinc level at the highest level of P application (90 kg P_2O_5 ha^{-1}) was found to increase the grain and straw yields of chickpea. Results indicate that response of chickpea to Zn application depends on the level of P application. From the results obtained, it can be inferred that 60 kg P_2O_5 and 5 kg Zn ha^{-1} seems to be optimum dose. Ullah *et al.* (2018) found similar results.

CONCLUSION

In the light of results summarized above, it may be concluded that the application of phosphorus and zinc proved more beneficial in improving the productivity of chickpea crop and $P_{90}Zn_5$ found best. Application of P and Zn also improved the growth and yields of the crop. Phosphorus requirement of chickpea was found more.

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