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Interaction Effect of Phosphorous and Zinc on Yield Attributes, Yield and Quality Characteristics of Chickpea under the Central Plain Zone of Uttar Pradesh

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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

The present field experiments were conducted on studies effect of phosphorus and zinc on yield and quality parameters of chickpeas taken up at Student's Instructional Farm, at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, (U.P.) India, during the *rabi* season 2021-22. The experiment consists of 16 treatment combinations in a factorial randomized block design

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with three replications consisting of a different combination of phosphorus and zinc. Chickpea variety *RVG-203* was grown with the recommended agronomic practices. On the basis of results emanating from the investigation, it can be concluded that among the yield components and productivity parameters maximum values in relation to the number of pods plant^{-1} (61.26), number of grains pod^{-1} (1.73), 100 grain wt. (20.20 gm), grain yield (18.85 q ha^{-1}), straw yield (23.35 q ha^{-1}), biological yield (42.20 q ha^{-1}), harvest index (44.67 %) and protein content in grain (20.93%) were found in the treatment T_{15} [$P_{90}Zn_6$]. Corresponding minimum values in relation to number of pods plant^{-1} (45.00), number of grains pod^{-1} (1.20), 100 grain wt. (16.96 gm), grain yield (12.25 q ha^{-1}), straw yield (17.16 q ha^{-1}), biological yield (29.41 q ha^{-1}), harvest index (41.65%) and protein content in grain (19.56%) were associated with the treatment T_1 [P_0Zn_0].

Keywords: Chickpea; phosphorous; protein; yield and zinc.

1. INTRODUCTION

"India is the largest producer and consumer of pulses in the world. Among the pulses, chickpea is the most important grown in every part of India. It is the largest produced food legume in South Asia. Chickpea (*Cicer arietinum* L.) is a major legume crop cultivated for its edible seeds legume of the genus *Cicer*, Tribe *Cicereae*, family *Fabaceae* (*leguminaceae*), and subfamily *Papilionaceae*. It provides protein rich diet to the vegetarian Indian and complements the stable cereals in the diets with proteins, essential amino acids, vitamins and minerals" [1]. "They contain carbohydrates (61.51%) and fat (4.5%) are relatively free from anti nutritional factors. Chickpea is rich in protein content (20.47g/100g), carbohydrate (62.95g/100g), fiber (12.2g/100g), phosphorous (252mg/l00g), high amount of minerals such as calcium (57mg/100g), magnesium (79mg/100g), iron (4.31mg/l00g) and zinc (15mg/100g), low in fat content and most of it is polyunsaturated" [2].

"India is the largest producer (25% of global production), the consumer (27% of world consumption) and the importer (14%) of pulses in the world. India ranks first in the world in terms of pulse production (25% of total world production) (FAOSTAT 2017). In India chickpea occupies 10.17 million ha area, with a production of 11.35 million tonnes registering a productivity of 1116 kg/ha. In Uttar Pradesh, the chickpea crop occupied 0.62 million hectares, 0.85 million tonnes of production, and 1371 kg/ha productivity" [3].

"Phosphorus deficiency can limit nodule number, leaf area, biomass and grain development in legumes. Symbiotic nitrogen fixation has a high P demand because the process consumes large amounts of energy" [4] and "energy-generating metabolism strongly depends upon the availability of P" [5]. Singh and Sale [6] reported that "P fertilization stimulates root growth, photosynthesis and increases the hydraulic conductibility of roots". "Phosphorus is used in numerous molecular and biochemical plant processes, particularly in energy acquisition, storage and utilization" [7]. "The phosphorus content per unit dry weight is usually considerably higher in the nodules than in the roots and shoots, particularly at low external phosphorus supply. Nitrogen fixing plants have an increased requirement for P over dose receiving direct nitrogen fertilization, probability due to the need for nodule development and signal transduction, and to P-lipids in a large number of bacteroids" [8]. "It acts as a catalyst in several biochemical reactions occurred in plants. It plays an important role in capturing and converting solar energy into useful plant compounds. These compounds help in the general health and vigor of plants" [9]. "Legumes are heavy feeders of phosphorus and less responsive to nitrogen because of their capacity to meet their own nitrogen requirement through symbiotic fixation" [10]. "Phosphorus is connected with some particular plant growth factors are root development, vigorous stem, enhanced flower formation and seed production, earlier and more uniform crop maturity, increase nitrogen fixing capacity of legumes, improvement in crop quality and resistance to plant diseases" [11]. "It is required for higher and more sustainable production of grain legumes. Generally, legumes have higher P requisites due to more energy consumption in the symbiotic nitrogen fixation process" [12].

"Phosphorus enhances the activity of rhizobia and increases the formation of root nodules thereby helping in fixing more atmospheric nitrogen in root nodules. Phosphorus is also an important fertilizer in chickpea production; it is a very important chemical fertilizer that can raise the water-holding capacity of the soil" [13].

Zinc is required for the proper functioning of various metabolic processes. It's necessary for chlorophyll and carbohydrate production. Several enzyme systems, auxin and protein synthesis, seed formation and maturity rate all require zinc, either directly or indirectly. Zinc is known to help with RNA synthesis, which is required for protein production. In the plant, zinc is not translocated. As a result, symptoms occur first on the plant's younger leaves and other sections. Stunted growth, the formation of light green yellowish patches and chlorotic bands on either side of the midrib in the plants are all common symptoms of zinc deficiency. Sustainable production needs a balanced supply of soil along with suitable physical and biological properties to attain a better growth of roots and efficient utilization of nutrients from the rhizosphere.

The soils of Kanpur are alkaline in nature, low in organic content in generally low in fertility status. All these factors lead to the deficiency of zinc in soils. As such, that the application of zinc may be helpful in increasing the yields of chickpeas under agro-climatic conditions of Kanpur.

2. RESOURCES AND METHODS

2.1 Experimental Site

The experiment was conducted during the *rabi* season of 2021-22 at the student's Instructional farm, C.S.A. University of Agriculture and Technology, Kanpur Nagar (U.P.). The field was well leveled and irrigated by a tube well. The farm is situated at the main campus of the university, in the west-northern part of Kanpur city under the sub-tropical zone in vth agroclimatic zone (central plain zone).

2.2 Edaphic Condition

The soil was moist, well drained with uniform plane topography. The soil of the experimental field was alluvial in origin, sandy loam in texture and slightly alkaline in reaction having pH 7.9 (1:2.5 soil: water suspension method given by [14], electrical conductivity 0.30 dSm^{-1} (1:2.5 soil: water suspension method given by Jackson,[14], Organic carbon percentage in the soil is 0.45 per cent (Walkley and Black's rapid titration method given by [15], with available nitrogen 210 kg ha^{-1} (Alkaline permanganate method given by [16], available phosphorus as sodium bicarbonate-extractable P was 12.8 kg ha^{-1} (Olsen's calorimetrically method, [17] available potassium was 198 kg ha^{-1} (Flame photometer method given by Hanwey and Heidel, [18], available and available zinc was 0.55 kg ha^{-1} (DTPA extraction method given by [19].

2.3 Detail of Treatments and Design

The 16 treatments combination of nutrient management practices of inorganic fertilizer (DAP and zinc sulphate). The experiment was laid out in a factorial randomized block design with three replications.

2.4 Crop Husbandry

Pre-sowing irrigation (Paleva) was done in the experimental field with an object to get optimum moisture conditions for attaining good germination. At proper tilth, one ploughing with tractor drawn mould bold plough was done followed by two ploughings by cultivator. full dose of Phosphorus, and Zinc were applied as basal at the time of sowing in the form of DAP and Zinc sulphate respectively. The sowing of seeds of Chickpea variety RGV-203 was done by line sowing by hand at 4-5 cm depth of soil and with line to line spacing of 45 cm to maintain uniform plant population.

2.5 Harvesting and Threshing

The crop was harvested at maturity and was allowed to dry in sun. Separate bundles were made for each plot and weighted. The after drying harvest was threshed manually.

2.6 Data Collection

2.6.1 Grain yield

After threshing the grain yield from each plot was separately weighed and recorded after converting it into quintals per hectare.

2.6.2 Straw yield

After subtracting the grain yield per plot from the total biological yield. After converting the yields into quintals per hectare, yields were recorded.

2.6.3 Biological yield (q ha^{-1})

Seed yield and Stover yield together were regarded as biological yield. The biological yield was calculated with the following formula:

$$\text{Biological yield} = \text{Seed yield} + \text{Stover yield}$$

2.6.4 Harvest index (%)

The recovery of grains in total dry matter was considered as the harvest index, expressed in percentage.

It has been calculated by following formula:

Harvest Index (%) = [Seed Yield (q ha^{-1}) / Biological Yield (q ha^{-1})] x 100

2.6.5 Protein content (%)

Nitrogen content (%) in grains was determined by Kjeldahl's method. The Protein content of the chickpea seed was determined by multiplying the N content of the chickpea seed with a factor of 6.25 (N % × 6.25). (A.O.A.C., 1970).

2.7 Statistical Analysis

The growth parameters and yields were recorded and analysed as per Gomez and Gomez [20] the tested at a 5% level of significance to interpret the significant differences.

3. RESULTS AND DISCUSSION

3.1 Yield Components

At glance over the data given in the Table 2. and depicted in Fig.1. clearly shows that among the yield attributing characters of chickpea such as the number of pods $plant^{-1}$, the number of grain pod^{-1} and 100 grain weight (gm) significant increase due to the application of Phosphorus and Zinc. Significantly response on yield components was recorded with T_{15} [P_{90} Zn_6] over other treatments. The number of pods $plant^{-1}$, number of grain pod^{-1} and 100-grain weight (gm) increased to the magnitude of 45.00 to 61.26, 1.20 to 1.73 and 16.96 to 20.20, respectively. The maximum number of pods $plant^{-1}$ (61.26), number of grain pod^{-1} (1.73) and 100-grain weight (20.20 gm) was associated with the treatment T_{15} [P_{90} Zn_6]. Minimum number of pods $plant^{-1}$ (45.00), number of grain pod^{-1} (1.20) and 100 grain weight (16.96 gm) was associated with the treatment T_1 [Control]. The results of the present investigation are also in agreement with the findings of Yadav et al. [21], Singh et al. [22], Kumar et al. [23], Yadav et al. [24] and Sachan et al. [25].

It is visualized from the data given in Table 3. and depicted in Fig. 2 clearly indicate that among the productivity parameters viz. grain yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index (%) significantly increase due to the application of Phosphorus and Zinc. Grain yield varied from 12.25 to 18.85 q ha^{-1}, straw yield varied from 17.16 to 23.35 q ha^{-1}, biological yield varied from 29.41 to 42.20 q ha^{-1} and harvest index varied from 41.65 to 44.67 %. The maximum grain yield (18.85 q ha^{-1}), straw yield (23.35 q ha^{-1}), biological yield (42.20 q ha^{-1}) and harvest index (44.67 %) were associated with the treatment T_{15} [$P_{90}Zn_6$] during the experimentation. The minimum grain yield (12.25 q ha^{-1}), straw yield (17.16 q ha^{-1}), biological yield (29.41 q ha^{-1}) and harvest index (41.65 %) were under the treatment T_1 [control] during the experimentation. "The surge in seed and straw yields under adequate nutrients supply might be attributed mainly to the collective effect of a greater number of pod $plant^{-1}$, the number of grains pod^{-1} and higher test weight, which was the result of improved translocation of photosynthates from source to sink ultimately yield is increased. The increase in grain yield under adequate nutrient supply mainly due to more yield attributes ultimately resulted in more grain yield. Grain, straw yield, biological yield and harvest index of chickpeas significantly increased due to the application of P 90 (kg ha^{-1}) and Zinc 6 (kg ha^{-1}) over their controls" [26]. These results also confirms the findings of Singh et al. [27], Pal et al. [28], Yadav et al. [29], Kumar et al. [30] and Sachan et al. [31].

Table 1. Detail of the treatment combinations

S. No.	Symbol	Treatment combination
1.	T_1	P_0 Zn_0
2.	T_2	P_0 Zn_3
3.	T_3	P_0 Zn_6
4.	T_4	P_0 Zn_9
5	T_5	P_{30} Zn_0
6.	T_6	P_{30} Zn_3
7.	T_7	P_{30} Zn_6
8.	T_8	P_{30} Zn_9
9.	T_9	P_{60} Zn_0
10.	T_{10}	$P_{60}Zn_3$
11.	T_{11}	P_{60} Zn_6
12.	T_{12}	P_{60} Zn_9
13.	T_{13}	P_{90} Zn_0
14.	T_{14}	P_{90} Zn_3
15.	T_{15}	P_{90} Zn_6
16.	T_{16}	P_{90} Zn_9

3.2 Quality Parameter

3.2.1 Protein

It is visualized from the data given in Table 4. clearly indicates that among the quality parameters viz. protein content increase due to the application of Phosphorus and Zinc. Protein content varied from 19.56 to 20.93 (%) The maximum protein content 20.93 % was associated with the treatment T_{15} [$P_{90}Zn_6$]. The minimum protein content 19.53% was under the treatment T_1 [control]. Similar findings were reported by Ahmed et al. [32], Vikrant et al. [33] and Tripathy et al. [34].

Table 2. Effect of different treatment combinations on yield components of chickpea

Treatment		No of pods plant^{-1}	No of grains pod^{-1}	100 Grains weight (g)
T_1		45.00	1.20	16.96
T_2		47.21	1.27	17.42
T_3		52.21	1.36	17.65
T_4		48.43	1.31	17.53
T_5		50.12	1.32	17.61
T_6		54.31	1.48	17.71
T_7		55.18	1.49	17.87
T_8		53.42	1.43	17.68
T_9		56.21	1.52	17.94
T_{10}		59.87	1.62	18.12
T_{11}		60.89	1.71	19.82
T_{12}		58.13	1.57	18.10
T_{13}		57.32	1.55	18.03
T_{14}		60.38	1.69	19.11
T_{15}		61.26	1.73	20.20
T_{16}		60.12	1.65	18.42
S.E (m) ±	P	0.055	0.34	0.010
	Zn	0.055	0.49	0.010
	P × Zn	0.110	0.59	0.019
CD at 5%	P	0.159	1.03	0.028
	Zn	0.159	1.48	0.028
	P × Zn	NS	NS	NS

Table 3. Effect of different treatment combinations on productivity parameters of chickpea

Treatment		Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
T_1		12.25	17.16	29.41	41.65
T_2		12.52	17.35	29.87	41.91
T_3		13.76	18.72	32.48	42.36
T_4		12.87	17.81	30.68	41.95
T_5		13.24	18.25	31.49	42.05
T_6		14.86	19.65	34.51	43.05
T_7		15.34	20.12	35.46	43.26
T_8		14.25	19.10	33.35	42.73
T_9		15.77	20.46	36.23	43.53
T_{10}		16.96	21.78	38.74	43.78
T_{11}		18.24	22.96	41.20	44.27
T_{12}		16.71	21.34	38.05	43.91
T_{13}		16.10	20.95	37.05	43.45
T_{14}		17.65	22.54	40.19	43.92
T_{15}		18.85	23.35	42.20	44.67
T_{16}		17.31	22.24	39.55	43.76
S.E (m) ±	P	0.022	0.021	0.043	0.010
	Zn	0.022	0.021	0.043	0.010
	P×Zn	0.044	0.043	0.087	0.019
CD at 5%	P	0.064	0.062	0.126	0.028
	Zn	0.064	0.062	0.126	0.028
	P×Zn	NS	NS	NS	NS

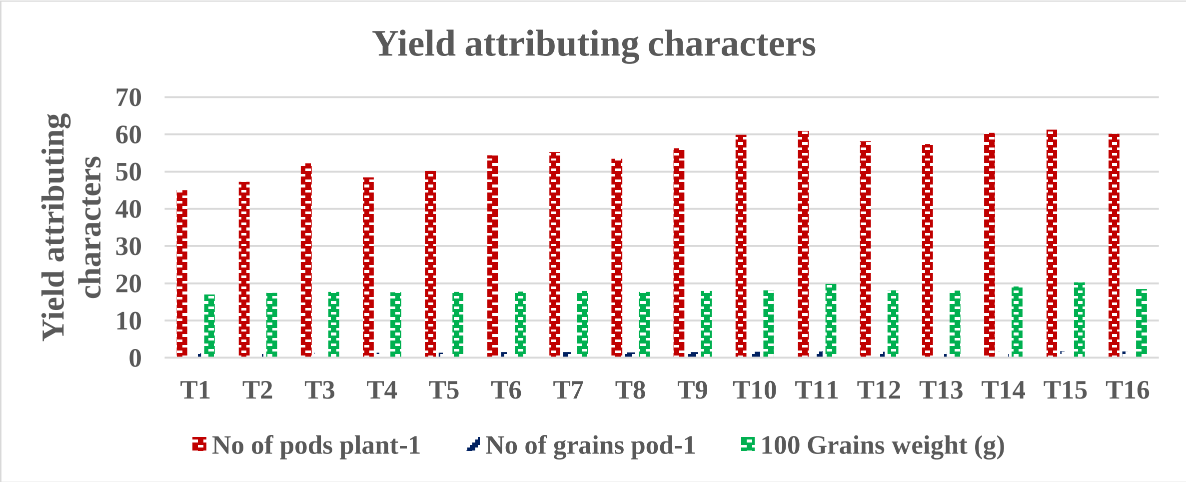

Fig. 1. Effect of different treatment combinations on yield components of chickpea Productivity Parameters

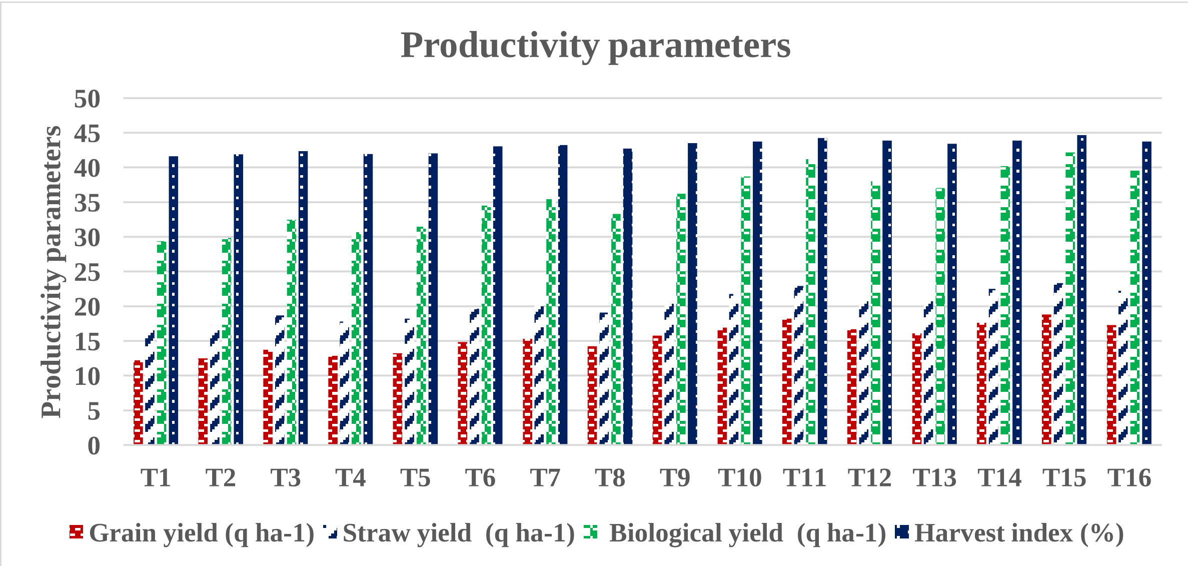

Fig. 2. Effect of different treatment combinations on productivity parameters of chickpea

Table 4. Effect of different treatment combinations on quality parameters of chickpea

Treatment	Treatment combination	Protein content in grain (%)
T_1	P_0Zn_0	19.56
T_2	P_0Zn_3	19.68
T_3	P_0Zn_6	19.94
T_4	P_0Zn_9	19.81
T_5	$P_{30}Zn_0$	19.87
T_6	$P_{30}Zn_3$	20.18
T_7	$P_{30}Zn_6$	20.25
T_8	$P_{30}Zn_9$	20.06
T_9	$P_{60}Zn_0$	20.37
T_{10}	$P_{60}Zn_3$	20.62
T_{11}	$P_{60}Zn_6$	20.87
T_{12}	$P_{60}Zn_9$	20.56
T_{13}	$P_{90}Zn_0$	20.44

Treatment	Treatment combination	Protein content in grain (%)
T_{14}	$P_{90}Zn_3$	20.75
T_{15}	$P_{90}Zn_6$	20.93
T_{16}	$P_{90}Zn_9$	20.68
S.E (m) ±	P	0.34
	Zn	0.29
	P×Zn	0.49
CD at 5%	P	1.03
	Zn	1.03
	P×Zn	NS

4. CONCLUSION

The current study demonstrates the benefit of the application of phosphorus 90 kg ha^{-1} and zinc 6 kg ha^{-1} significantly increased yield attributes, productivity and quality parameters like the number of pod $plant^{-1}$, number of grains pod^{-1}, test weight of 100 seeds, grain yield, straw yield, biological yield, harvest index and protein quality. Finally it can be concluded that the treatment T_{15} [$P_{90}Zn_6$] is the best option for improving productivity, yields and quality parameter of chickpea crops.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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