



# Effect of Phosphorous and Potassium on Growth Parameters, Yield and Yield Attributes of Chickpea (*Cicer arietinum* L.) under the Rainfed Condition in Chitrakoot, India

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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 study investigate the effect of phosphorous and potassium on growth parameters, yield and yield attributes of chickpea (*Cicer arietinum* L.) under the rainfed condition in Chitrakoot, India. Field experiments were carried out to investigate the effect of phosphorus and potassium on chickpea growth parameters, yield components, and yield during the rabi season of 2021-22 at Rajoula Agriculture farm, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.). The experiment consist of nine treatments combinations in factorial randomized block design with three replications consisted of three levels of phosphorous (50, 60 and 70 kg ha<sup>-1</sup>) and

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three potassium levels (30, 40 and 50 kg ha<sup>-1</sup>). Chickpea variety *IPC-2011-112* was grown with the recommended agronomic practices. On the basis of results emanated from investigation it can be concluded that among the growth parameters maximum plant height at 90 DAS is 37.40 cm, maximum number of branches at 90 DAS is 32.53 and maximum number of nodules plant<sup>-1</sup> at 45 DAS is 46.00 during the study were associated with the treatment T<sub>9</sub> [70 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>+ 50 kg K<sub>2</sub>O ha<sup>-1</sup>]. Similarly, among the yield components and productivity parameters maximum values in relation to number of pod plant<sup>-1</sup> (69.33), number of seed pod<sup>-1</sup> (1.73), 100 grain wt. (22.66 gm) and grain yield (16.85 q ha<sup>-1</sup>) was also found in the treatment T<sub>9</sub> [70 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>+ 50 kg K<sub>2</sub>O ha<sup>-1</sup>].

**Keywords:** Chickpea; growth; phosphorous; potassium; yield.

## 1. INTRODUCTION

“Pulses play a pivotal role and occupy a unique position in Indian agriculture by virtue of their inherent capacity to grow on marginal lands. It is an easily available source of protein in the rural heart of India. Pulses provide significant nutritional and health benefits and are known to reduce several non-communicable diseases such as colon cancer and cardio-vascular diseases” [1].

“India is the largest producer (25% of global production), consumer (27% of world consumption) and 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 the productivity of 1116 kg/ha. In Uttar Pradesh, chickpea crop occupied 0.62 million hectares area, 0.85 million tonnes production and 1371 kg/ha productivity” [2].

“More than 90 per cent of total pulse production has been contributed from 10 states namely Rajasthan, Maharashtra, Madhya Pradesh, Uttar Pradesh, Karnataka, Gujarat, Andhra Pradesh, Jharkhand, Telangana and Tamil Nadu. Rajasthan has the highest area (24.21%) under chickpea, followed by Maharashtra (22.82%), Madhya Pradesh (18.94%), Karnataka (10.27%), Uttar Pradesh (6.10%) and Andhra Pradesh (4.56%)” [2].

“Phosphorus (P) is an essential nutrient of numerous vital plant structural compounds. Phosphorus is one of the essential nutrients for legume growth and BNF” [3].

“Phosphorus deficiency can limit nodule number, leaf area, and 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 hydraulic conductivity of roots. Phosphorus is used in numerous molecular and biochemical plant processes, particularly in energy acquisition, storage and utilization” [7].

“Legumes are heavy feeder of phosphorus and less responsive to nitrogen because of their capacity to meet their own nitrogen requirement through symbiotic fixation” [8]. “Phosphorus is connected with some particular plant growth factors that 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” [9]. “It is required for higher and sustainable production of grain legumes. Generally, legumes have higher P requisites due to more consumption of energy in the process of symbiotic nitrogen fixation” [10].

“Potassium application has been neglected in many countries, including India, which has resulted in soil K depletion in agricultural ecosystems and a decline in crop yields” (Regmi et al., 2002). “Higher yields and crop quality can be obtained at optimal N: K nutritional ratios. K is an essential macronutrient required for proper development of plants. In addition to activation of numerous enzymes, K plays an important role in the maintenance of electrical potential gradients across cell membranes and the generation of turgor. It is also essential for photosynthesis, protein synthesis and regulation of stomatal movement and is the major cation in the maintenance of cation-anion balances” [11]. “High availability of K enhances root development, producing more branching and lateral roots” [12].

“Potassium is involved in many physiological process such as photosynthesis [13], photosynthetic translocation, protein and starch synthesis, water energy relations [14], translocation of assimilates and activation of number of enzymes” [15].

## 2. METHODS AND MATERIALS

### 2.1 Experimental Sites

The experiment was carried out at Rajaula Agriculture farm, Mahatma Gandhi Chitrakoot Gramoday Vishwavidyalaya Chitrakoot, Satna (M.P.) which lies in the semi- arid and sub-tropical region of Madhya Pradesh between 25.148° North latitude and 80.855° East longitude. The altitude of town is about 190-210 meter above mean sea level.

### 2.2 Edaphic Condition

The soil of the experimental field was alluvial in origin, sandy loam in texture and slightly alkaline in reaction having pH 7.28 (1:2.5 soil: water suspension method given by Jackson, [16]), organic carbon percentage in soil is 0.34 per cent (Walkley and Black’s rapid titration method given by Walkley and Black, [17], with available nitrogen 98.0 kg ha<sup>-1</sup> (Alkaline permanganate method given by Subbiah and Asija, [18]), available phosphorus as sodium bicarbonate-extractable P<sub>2</sub>O<sub>5</sub> was 17.32 kg ha<sup>-1</sup> (Olsen’s calorimetrically method, Olsen et al. [19]) available potassium was 305.99 kg ha<sup>-1</sup> (Flame photometer method given by Hanwey and Heidel, [20]).

### 2.3 Detail of Treatments and Design

The nine treatments combination of nutrient management practices having three each phosphorus levels (50, 60 and 70 kg ha<sup>-1</sup>) and potassium levels (30, 40 and 50 kg ha<sup>-1</sup>). Experiment was laid out in factorial randomized block design with three replications.

### 2.4 Crop Husbandry

In the experimental field, a pre-sowing irrigation (Paleva) was carried out with the goal of achieving the ideal moisture conditions for achieving good germination. A tractor-drawn mould board plough was used for one ploughing at the proper tillage, followed by two cultivator plowings. Urea is used to apply nitrogen at a uniform rate of Phosphorus and potassium was applied as per treatment at the time of sowing

through single super phosphate and murate of potash respectively. The sowing of chickpea crop was done using a seed rate of 80 kg ha<sup>-1</sup> in furrows opened by plough in the furrows spaced at 45 cm apart. Planking was done to cover the seeds with fine soil after sowing.

### 2.5 Harvesting and Threshing

When the crop was fully grown, it was harvested and allowed to dry in the sun. Each plot received a unique bundle that was weighted. The harvest was manually threshed after drying.

### 2.6 Grain Yield

Following threshing, the grain yield from each plot was individually weighed, converted to quintals per hectare, and recorded.

## 3. RESULTS AND DISCUSSION

### 3.1 Growth Parameters

#### 3.1.1 Plant height (cm)

Plant height (cm) was significantly influenced by the use of different phosphorous and potassium levels. Plant height (cm) at 90 DAS was significantly higher P<sub>2</sub>O<sub>5</sub>@70 kg ha<sup>-1</sup> as compared to P<sub>2</sub>O<sub>5</sub>@60 kg ha<sup>-1</sup> and P<sub>2</sub>O<sub>5</sub>@50 kg ha<sup>-1</sup>. The mean plant height (cm) at P<sub>50</sub>, P<sub>60</sub> and P<sub>70</sub> were 33.79, 34.75 and 36.80 cm at 90 DAS. Plant height (cm) at 90 DAS was significantly higher in K<sub>2</sub>O @50 kg ha<sup>-1</sup> as compared to K<sub>2</sub>O @40 kg ha<sup>-1</sup> and K<sub>2</sub>O @30 kg ha<sup>-1</sup>. The mean plant height (cm) at K<sub>30</sub>, K<sub>40</sub> and K<sub>50</sub> were 34.52, 35.03 and 35.80 cm at 90 DAS. The height of shoot was stimulated due to phosphorous which may be attributed to its essentiality in cell division. The consequences of the current investigation are additionally in concurrence with the investigation of Murari et al. [21], Singh and Singh [22] and Yadav et al. [23].

#### 3.1.2 Number of branches plant<sup>-1</sup>

The no. of branches per plant is an important indication of growth. No. of branches per plant was significantly influenced by the use of different phosphorous levels at all growth stages. No. of branches per plant at 90 DAS was significantly higher P<sub>2</sub>O<sub>5</sub>@70 kg ha<sup>-1</sup> as compared to P<sub>2</sub>O<sub>5</sub>@60 kg ha<sup>-1</sup> and P<sub>2</sub>O<sub>5</sub>@50 kg ha<sup>-1</sup>. The mean no. of branches per plant at P<sub>50</sub>, P<sub>60</sub> and P<sub>70</sub> were 30.20, 31.22 and 32.24 at 90 DAS. No. of branches per plant of chickpea significantly increased with the use of different potassium levels. No. of branches per plant at 90

DAS was significantly higher in  $K_2O@50 \text{ kg ha}^{-1}$  as compared to  $K_2O @40 \text{ kg ha}^{-1}$  and  $K_2O @30 \text{ kg ha}^{-1}$ . The mean no. of branches per plant at  $K_{30}$ ,  $K_{40}$  and  $K_{50}$  were 30.68, 31.37 and 31.60 at 90 DAS. The results of the present investigation are also in agreement with the findings of Jaybhay et al. [24] and Yadav et al. [25].

### 3.1.3 Number of nodule plant<sup>-1</sup>

The no. of nodule per plant is an important indication of growth. No. of nodule per plant was significantly influenced by the use of different phosphorous levels at all growth stages. No. of nodule per plant at 45 was significantly higher  $P_2O_5@70 \text{ kg ha}^{-1}$  as compared to  $P_2O_5@60 \text{ kg ha}^{-1}$  and  $P_2O_5@50 \text{ kg ha}^{-1}$ . The mean no. of nodule per plant at  $P_{50}$ ,  $P_{60}$  and  $P_{70}$  were 29.00, 37.66 and 42.66 respectively at 45 days after sowing. No. of nodule per plant of chickpea significantly increased with the use of different potassium levels. No. of nodule per plant at 45 DAS was significantly higher in  $K_2O@50 \text{ kg ha}^{-1}$  as compared to  $K_2O @40 \text{ kg ha}^{-1}$  and  $K_2O @30 \text{ kg ha}^{-1}$ . The mean no. of nodule per plant at  $K_{30}$ ,  $K_{40}$  and  $K_{50}$  were 33.33, 36.33 and 39.66 respectively at 30 DAS. The consequences of the current investigation are additionally in

concurrence with the investigation of Thesiya et al. [26] and Badini et al. [27].

## 3.2 Yield Components and Yield

### 3.2.1 No. of pod plant<sup>-1</sup>

No. of pod plant<sup>-1</sup> is an important indication of yield attributing characters. No. of pod plant<sup>-1</sup> was significantly influenced by the use of different phosphorous levels at harvest stages. No. of pod plant<sup>-1</sup> at harvest stage was significantly higher  $P_2O_5@70 \text{ kg ha}^{-1}$  as compared to  $P_2O_5@60 \text{ kg ha}^{-1}$  and  $P_2O_5@50 \text{ kg ha}^{-1}$ . The mean no. of pod plant<sup>-1</sup> at  $P_{50}$ ,  $P_{60}$  and  $P_{70}$  were 54.86, 60.91 and 67.71 respectively at harvest stage. No. of pod plant<sup>-1</sup> of chickpea significantly increased with the use of different potassium levels. No. of pod plant<sup>-1</sup> at harvest stage was significantly higher in  $K_2O@50 \text{ kg ha}^{-1}$  as compared to  $K_2O @40 \text{ kg ha}^{-1}$  and  $K_2O @30 \text{ kg ha}^{-1}$ . The mean no. of pod plant<sup>-1</sup> at  $K_{30}$ ,  $K_{40}$  and  $K_{50}$  were 59.44, 60.86 and 63.17 respectively at harvest stage. The results of the present investigation are also in agreement with the findings of Neenu et al. [28], Ullah et al. [29] and Kumar et al. [30].

**Table 1. List of treatments used for the study**

Treatment	Treatment details	Symbol
T <sub>1</sub>	50 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> + 30 kg K <sub>2</sub> O ha <sup>-1</sup>	P <sub>50</sub> K <sub>30</sub>
T <sub>2</sub>	50 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> + 40 kg K <sub>2</sub> O ha <sup>-1</sup>	P <sub>50</sub> K <sub>40</sub>
T <sub>3</sub>	50 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> + 50 kg K <sub>2</sub> O ha <sup>-1</sup>	P <sub>50</sub> K <sub>50</sub>
T <sub>4</sub>	60 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> + 30 kg K <sub>2</sub> O ha <sup>-1</sup>	P <sub>60</sub> K <sub>30</sub>
T <sub>5</sub>	60 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> + 40 kg K <sub>2</sub> O ha <sup>-1</sup>	P <sub>60</sub> K <sub>40</sub>
T <sub>6</sub>	60 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> + 50 kg K <sub>2</sub> O ha <sup>-1</sup>	P <sub>60</sub> K <sub>50</sub>
T <sub>7</sub>	70 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> + 30 kg K <sub>2</sub> O ha <sup>-1</sup>	P <sub>70</sub> K <sub>30</sub>
T <sub>8</sub>	70 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> + 40 kg K <sub>2</sub> O ha <sup>-1</sup>	P <sub>70</sub> K <sub>40</sub>
T <sub>9</sub>	70 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> + 50 kg K <sub>2</sub> O ha <sup>-1</sup>	P <sub>70</sub> K <sub>50</sub>

**Table 2. Growth parameters of chickpea as influenced by phosphorous and potassium levels**

Treatments	Plant height (cm)	No. of branches plant <sup>-1</sup>	No. of nodule plant <sup>-1</sup>
P (kg ha <sup>-1</sup> )	90 DAS	90 DAS	45 DAS
50	33.79	30.20	29.00
60	34.75	31.22	37.66
70	36.80	32.24	42.66
SE(m)±	0.41	0.46	0.50
CD(P=0.05)	1.24	1.40	1.51
K (kg ha <sup>-1</sup> )			
30	34.52	30.68	33.33
40	35.03	31.37	36.33
50	35.80	31.60	39.66
SE(m)±	0.41	0.46	0.50
CD(P=0.05)	1.24	1.40	1.51
Interaction	S	S	S

**Table 3. Yield components and yield of chickpea as influenced by phosphorous and potassium levels**

Treatments	No. of pod plant <sup>-1</sup>	No. of seed pod <sup>-1</sup>	Seed index (g)	Seed yield (q ha <sup>-1</sup> )
P (kg ha <sup>-1</sup> )	At harvest	At harvest	At harvest	At harvest
50	54.86	1.52	20.33	13.02
60	60.91	1.60	21.44	14.49
70	67.71	1.69	22.33	16.20
SE(m)±	0.94	0.65	0.37	0.017
CD(P=0.05)	2.84	1.95	1.13	0.052
K (kg ha <sup>-1</sup> )				
30	59.44	1.57	20.88	14.02
40	60.86	1.60	21.44	14.56
50	63.17	1.63	21.77	15.13
SE(m)±	0.94	0.65	0.37	0.017
CD(P=0.05)	2.84	1.95	1.13	0.052
Interaction	S	S	S	S

### 3.2.2 No. of seed pod<sup>-1</sup>

No. of seed pod<sup>-1</sup> is an important indication of yield attributing characters. No. of seed pod<sup>-1</sup> was significantly influenced by the use of different phosphorous levels at harvest stage. No. of seed pod<sup>-1</sup> at harvest stage was significantly higher P<sub>2</sub>O<sub>5</sub>@70 kg ha<sup>-1</sup> as compared to P<sub>2</sub>O<sub>5</sub>@60 kg ha<sup>-1</sup> and P<sub>2</sub>O<sub>5</sub>@50 kg ha<sup>-1</sup>. The mean no. of seed pod<sup>-1</sup> at P<sub>50</sub>, P<sub>60</sub> and P<sub>70</sub> were 1.52, 1.60 and 1.69 respectively at harvest stage. No. of seed pod<sup>-1</sup> of chickpea significantly increased with the use of different potassium levels. No. of seed pod<sup>-1</sup> at harvest stage was significantly higher in K<sub>2</sub>O@50 kg ha<sup>-1</sup> as compared to K<sub>2</sub>O @40 kg ha<sup>-1</sup> and K<sub>2</sub>O @30 kg ha<sup>-1</sup>. The mean no. of seed pod<sup>-1</sup> at K<sub>30</sub>, K<sub>40</sub> and K<sub>50</sub> were 1.57, 1.60 and 1.63 respectively at harvest stage. The consequences of the current investigation are additionally in concurrence with the investigation of Shelake et al. [31], Billore et al. [32] and Patel et al. [33].

### 3.2.3 Seed index

Seed index is an important indication of yield attributing characters. Seed index was significantly influenced by the use of different phosphorous levels at harvest stage. Seed index at harvest stage was significantly higher P<sub>2</sub>O<sub>5</sub>@70 kg ha<sup>-1</sup> as compared to P<sub>2</sub>O<sub>5</sub>@60 kg ha<sup>-1</sup> and P<sub>2</sub>O<sub>5</sub>@50 kg ha<sup>-1</sup>. The mean seed index at P<sub>50</sub>, P<sub>60</sub> and P<sub>70</sub> were 20.33, 21.44 and 22.33 gm respectively at harvest stage. Seed index of chickpea significantly increased with the use of different potassium levels. Seed index at harvest stage was significantly higher in K<sub>2</sub>O @50 kg ha<sup>-1</sup> as compared to K<sub>2</sub>O @40 kg ha<sup>-1</sup> and K<sub>2</sub>O @30 kg ha<sup>-1</sup>. The mean seed index at K<sub>30</sub>, K<sub>40</sub> and K<sub>50</sub> were 20.88, 21.44 and 21.77 gm respectively at

harvest stage. These results also confirms the findings of Kumar et al. [8], Sahare et al. [34] and Sachan et al. [35].

### 3.2.4 Seed yield (q ha<sup>-1</sup>)

Seed yield (q ha<sup>-1</sup>) is an important indication of productivity characters. Seed yield (q ha<sup>-1</sup>) was significantly influenced by the use of different phosphorous levels at harvest stage. Seed yield (q ha<sup>-1</sup>) at harvest stage was significantly higher P<sub>2</sub>O<sub>5</sub>@70 kg ha<sup>-1</sup> as compared to P<sub>2</sub>O<sub>5</sub>@60 kg ha<sup>-1</sup> and P<sub>2</sub>O<sub>5</sub>@50 kg ha<sup>-1</sup>. The mean seed yield (q ha<sup>-1</sup>) at P<sub>50</sub>, P<sub>60</sub> and P<sub>70</sub> were 13.02, 14.49 and 16.20 q ha<sup>-1</sup> respectively at harvest stage. Seed yield (q ha<sup>-1</sup>) of chickpea significantly increased with the use of different potassium levels. Seed yield (q ha<sup>-1</sup>) at harvest stage was significantly higher in K<sub>2</sub>O@50 kg ha<sup>-1</sup> as compared to K<sub>2</sub>O @40 kg ha<sup>-1</sup> and K<sub>2</sub>O @30 kg ha<sup>-1</sup>. The mean seed yield (q ha<sup>-1</sup>) at K<sub>30</sub>, K<sub>40</sub> and K<sub>50</sub> were 14.02, 14.56 and 15.13 q ha<sup>-1</sup> respectively at harvest stage. The results of the present investigation are also in agreement with the findings of Tripathy et al. [36], Pal et al. [37], Singh et al. [38] and Sachan et al. [39].

## 4. CONCLUSION

The present findings concluded that application of 70 kg P<sub>2</sub>O<sub>5</sub> along with 50 kg K<sub>2</sub>O ha<sup>-1</sup> proved the most optimum and the beneficial fertility management for the "IPC-2011-112" Variety of Chickpea for the Bundelkhand /Chitrakoot region of Madhya Pradesh. This fertility management (P<sub>70</sub>K<sub>50</sub>) resulted to attain maximum growth parameters as well as yield and yield attributing characters.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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