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# RESPONSE OF PHOSPHORUS AND BORON LEVELS ON GROWTH, YIELD, AND QUALITY OF CHICKPEA (*CICER ARIETINUM* L.)

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**ABSTRACT**

A field experiment was conducted during the *Rabi* season of 2023-2024 at the Research farm, Department of Agronomy, AKS University, Satna, Madhya Pradesh, to evaluate the effects of phosphorus and boron on chickpea (variety JG-63) growth, yield, and quality. The study employed a Factorial Randomized Block Design with two factors and three replications. There were four levels of Phosphorus i.e., Control, 30 kg $P_2O_5$ha$^{-1}$, 40 kg $P_2O_5$ha$^{-1}$and 50 kg $P_2O_5$ha$^{-1}$ and three levels of boron i.e., 1.5 kgha $^1$, 2.5 kg ha-1 and 3.5 kg ha$^{-1}$. Results indicated that applying 50 kg $P_2O_5$ ha$^{-1}$ + 3.5 kg Boron ha$^{-1}$ significantly enhanced plant height (43.57 cm), number of branches (18.20), root nodules (22.00). Furthermore, yield attributes, grain yield (2492.81 kg ha$^{-1}$), stover yield (4115.56 kg ha$^{-1}$), and protein content (22.13 %) were also highest with the same treatment combination. Economically, the application of 50 kg $P_2O_5$ ha$^{-1}$ + 3.5 kg Boron ha$^{-1}$ registered the highest benefit-cost ratio (4.16:1) and net monetary returns ($^1$ 1,07,275.35 ha$^{-1}$) as compared to other doses.

**Keywords**: Boron, factorialgro wth, chickpea, phosphorus, yield

## INTRODUCTION

Chickpea (*Cicer arietinum* L.) stands out as an important pulse crop, traditionally cultivated during the *Rabi* season in India and primarily grown in semi-arid and warm temperate regions worldwide, where temperatures range from 20 to 30 degrees Celsius. Belonging to the *Leguminaceae* family, chickpea boasts a protein content, nearly three times higher than that of cereals, making it the top protein-yielding grain legume. It can fix 140 kg of nitrogen per hectare during a growing season (Harsha, 2022). In India, chickpea was cultivated in an area of 10.74 million ha with a production of 13.54 million tonnes and average productivity was 1261 kg ha$^{-1}$ in 2021-22 (AIRCP Report, 2022-23). Madhya Pradesh, Rajasthan, Maharashtra, Karnataka and Uttar Pradesh are the main chickpea-growing states in the country (AICRP Report, 2022-23). It is highly nutritious legume, offering a variety of essential nutrients. A 100g serving of cooked chickpeas contains 164 calories, 8.9g of protein, 27.4g of carbohydrates (including 7.6g of fiber), and 2.6g of fat, with minimal saturated fat. With their high fiber content and low

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glycemic index, chickpeas benefit digestive health, regulate blood sugar, and provide long-lasting satiety. The combination of protein, fiber, and micronutrients makes chickpeas an excellent choice for a plant-based diet.

An adequate supply of phosphorus to plants accelerates their maturation, enhances nodulation and pod development rates, and promotes shoot hardiness. Phosphorus also plays a crucial role in improving overall plant quality, regulating photosynthesis, and governing various physico-biochemical processes. Given its role in fostering root development, phosphorus application becomes essential, particularly for crops cultivated under rainfed conditions. The application of Phosphorus 60 kg $ha^{-1}$ + PSB produced higher plant height (52.56 cm), No. of nodules/plant (23.03), dry weight (8.19g), No. of pods/plant (30.90), No. of seeds/pod (1.53), seed yield (2570.74 kg $ha^{-1}$) and stover yield (3583.33 kg $ha^{-1}$) in chickpeas (Lalrinzuali *et al*., 2023).

Boron deficiency leads to flower drop and subsequently poor pod development in chickpeas, resulting in diminished yields. Boron plays a crucial role in the synthesis of amino acids and proteins, as well as in regulating carbohydrate metabolism and the mechanism of root growth. It is also essential for the translocation of sugars and phosphorus and aids in the absorption of nitrogen while facilitating the formation of nodules (Singh *et al*., 2015). The application of Boron 2 kg $ha^{-1}$ + Gibberellic acid 30 ppm recorded significantly higher Plant height (56.6 cm), Plant dry weight (45.7 g/plant), number of nodules per plant (11.7). Significantly maximum number of pods per plant (31.60), number of seeds per pod (2.53), Seed yield (1103.90 kg $ha^{-1}$) (Vaishnavi U Nair *et al.,* 2024). Hence the present research was formulated to study on the response of phosphorus and boron levels on growth, yield, and quality is essential to determine the optimal nutrient requirements for healthy plant development. It helps enhance crop productivity and quality, ensures efficient use of fertilizers, reduces environmental impact, and supports sustainable agricultural practices tailored to specific soil and crop needs

## MATERIAL AND METHODS

The field experiment was conducted at the Research Farm, Department of Agronomy, AKS University, Sherganj, Satna (M.P.) during the *Rabi* season of 2023-2024. The experimental site is situated in the semi-arid region of Satna district, at an elevation of approximately 315 meters above sea level. It lies in the northern part of Madhya Pradesh, between a latitude of 24.34°N and a longitude of 80.49°E. The soil of the experimental field has a sandy clay loam texture. It is neutral in reaction (pH 7.45), with medium organic carbon content (0.61 %), available nitrogen (220.34 kg/$ha^{-1}$), available phosphorus (15.84 kg $ha^{-1}$), and available potassium (214.63 kg $ha^{-1}$). The experiment was designed as a Factorial Randomized Block Design with two factors and three replications, consisting of 36 plots. There were four levels of Phosphorus i.e., Control (00 kg $P_2O_5$ $ha^{-1}$) ($P_0$), 30 kg $P_2$ / $ha^{-1}$ ($P_1$), 40 kg $P_2O_5$ / $ha^{-1}$ ($P_2$) and 50 kg $P_2O_5$ / $ha^{-1}$ ($P_3$) and three levels of boron i.e., 1.5 kg / $ha^{-1}$ ($B_1$), 2.5 kg / $ha^{-1}$ ($B_2$) and 3.5 kg / $ha^{-1}$ ($B_3$). A total of twelve treatment combinations were drawn from the treatments of phosphorus and boron i.e. 00 kg $P_2O_5$ $ha^{-1}$ + 1.5 kg B $ha^{-1}$ ($T_1$ - $P_0$ $B_1$), 00 kg $P_2O_5$ $ha^{-1}$ + 2.5 kg B $ha^{-1}$ ($T_2$- $P_0$ $B_2$), 00 kg $P_2O_5$ $ha^{-1}$+ 3.5 kg B $ha^{-1}$($T_3$ - $P_0$ $B_3$), Application of 30 kg P2O5 $ha^{-1}$ + 1.5 kg Boron $ha^{-1}$ ($T_4$ – $P_1$ $B_1$), Application of 30 kg P2O5 $ha^{-1}$ + 2.5 kg Boron $ha^{-1}$ ($T_5$- $P_1$ $B_2$), Application of 30 kg P2O5 $ha^{-1}$ + 3.5 kg Boron $ha^{-1}$ ($T_6$ – $P_1$ $B_3$), Application of 40 kg P2O5 ha-1 + 1.5 kg Boron $ha^{-1}$ ($T_7$ – $P_2$ $B_1$), Application of 40 kg P2O5 $ha^{-1}$ + 2.5 kg Boron $ha^{-1}$ ($T_8$ – $P_2$ $B_2$), Application of 40 kg P2O5 $ha^{-1}$ + 3.5 kg Boron $ha^{-1}$ ($T_9$ – $P_2$ $B_3$), Application of 50 kg P2O5 $ha^{-1}$ + 1.5 kg Boron $ha^{-1}$ ($T_{10}$ – $P_3$ $B_1$), Application of 50 kg P2O5 $ha^{-1}$ + 2.5 kg Boron $ha^{-1}$ ($T_{11}$ - $P_3$ $B_2$), Application of 50 kg P2O5 $ha^{-1}$ + 3.5 kg Boron $ha^{-1}$($T_{12}$ - $P_3$ $B_3$). Each plot measured 5 m × 3 m, and the main irrigation channel had a width of 1 m. The chickpea variety JG-63 was used for the experiment, with a seed rate of 80 kg $h^{-1}$ Before sowing, the seeds were treated with Carbendazim 50% WP @ 2 g/kg seed followed by seed inoculation with liquid *Rhizobium* culture @ 10 ml/kg seed. The recommended doses for nitrogen and potassium were each set at 20 kg $ha^{-1}$. Phosphorus and boron were applied according to the specific treatment plans. Urea, Single Super Phosphate, Muriate of Potash, and Borax were used as sources of nitrogen, phosphorus, potassium, and boron, respectively. Each fertilizer i.e., nitrogen, phosphorus, potassium and boron were applied in each plot as basal at the time of sowing as 100 % fertility levels. Fertilizers were applied by placement i.e., 5 cm away from the seed row and of 5 cm below the seed zone. The data, procured on various growth characters (Plant height, number of branches and root nodules per plant), yield attributes (Number of pods per plant and number of seeds per pod), grain and stover yield), were subjected to statistical analysis using the standard method of Analysis of Variance.

## RESULTS AND DISCUSSION

The data specified on Table 1, 2 and 3 revealed that there was a significant improvement in the growth characteristics, yield, protein content and profitability of chickpea due to different phosphorus and boron levels.

### Growth Characters

An appraisal of the data in Table1 indicates that the application of treatment $P_3B_3$(Phosphorus @ 50 kg $ha^{-1}$+ Boron @ 3.5 kg $ha^{-1}$) brought significant enhancement in the plant height of chickpea which was 47.53 cm. However, the lowest plant height (36.49 cm) was measured under treatment $P_0B_1$ (Control + Boron @ 1.5 kg $ha^{-1}$). The enhancement in plant height under $P_3B_3$ was to the tune of 30.25 % over $P_0B_1$.

A critical examination of the data in Table 1 indicates that the application of treatment $P_3B_3$ (Phosphorus @ 50 kg $ha^{-1}$ + Boron @ 3.5 kg $ha^{-1}$) brought significant enhancement in the number of branches per plant of chickpea which was 18.20. However, the lowest number of branches per plant (13.47) was noted under treatment $P_0B_1$ (Control + Boron @ 1.5 kg $ha^{-1}$). The enhancement in number of branches per plant under $P_3B_3$ was to the tune of 35.11 % over $P_0B_1$.

Data arranged in Table 1 manifests that the application of treatment $P_3B_3$ (Phosphorus @ 50 kg $ha^{-1}$ + Boron @ 3.5 kg $ha^{-1}$) brought significant enhancement in the number of root nodules per plant of chickpea which was 22.00. However, the lowest number of root nodules per plant (15.87) was noted under treatment $P_0B_1$ (Control + Boron @ 1.5 kg $ha^{-1}$). The enhancement in number of root nodules per plant under $P_3B_3$ was to the tune of 38.63 % over $P_0B_1$.

Sabur and Abdus (2020) found that boron application at 1.5 kg $ha^{-1}$ showed higher results on branch $plant^{-1}$ (25.17), pod length (1.75cm), effective pods $plant^{-1}$ (40.96), total pods $plant^{-1}$ (47.03), seed per pod (1.93), 1000-grain weight (153.45 g), grain yield (2.19 t $ha^{-1}$) and straw yield (2.37 t $ha^{-1}$) over no boron application. Naik, (2012) Observed that the application of 50 kg $P_2O_5 ha^{-1}$ recorded significantly 14.7 and 33.7 per cent higher grain yield (1808 kg $ha^{-1}$) of Kabuli chickpea than the application of 25 kg $P_2O_5$ $ha^{-1}$ (1577

**Table 1. Growth characters of chickpea as influenced by levels of phosphorus, boron and their interaction.**

| Treatments | Plant height | Number of (cm) branches per plant | Number of root nodules per plant |
|---|---|---|---|
| Control + 1.5 kg B $ha^{-1}$ | 36.49 | 13.47 | 15.87 |
| Control + 2.5 kg B $ha^{-1}$ | 36.89 | 13.73 | 16.73 |
| Control + 3.5 kg B $ha^{-1}$ | 37.10 | 13.80 | 17.07 |
| Application of 30 kg $P_2O_5$ $ha^{-1}$ + 1.5 kg Boron ha-1 | 36.79 | 13.93 | 16.67 |
| Application of 30 kg $P_2O_5$ $ha^{-1}$ + 2.5 kg Boron $ha^{-1}$ | 37.55 | 14.07 | 17.73 |
| Application of 30 kg $P_2O_5$ $ha^{-1}$ + 3.5 kg Boron $ha^{-1}$ | 37.40 | 14.27 | 20.20 |
| Application of 40 kg $P_2O_5$ $ha^{-1}$ + 1.5 kg Boron $ha^{-1}$ | 37.25 | 14.73 | 19.07 |
| Application of 40 kg $P_2O_5$ $ha^{-1}$ + 2.5 kg Boron $ha^{-1}$ | 38.32 | 14.80 | 20.93 |
| Application of 40 kg $P_2O_5$ $ha^{-1}$ + 3.5 kg Boron $ha^{-1}$ | 41.03 | 15.60 | 21.13 |
| Application of 50 kg $P_2O_5$ $ha^{-1}$ + 1.5 kg Boron $ha^{-1}$ | 40.35 | 16.00 | 21.87 |
| Application of 50 kg $P_2O_5$ $ha^{-1}$ + 2.5 kg Boron $ha^{-1}$ | 42.35 | 17.47 | 21.60 |
| Application of 50 kg $P_2O_5$ $ha^{-1}$ + 3.5 kg Boron $ha^{-1}$ | 43.57 | 18.20 | 22.00 |
| S.Em± | 0.50 | 0.28 | 0.49 |
| C.D. (P=0.05) | 1.47 | 0.82 | 1.44 |

kg $ha^{-1}$) and control (1352 kg $ha^{-1}$). significantly Higher N, P and K uptake was recorded with the application of 50 kg $P_2O_5$ $ha^{-1}$ (64.55 kg N, 28.82 kg $P_2O_5$ and 37.89 kg $K_2O$ $ha^{-1}$) than with 25 kg $P_2O_5$ $ha^{-1}$ and control. Similar results were reported by Kumar *et al*. (2023) and Embadwar *et al*., (2023).

**Yield attributes and yield**

Maximizing economic yield is the primary goal of an agronomist. Key yield attributes, such as the number of pods per plant, grains per pod, and grain and stover yield per hectare, significantly influence the overall productivity of a crop.

**Table 2. Yield attributes, yield and protein content of chickpea as influenced by levels of phosphorus, boron and their interaction.**

| Treatments | Number of pods per plant | Number of seeds per pod | Grain yield (kg $ha^{-1}$) | Stover yield (kg $ha^{-1}$) | Protein content (%) |
|---|---|---|---|---|---|
| Control + 1.5 kg B $ha^{-1}$ | 36.80 | 1.07 | 1263.14 | 2724.99 | 18.46 |
| Control + 2.5 kg B $ha^{-1}$ | 38.80 | 1.13 | 1329.02 | 3337.66 | 19.02 |
| Control + 3.5 kg B ha-1 | 39.27 | 1.33 | 1546.80 | 3512.61 | 19.12 |
| Application of 30 kg P2O5 $ha^{-1}$ + 1.5 kg Boron $ha^{-1}$ | 38.87 | 1.27 | 1539.24 | 3389.50 | 19.04 |
| Application of 30 kg $P_2O_5$ $ha^{-1}$ + 2.5 kg Boron $ha^{-1}$ | 39.33 | 1.33 | 1555.44 | 3704.47 | 19.63 |
| Application of 30 kg $P_2O_5$ $ha^{-1}$ + 3.5 kg Boron $ha^{-1}$ | 40.87 | 1.40 | 1765.66 | 3738.67 | 19.70 |
| Application of 40 kg $P_2O_5$ $ha^{-1}$ + 1.5 kg Boron $ha^{-1}$ | 39.53 | 1.33 | 1608.72 | 3788.34 | 20.30 |
| Application of 40 kg $P_2O_5$ $ha^{-1}$ + 2.5 kg Boron $ha^{-1}$ | 42.27 | 1.53 | 1849.90 | 3804.54 | 20.36 |
| Application of 40 kg $P_2O_5$ $ha^{-1}$ + 3.5 kg Boron $ha^{-1}$ | 44.80 | 1.73 | 2088.56 | 3858.90 | 20.50 |
| Application of 50 kg $P_2O_5$ $ha^{-1}$ + 1.5 kg Boron $ha^{-1}$ | 43.47 | 1.67 | 1964.73 | 3668.11 | 20.60 |
| Application of 50 kg $P_2O_5$ $ha^{-1}$ + 2.5 kg Boron $ha^{-1}$ | 47.20 | 1.93 | 2221.03 | 3987.05 | 21.24 |
| Application of 50 kg $P_2O_5$ $ha^{-1}$ + 3.5 kg Boron $ha^{-1}$ | 49.73 | 2.07 | 2492.81 | 4115.56 | 22.13 |
| S.Em± | 0.62 | 0.10 | 47.16 | 57.44 | 0.17 |
| C.D. (P=0.05) | 1.82 | NS | 138.32 | 168.47 | 0.50 |

An appraisal of the data in Table 2 indicates that the application of treatment $P_3B_3$ (Phosphorus @ 50 kg $ha^{-1}$+ Boron @ 3.5 kg $ha^{-1}$) brought significant enhancement in the number of pods per plant of chickpea which was 49.73. However, the lowest number of pods per plant (36.80) was noted under treatment $P_0B_1$ (Control + Boron @ 1.5 kg $ha^{-1}$). The enhancement in number of pods per plant under $P_3B_3$ was to the tune of 35.14 % over $P_0B_1$.

A critical examination of the data in Table 2 indicates that the application of different phosphorus and boron levelscould not bring any significant enhancement in the number of seeds per pod of chickpea. It islikely due to the genetic characteristics of the cultivar, as such traits are often determined by genetic factors.

Data arranged in Table 2 manifests that the application of treatment $P_3B_3$ (Phosphorus @ 50 kg ha-1+ Boron @ 3kg ha$^{-1}$) brought significant enhancement in the grain yield of chickpea which was 2492.81 kg ha$^{-1}$. However, the lowest grain yield (1263.14 kg ha$^{-1}$) was noted under treatment $P_0B_1$ (Control + Boron @ 1.5 kg ha$^{-1}$). The enhancement in grain yield under $P_3B_3$ was to the tune of 97.35 % over $P_0B_1$. The higher yield attributes under $P_3B_3$ treatments might be responsible for the greater grain yield.

The data in Table 2clearly shows that the application of treatment $P_3B_3$ (Phosphorus @ 50 kg ha$^{-1}$ + Boron @ 3.5 kg ha$^{-1}$) brought significant enhancement in the stover yield of chickpea, which was 4115.56 kg ha$^{-1}$. However, the lowest stoveryield (2724.99 kg ha$^{-1}$) was noted under treatment $P_0B_1$ (Control + Boron @ 1.5 kg ha$^{-1}$). The enhancement in stoveryield under $P_3B_3$ was to the tune of 51.03 % over $P_0B_1$.

Badini (2015) evident that application of phosphorus @ 55 kg ha$^{-1}$ brought significant effect on days taken to flowering, pods plant$^{-1}$ (44.50), seeds plant$^{-1}$ (49.33), pod length (1.38 cm), test weight (215.12 g) and seed yield (1691.21 kg ha$^{-1}$) as compared to phosphorus level of 45 kg, 35 kg, 25 kg and 15 kg ha$^{-1}$. Similar results were reported by Shukla *et al*. (2017) & Reddy and Umesha (2022).

**Protein Content**

A critical examination of the data in Table 2 indicates that the application of treatment $P_3B_3$ (Phosphorus @ 50 kg ha$^{-1}$ + Boron @ 3.5 kg ha$^{-1}$) brought significant enhancement in the protein content in grains of chickpea, which was 22.13 %. However, the lowest protein content (18.46 %) was noted under treatment $P_0B_1$ (Control + Boron @ 1.5 kg ha$^{-1}$). The enhancement in protein content under $P_3B_3$ was to the tune of 19.88 % over $P_0B_1$.

Boron plays a crucial role in the synthesis of amino acids and proteins, as well as in regulating carbohydrate metabolism and the mechanism of root growth. It is also essential for the translocation of sugars and phosphorus and aids in the absorption of nitrogen while facilitating the formation of nodules (Singh *et al.,* 2015) Legume crops particularly demand ample boron compared to other field crops, as it is indispensable for the proper development of their reproductive organs. Insufficient boron levels can induce sterility in plants by causing abnormalities in reproductive tissues, hampering pollen germination, and consequently increasing flower drop while reducing fruit yield (Subasinghe *et al.,* 2003).

**Economics**

Evaluating the economics of the treatments is essential for making sound recommendations. Even the most effective treatment can become impractical if the production and input costs are too high. An appraisal of the data in Table 3 indicates that the application of treatment $P_3B_3$ (Phosphorus @ 50 kg ha$^{-1}$ + Boron @ 3.5 kg ha$^{-1}$) brought significant enhancement in the gross return of chickpea which was ¹ 1,41,222 ha$^{-1}$. However, the lowest gross return (¹ 72,839 ha$^{-1}$) was measured under treatment $P_0B_1$ (Control + Boron @ 1.5 kg ha$^{-1}$). The enhancement in gross return under $P_3B_3$ was to the tune of 93.88 % over $P_0B_1$.

A critical examination of the data in Table 3 indicates that the application of treatment $P_3B_3$ (Phosphorus @ 50 kg ha$^{-1}$ + Boron @ 3.5 kg ha$^{-1}$) brought significant enhancement in the net return of chickpea which was ¹ 1,07,275 ha$^{-1}$. However, the lowest net return (¹ 42,030 ha$^{-1}$) was noted under treatment $P_0B_1$ (Control + Boron @ 1.5 kg ha$^{-1}$). The enhancement in net return under $P_3B_3$ was to the tune of 155.24 % over $P_0B_1$.

**Table 3. Economics of chickpea as influenced by levels of phosphorus, boron and their interaction.**

| Treatments | Gross returns ($ha^{-1}$) | Net returns ($ha^{-1}$) | B:C ratio |
|---|---|---|---|
| Control + 1.5 kg B $ha^{-1}$ | 72839 | 42030 | 2.37 |
| Control + 2.5 kg B $ha^{-1}$ | 77579 | 46334 | 2.49 |
| Control + 3.5 kg B $ha^{-1}$ | 89547 | 57866 | 2.83 |
| Application of 30 kg $P_2O_5 ha^{-1}$ + 1.5 kg Boron $ha^{-1}$ | 88898 | 56729 | 2.77 |
| Application of 30 kg $P_2O_5$ $ha^{-1}$ + 2.5 kg Boron $ha^{-1}$ | 90392 | 57787 | 2.78 |
| Application of 30 kg $P_2O_5$ $ha^{-1}$ + 3.5 kg Boron $ha^{-1}$ | 101675 | 68634 | 3.08 |
| Application of 40 kg $P_2O_5$ $ha^{-1}$ + 1.5 kg Boron $ha^{-1}$ | 93402 | 60780 | 2.87 |
| Application of 40 kg $P_2O_5$ $ha^{-1}$ + 2.5 kg Boron $ha^{-1}$ | 106301 | 73243 | 3.22 |
| Application of 40 kg $P_2O_5$ $ha^{-1}$ + 3.5 kg Boron $ha^{-1}$ | 119142 | 85648 | 3.56 |
| Application of 50 kg $P_2O_5$ $ha^{-1}$ + 1.5 kg Boron $ha^{-1}$ | 112154 | 79079 | 3.40 |
| Application of 50 kg $P_2O_5$ $ha^{-1}$ + 2.5 kg Boron $ha^{-1}$ | 126466 | 92955 | 3.78 |
| Application of 50 kg $P_2O_5$ $ha^{-1}$ + 3.5 kg Boron $ha^{-1}$ | 141222 | 107275 | 4.16 |
| S.Em± | 2548 | 2548 | 0.08 |
| C.D. (P=0.05) | 7473 | 7473 | 0.24 |

Data arranged in Table 3 manifests that the application of treatment $P_3B_3$ (Phosphorus @ 50 kg $ha^{-1}$ + Boron @ 3.5 kg $ha^{-1}$) brought significant enhancement in the B:C ratio of chickpea which was 4.16. However, the lowest B:C ratio (2.37) was noted under treatment $P_0B_1$ (Control + Boron @ 1.5 kg $ha^{-1}$). The enhancement in the B:C ratio under $P_3B_3$ was to the tune of 75.53 % over $P_0B_1$.

Kumar *et al., 2022* evident that the maximum seed and stover yield (18.9 and 29.6 q $ha^{-1}$), protein content, gross returns (81.6 × 103 $^{1}$ $ha^{-1}$), net returns (53.7 × 103 $^{1}$ $ha^{-1}$) and B: C ratio (1.94) were noticed under 60 kg $P_2O_5$ $ha^{-1}$ as compared to the control plot. They further reported that maximum NPK uptake by seed (63.8, 7.49 and 26.5 kg $ha^{-1}$) and stover (44.5, 5.31 and 81.6 kg $ha^{-1}$) was also recorded under 60 kg $P_2O_5$ $ha^{-1}$as compared to the control plot. Similar findings were documented by Jaiswal and Tomar(2022)

## CONCLUSIONS

From the summarization of the result, Phosphorus application @ 50 $kgha^{-1}$ registered the highest growth and yield attributes. Furthermore, higher grain yield (2226 $kgha^{-1}$), protein content (21.32 %) and B:C ratio (3.78:1) were also higher under the same treatment. Boron@ 3.5 $kgha^{-1}$ proved superior in terms of growth, yield attributes and yield (1973 $kgha^{-1}$) of chickpea. A higher protein content (20.36 %) and B:C ratio (3.41:1) were also obtained under the same boron level. Regarding the interaction effect, the application of 50 kg $P_2O_5$ $ha^{-1}$ in combination with 3.5 kg B $ha^{-1}$ produced superior results in terms of growth, yield attributes and yield (2492 $kgha^{-1}$) of chickpeas. Additionally, under the same treatment combination, a greater B:C ratio (4.16:1) and protein content (22.13%) were attained. In light of the current agroclimatic conditions in the area, the chickpea crop should be fertilized with phosphorus at a rate of 50 $kgha^{-1}$ and boron at a rate of 3.5 $kgha^{-1}$ for optimal results.

The balanced application of phosphorus and Boron at the time of sowingat 5 cm away from the seed row and of 5 cm below the seed zoneensures optimal metabolic activity, better reproductive success, and improved nutrient use efficiency. Therefore, integrated nutrient management involving both phosphorus and Boron is essential for maximising chickpea productivity, especially in nutrient-deficient or marginal soils.

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