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# Influence of Phosphorus and Foliar Application of Iron and Zinc on Growth and Yield of Cowpea (*Vigna unguiculata* L.)

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## ABSTRACT

In *kharif* 2022, a field experiment was conducted at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (UP) to determine the "Effect of Phosphorus and foliar application of iron and zinc on growth and yield of cowpea (*Vigna unguiculata* L.)." The findings showed that treatment-9 (Phosphorus 75 kg/ha + Fe-0.5 % + Zn-0.5 %) significantly increased plant height (75.57 cm), plant dry mass (17.66 g/plant), crop growth rate (5.97 g/m$^2$/day), higher number of pods/plant (14.76), higher number of seeds/pod (10.52), seed yield (1.25 t/ha), stover yield (2.81 kg/ha), gross return (79,219.00 ₹/ha), net return (54,092.46 ₹/ha) and also, the maximum B:C ratio (2.15) was taken captive in treatment-9 (Phosphorus 75 kg/ha + Fe-0.5 % + Zn-0.5 %) in comparison to different treatments.

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**Keywords** Cowpea, Phosphorus, Iron, Zinc, Growth parameters, Yield attributes, Economics.

## INTRODUCTION

The world's population is predicted to increase by 70% by 2050, posing enormous problems to the global food community in terms of supplying safe and secure food supplies (Omomowo and Babalola 2021). One food item that helps meet the sustainable goal of offering a sufficient number of critical nutrients, notably affordable protein, is legumes. One such resilient and adaptable legume crop that may grow in locations with limited water supplies and infertile soils is the cowpea. Three sustainable development objectives, namely SDGs 2, 3 and 13, will be achieved owing to it because of its high protein content, low carbon footprint, shorter growing time, and high productivity in regions with limited resources.

A warm-weather legume, cowpea (*Vigna unguiculata*) is native to Central Africa. belonging to the Fabaceae family (Harlan 1971). Over 12.5 million hectares (ha) of area used for cowpea farming worldwide, with 98% of that land being in Africa. According to the FAO (FAO 2019), Nigeria produces the most cowpeas, making about 48% of all output in Africa. Central and South America are also significant producers. It is an inconspicuous pulse grown in India on 3.9 million hectares of land, producing 2.21 million tonnes year (Giridhar *et al.* 2020), mostly in dry and semi-arid regions.

Children in poor and developing countries, where a diet based mostly on cereals is consumed, are more at risk for malnutrition, which is notably associated to inadequate intakes containing protein, iron, and zinc (Gonçalves *et al.* 2016). One such legume is the cowpea, which has a high protein level (20.7–27.3%), low fat content and considerable amounts of carbs, minerals, and other nutrients. It is ideally suited for growing in nations with protein shortages due to its remarkable adaptability to various conditions, affordable raw prices, and high yield. According to Elharadallou *et al.* (2015), the protein content of cowpeas exhibits significant genetic diversity (18.3-30.3%). A high-protein cultivar with a protein level of 30%, which is comparable to certain soybeans, was created cultivars (*Glycine max*).

However, in cultivars of cowpea growing now, According to Boukar *et al.* (2011), the amount of protein in seeds is in the range of 22–25%. In terms of biochemistry, cowpea protein is less (Nikmaram *et al.* 2017) Methionine and increased levels of lysine, leucine, and isoleucine.

Cowpea grains have significant function as an antioxidant and free radical scavenger due to their high phenolic content, tannin content and flavonoid content. Protocatechuic acid is the main polyphenol present in cowpea, followed by ferulic acid and p-coumaric acid, and is found in greater concentrations in colored seeds than in white ones (Awika and Duodu 2017). Ferulic acid and p-coumaric acid are also present, although to a lesser extent.

In plants, phosphorus is essential for photosynthesis, sugar metabolism, energy storage and transfer, cell division, cell enlargement, genetic information transmission, root development, nodulation, and nitrogen fixation. Due to the widespread lack of P in Indian soils generally, the increase in yield brought about by P treatment is large and economically viable. Additionally, it is crucial for photosynthesis, energy transit and conservation, grain quality, meristematic development in living tissues, and the majority of physico-biochemical processes. Accordingly, 80 percent of Indian soils require the use of P at recommended amounts, and the application of some P fertilizer would be necessary to stop P mining from the soils in order to maintain good agricultural yields. Micronutrients are recognized to have a wide range of intricate functions in the growth and health of plants. These include photosynthesis, chlorophyll synthesis, respiration, enzyme function, formation of hormones, metabolic processes, nitrogen fixation and reducing nitrates to usable forms, cell division and development, and regulation of water uptake. A plant's genetic potential is maximized when its robust, consistent development results in bigger yields and better-quality harvests. Their presence can have a significant effect on a variety of plant processes, including root growth, fruit setting and grain filling, seed viability, and plant vigour and health.

Micronutrient deficits in soil have been brought on by intensive agricultural operations as a result of the expanding human population. Especially in calcareous soils, zinc insufficiency is widespread across the world. In India, soils were found to be low in Zn and Fe in 51.2% and 19.2% of cases, respectively (Shukla *et al.* 2021). Micronutrient deficiency in people and animals has been linked to severe repercussions of micronutrient deficiencies in soils and crops, including lower yield and low micronutrient concentration in crops. Zn and Fe deficits affect one-third and one-fifth of the population worldwide, respectively. The majority of developing nations have been found to have zinc deficiencies (Bailey *et al.* 2015). It is necessary for protein and DNA synthesis, immune system development, enzyme-catalyzed biochemical processes, and neurobehavioral development. Allen *et al.* (2006) and its lack causes unhealthy conditions including diarrhoea, impaired physical and mental development, loss of appetite. Anaemia, which is caused by an iron shortage, has been linked to 20.0% of maternal fatalities worldwide and has impacted 40.0 and 42.0% of pregnant women and infants, respectively. The immune system is weakened and pregnant women and neonates die at higher rates due to inadequate Fe consumption.

Keeping these points in view, the present study entitled "Influence of Phosphorus and Foliar Application of Iron and Zinc on Growth and Yield of Cowpea (*Vigna unguiculata* L.)" was conducted at Crop

Research Farm of Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh during *kharif* 2022.

## MATERIALS AND METHODS

The experiment was carried out at Crop Research Farm, Department of Agronomy during *kharif* 2022. Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh which is located at 25.24' 42'' N latitude, 81.50' 56" E longitude and 98 m altitude above the mean sea level (SL). The experiment was conducted in Randomized Block Design with 10 treatments each replicated thrice. The plot size of each treatment was 3 m × 3 m. Factors are three levels of Phosphorus (25, 50 and 75 kg/ha) and three levels of Micro-nutrients (Fe at 0.5%, Zn at 0.5%, Fe-0.5%+Zn- 0.5%). The P was supplied applied as basal during the sowing process. The crop was sown on 26 July 2022 by maintaining a spacing of 30 cm × 10 cm. Harvesting was done taking 1m$^2$ area from each plot and from it three plants were randomly selected for recording growth and yield parameters. The treatment combi are : $T_1$ -( phosphorus at 25 kg/ha + Fe at 0.5%), $T_2$ -(Phosphorus at 25 kg/ha + Zn at 0.5%), $T_3$ – (Phosphorus at 25 kg/ha + (Fe -0.5%+Zn-0.5%)), $T_4$ -( Phosphorus at 50 kg/ha + Fe at 0.5%), $T_5$ -( Phosphorus at 50 kg/ha + Zn at 0.5%), $T_6$- (Phosphorus at 50 kg/ha +(Fe -0.5%+Zn-0.5%)), $T_7$ -( Phosphorus at 75 kg/ha + Fe at 0.5%), $T_8$ -(Phosphorus at 75 kg/ha + Zn at 0.5%), $T_9$ -( Phosphorus at 75 kg/ha +( Fe -0.5%+Zn-0.5%)), $T_{10}$-(N 25 kg/ha + P 50 kg/ha +k 25 kg/ha) control. The observations were recorded for plant height, nodules/plant, dry weight, grain yield and stover yield. The data were subjected to statistical analysis by analysis of variance method (Gomez and Gomez 1976).

## RESULTS AND DISCUSSION

### Growth parameters

***Height of the plant -*** The result revealed that a significantly higher plant height (75.57 cm) was recorded with treatment-9 (Phosphorus at 75 kg/ha + (Fe-0.5% + Zn-0.5%)). However, the treatments-8 (Phosphorus at 75 kg/ha + Zn-0.5%) and treatment-7 (Phosphorus at 75 kg/ha + Fe-0.5%) were shown to be statistically equivalent to treatment-9 (Phosphorus at 75 kg/ha + (Fe- 0.5% + Zn-0.5%)) with a significant and larger plant height, the application of phosphorus. Phosphorus promotes the growth of new cells, increases plant vigour, and speeds up the development of leaves, all of which help plants capture more solar energy and make better use of nitrogen, which help towards higher growth attributes Mir *et al.* (2013). Plant height will also rise with the addition of micronutrients like iron and zinc, this might be due to its role in starch formation and synthesis of protein as well as maintenance and synthesis of chlorophyll in plants. The increase in the availability of iron to plant might have stimulated the metabolic and enzymatic activities thereby increasing the growth of the crop. Similar findings were also reported by Kuldeep *et al*. (2018) (Table 1).

***Dry weight-*** The result revealed that a significantly higher dry weight (17.66/plant) was recorded with application of Phosphorus at 75 kg/ha + (Fe-0.5%+Zn-0.5%). However, Phosphorus at 75 kg/ha + Zn at 0.5% (17.23 g/plant) and Phosphorus at 75 kg/ha + Fe at 0.5% (16.90 g/plant) were found to be statistically at par with Phosphorus at 75 kg/ha + (Fe-0.5%+Zn- 0.5%). It could be because phosphorus, which is a key component of nucleoproteins and lipoids, is abundant in the meristematic zone, which may have aided in cell division and multiplication as well as nitrogen fixation, carbohydrate transformation, and cell division, all of which contribute to increased plant development. Parashar *et al.* (2020) observed similar findings. Further, increase in dry matter could result from the application zinc. Zinc plays a major role in photosynthesis, enzymes activation, fertilization and translocation of assimilates which are responsible for the increase in seed yield. The better crop growth and development could result from combined application of zinc. The results of the present investigation are in close conformity with the findings of Tiwari *et al.* (2018).

***Crop growth rate –*** Significantly the higher crop growth rate (5.97 g/m²/day) was recorded with in treatment-9 (Phosphorus at 75 kg/ha + (Fe-0.5 % + Zn-0.5%)). However, the treatments-8 (Phosphorus

**Table 1.** Influence of phosphorus and foliar application of iron and zinc on growth parameters of cowpea.

| Sl. No. | Treatment combinations | Plant height (cm) | Plant dry weight (g/plant) | Crop growth rate ($g/m^2/day$) |
|---|---|---|---|---|
| 1 | Phosphorus 25 kg/ha + Fe at 0.5% | 69.40 | 12.99 | 4.16 |
| 2 | Phosphorus 25 kg/ha + Zn at 0.5% | 70.17 | 13.92 | 4.54 |
| 3 | Phosphorus 25 kg/ha + (Fe-0.5% + Zn- 0.5%) | 70.32 | 14.79 | 5.11 |
| 4 | Phosphorus 50 kg/ha + Fe at 0.5% | 71.17 | 15.38 | 5.36 |
| 5 | Phosphorus 50 kg/ha + Zn at 0.5% | 71.37 | 15.79 | 5.38 |
| 6 | Phosphorus 50kg/ha + (Fe -0.5%+Zn -0.5%) | 72.93 | 16.36 | 5.44 |
| 7 | Phosphorus 75 kg/ha + Fe at 0.5% | 73.17 | 16.90 | 5.73 |
| 8 | Phosphorus 75kg/ha + Zn at 0.5% | 74.77 | 17.23 | 5.82 |
| 9 | Phosphorus 75 kg/ha + (Fe-0.5%+Zn-0.5%) | 75.57 | 17.66 | 5.97 |
| 10 | Control (RDF) | 64.87 | 11.45 | 3.51 |
| | F-test | S | S | S |
| | SEm(±) | 1.70 | 0.862 | 0.98 |
| | CD (p=0.05) | 5.07 | 2.563 | 2.75 |

at 75 kg/ha + Zn-0.5%) was found to be statistically at par with treatment-9 (Phosphorus at 75 kg/ha + (Fe- 0.5% + Zn-0.5%)). This might be due to the application of phosphorus. Phosphorus being the constituent of nucleic acid and different forms of proteins, might have stimulated cell division resulting in increased growth of plants similar results reported by Niraj and Prakash (2014).

## Yield attributes

***Number of pods/plant -*** Significantly higher number of pods/plant (14.76) were recorded with the treatment combination of Phosphorus at 75 kg/ha + (Fe-0.5% + Zn-0.5%). However, Phosphorus at 75 kg/ha + Zn at 0.5% (14.15) and Phosphorus at 75 kg/ha + Fe at 0.5% (13.57) were shown to be statistically equivalent to Phosphorus at 75 kg/ha + (Fe-0.5% + Zn-0.5%). Significantly more instances of pods/plant (14.76) were recorded with the application of phosphorus, due to improved early vegetative development, including larger leaf area, dry matter buildup, and a robust root system, more branches were produced as a result of the phosphorus application, which considerably increased the number of branches carrying pods. Singh *et al.* (2020) reported observing similar results. Further, increase in pods per plant might be due to application of zinc (Table 2). Zinc has a greater role in the production of auxin and indole acetic acid, which helps in increased plant growth which resulted in more pods per plant similar result were reported by Upadhyay and Singh (2016).

**Table 2.** Influence of phosphorus and foliar application of iron and zinc on yield attributes of cowpea.

| Sl. No. | Treatment combinations | Number of pods/plant | Number of seeds/pod | Seed index (g) | Seed yield (t/ha) | Stover yield (t/ha) | Harvest index (%) |
|---|---|---|---|---|---|---|---|
| 1 | Phosphorus 25 kg/ha + Fe at 0.5% | 9.73 | 6.52 | 9.31 | 0.78 | 2.29 | 25.43 |
| 2 | Phosphorus 25 kg/ha + Zn at 0.5% | 10.37 | 6.87 | 9.40 | 0.82 | 2.39 | 25.55 |
| 3 | Phosphorus 25 kg/ha + (Fe-0.5% + Zn- 0.5%) | 10.81 | 7.37 | 9.63 | 0.87 | 2.42 | 26.44 |
| 4 | Phosphorus 50 kg/ha + Fe at 0.5% | 11.43 | 8.10 | 9.65 | 0.92 | 2.29 | 28.73 |
| 5 | Phosphorus 50 kg/ha + Zn at 0.5% | 12.21 | 8.52 | 9.94 | 0.97 | 2.61 | 27.24 |
| 6 | Phosphorus 50 kg/ha + (Fe -0.5%+Zn -0.5%) | 13.10 | 8.92 | 10.06 | 1.04 | 2.58 | 28.77 |
| 7 | Phosphorus 75 kg/ha + Fe at 0.5% | 13.57 | 9.37 | 10.30 | 1.14 | 2.63 | 30.20 |
| 8 | Phosphorus 75 kg/ha + Zn at 0.5% | 14.15 | 10.04 | 10.34 | 1.19 | 2.72 | 30.56 |
| 9 | Phosphorus 75 kg/ha + (Fe-0.5%+Zn-0.5%) | 14.76 | 10.52 | 10.94 | 1.25 | 2.81 | 30.77 |
| 10 | Control (RDF) | 9.06 | 5.99 | 9.06 | 0.72 | 2.10 | 25.78 |
| | F-test | S | S | NS | S | S | S |
| | SEm (±) | 0.35 | 0.53 | 0.95 | 0.53 | 1.21 | 0.90 |
| | CD (p=0.05) | 1.05 | 1.58 | 0.00 | 1.58 | 3.62 | 2.67 |

**Table 3.** Influence of phosphorus and foliar application of iron and zinc on economic analysis of cowpea.

| Sl. No. | Treatment combinations | Cost of cultivation (INR/ha) | Gross returns (INR/ha) | Net return (INR/ha) | Benefit : Cost ratio |
|---|---|---|---|---|---|
| 1 | Phosphorus at 25 kg/ha + Fe at 0.5% | 22,251.61 | 50,317.00 | 28,065.39 | 1.26 |
| 2 | Phosphorus at 25 kg/ha + Zn at 0.5% | 23,501.62 | 52,912.50 | 29,410.88 | 1.25 |
| 3 | Phosphorus at 25 kg/ha + (Fe-0.5% + Zn- 0.5%) | 24,751.54 | 55,959.00 | 31,207.46 | 1.26 |
| 4 | Phosphorus at 50 kg/ha + Fe at 0.5% | 22,251.61 | 58,984.50 | 36,732.89 | 1.65 |
| 5 | Phosphorus at 50 kg/ha + Zn at 0.5% | 23,501.62 | 62,640.50 | 39,138.88 | 1.67 |
| 6 | Phosphorus at 50kg/ha + (Fe -0.5%+Zn -0.5%) | 24,751.54 | 66,431.50 | 41,679.96 | 1.68 |
| 7 | Phosphorus at 75 kg/ha + Fe at 0.5% | 22,626.61 | 72,478.50 | 49,851.89 | 2.20 |
| 8 | Phosphorus at 75kg/ha + Zn at 0.5% | 23,876.62 | 75,942.50 | 52,065.88 | 2.18 |
| 9 | Phosphorus at 75 kg/ha + (Fe-0.5%+Zn-0.5%) | 25,126.54 | 79,219.00 | 54,092.46 | 2.15 |
| 10 | Control (RDF) | 23,126.62 | 46,910.10 | 23,783.48 | 1.03 |

***Number of seeds/pods-*** Significantly, more number of seeds/pod (10.52) were recorded with the treatment combination of Phosphorus at 75 kg/ha + (Fe-0.5%+Zn-0.5%) over all the treatments. However, Phosphorus at 75 kg/ha + Zn at 0.5% (10.04) and Phosphorus at 75 kg/ha + Fe at 0.5% (9.37) were found to be statistically at par with Phosphorus at 75 kg/ha + (Fe-0.5% + Zn-0.5%). The greatest number of seeds/pod were produced when phosphorus (50 kg/ha) was applied. This may be because more other plant nutrients were available, which increased the development of carbohydrates and their re-mobilization to the plant's reproductive parts, which are the closest sinks. Since phosphorus is known to boost flowering and fruiting, this may have encouraged the plants to create more pods and allowed for higher plant growth, which in turn allowed for increased development of seed/pod numbers. Shah *et al.* (2000) reported the same outcomes. Moreover, considerable improvement was seen with zinc administration. This might be because zinc increased photosynthate translocation to the reproductive system, increasing crop output. Because there was reduced crop rivalry among the plants as a result of increased photosynthetic activity, there may have been improved photosynthate translocation from source to sink and higher yield qualities. These findings are comparable to those made public by Krishna Reddy and Ahlawat (1996).

***Seed index (g) –*** The Maximum Seed index (10.94 g) was recorded with the treatment-9 (Phosphorus at 75 kg/ha + (Fe-0.5%+Zn-0.5%)) over all the treatments and the Minimum seed index was observed in treatment-10 (Control (N 25 kg/ha + P 50 kg/ha +k 25 kg/ha)). However, there was no significant difference among the treatments. Because using phosphorus in application is explained by the source-sink connection. The seed output appears to have risen due to a higher transfer of photosynthates from source to sink (seed). The significant positive association between seed production and pods per plant, seeds per pod, and 100-seeds weight (Table 3) suggests that it may possibly be the result of improvements in yield qualities that eventually enhanced seed output. These results unmistakably point to a significant role for phosphorus fertilization in maximizing the capacity for vegetative and reproductive development, which eventually led to an improvement in cowpea crop output (Balai *et al.* 2017).

***Seed yield (t/ha) -*** Significantly higher seed yield (1.25 t/ha) was recorded in treatment-9 (Phosphorus at 75kg/ha + (Fe-0.5%+Zn-0.5%)). However, treatment-8 (Phosphorus at 75 kg/ha + Zn at 0.5%) and treatment-7 (Phosphorus at 75 kg/ha + Fe-0.5%/ha) were found to be statistically at par with treatment-9 (Phosphorus at 75 kg/ha + (Fe-0.5%+Zn-0.5%)). With the treatment, a significant and greater seed production was seen. Phosphorus (75 kg/ha) may be responsible for the increased photosynthesis and assimilate translocation to various plant parts for the crop's enhanced growth and yield-attributing characteristics, as seen in the number of pods/plant and number of seeds/pods. Later on, the excess assimilates stored in the leaves were translocated towards sink development, which ultimately contributed to higher seed yield. Yumnam *et al.* (2018) observed similar findings. Further increase in seed yield may result from the application of iron. This may be as a result of its function in the production of protein and starch as well as in the upkeep and synthesis of chlorophyll in plants. It's possible that the increased availability of iron to plants accelerated their metabolic and enzymatic processes, resulting in a growth in the crop. The same outcomes were also by Kuldeep *et al.* (2018), who found that iron treatment greatly improved cowpea production characteristics. The combined impact of growth-attributing traits and yield-characteristics like pods per plant determines cowpea production. Doodhwal *et al.* (2020) have confirmed these results. Increase in these attributes due to the involvement of the zinc in enzyme activation, membrane integrity, chlorophyll formation, stomatal balance and starch utilization at early stages which enhanced accumulation of assimilate in the grains resulting in heavier grains. These results are in agreement with the findings of Krishna *et al.* (2022).

***Stover yield (t/ha)-*** Significantly higher stover yield (2.81 t/ha) was recorded in treatment-9 (Phosphorus at 75kg/ha + (Fe-0.5%+Zn-0.5%)). However, treatment-8 (Phosphorus at 75 kg/ha + Zn at 0.5%) and treatment-7 (Phosphorus at 75 kg/ha + Fe-0.5%/ha) were found to be statistically at par with treatment-9 (Phosphorus 75 kg/ha + (Fe-0.5%+Zn-0.5%)). this might result from the synergistic effect of Phosphorus may be due to utilization of high quantities of nutrients through their well-developed root system and nodules which might have resulted in better growth and yield at medium. These results confirm the earlier findings of Islam *et al.* (2006).

## Economics

The result revealed that maximum gross return (79,219.00 INR/ha), maximum net return (54,092.46 INR/ha) and highest benefit-cost ratio (2.15) was recorded in treatment-9 (Phosphorus 75 kg/ha + (Fe-0.5%+Zn-0.5%)) as compared to other treatments (Table 3). Higher gross return, net return and benefit cost ratio was recorded with the application of (Phosphorus at 75 kg/ha + (Fe-0.5%+Zn-0.5%)) it might result from the higher growth and yield attributes resulting in more seed and stover yield with the recommended dose of phosphorus. Similar results were reported by Bhat *et al.* (2013) in field pea.

## CONCLUSION

Based on the aforementioned results, it can be stated that application of phosphorus along with application of foliar Iron and zinc, have improved growth metrics and yield characteristics while also being economically viable. Additional tests are required to corroborate the findings because they are based only on one season.

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