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Effect of biofertilizers, phosphorus and zinc application on growth and yield of Cowpea (*Vigna unguiculata* L.)

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Abstract

A field experiment entitled “Effect of Biofertilizers, Phosphorus and Zinc application on Growth and Yield of Cowpea (*Vigna unguiculata* L.)” conducted at Narayan Bagh Research Farm, Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Bundelkhand University, Jhansi, U.P., situated at Bundelkhand region of Uttar Pradesh at 25°31'07.1" N latitude and longitude of 78°33'47.4 E with 284 meters above from mean sea level (MSL) during *kharif*, 2025. The experiment consisted 10 treatments; Control (T₀), RDF (T₁), P₁ (60 kg ha⁻¹) + Zn₁ (10 kg ha⁻¹) + Rhizobium + N (20 kg ha⁻¹), K (50 kg ha⁻¹) + FYM (5t/ha⁻¹) + VC (2.5 t/ha⁻¹) (T₂), P₁ (60 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + Rhizobium + NK + FYM + VC (T₃), P₂ (80 kg ha⁻¹) + Zn₁ (10 kg ha⁻¹) + Rhizobium + NK + FYM + VC (T₄), P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + Rhizobium + NK + FYM + VC (T₅), P₁ (60 kg ha⁻¹) + Zn₁ (10 kg ha⁻¹) + PSB + NK + FYM + VC (T₆), P₁ (60 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK + FYM + VC (T₇), P₂ (80 kg ha⁻¹) + Zn₁ (10 kg ha⁻¹) + PSB + NK + FYM + VC (T₈) and P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK + FYM + VC (T₉). The experiment was laid out in a randomised block design with three replications. The results clearly revealed that application of biofertilizers, phosphorus, and zinc significantly increased plant height, no. of branches, no. of pods plant⁻¹, no. of seeds pod⁻¹, test weight and yield at harvest stage of cowpea were observed with application of P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK + FYM + VC (T₉) over rest of the treatments. Therefore, it can be summarized that the addition of P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK + FYM + VC (T₉) in cowpea should be applied for better growth throughout the cropping season for obtaining higher yields over the rest of the treatments.

Keywords: Nanourea, conventional urea, growth, LAI, yield and wheat

Introduction

Cowpea (*Vigna unguiculata* L.) is one of the most important vegetable crops grown as a pulse, vegetable and fodder. It is a poor man's protein source and considered one of the most ancient human food sources and has probably been used as a crop plant since Neolithic times (Ng and Marechal 1985)^[14]. Cowpea is an important multipurpose grain legume extensively cultivated in arid and semiarid tropics. It is an important source of nutrients and provides high-quality, inexpensive protein to diets based on cereal grains and starchy foods. Cowpea is a good source of food, fodder, vegetables and certain snacks (Singh *et al.* 2012)^[20]. India is the largest producer, consumer, and cultivator of pulses globally, accounting for 38% of the global area and 28% of global production. Major pulse-producing states include Madhya Pradesh, Maharashtra, Rajasthan, and Uttar Pradesh. Indian Directorate of Pulses Development (DPD) for the 2022-23 period shows India's total pulses cultivation area at 35 million hectares with a productivity of approximately 953 kg/ha, and the Directorate of Pulses Development also reported an increase in pulses production and area between 2016-17 and 2021-22. India's cowpea cultivation in 2024 showed an area of 0.32 million hectares and a gross production of 0.198 million tonnes, leading to an average productivity of approximately 618.75 kg/ha.

Bio-fertilizers, a component of integrated nutrient management, are considered to be cost-effective, eco-friendly and a renewable source of non-bulky, low-cost plant nutrients, supplementing chemical fertilizers in a sustainable agricultural system in India. Their role assumes a special significance in the present context of high costs of chemical fertilizers.

Biofertilizers stimulate the activity of microorganisms that makes the plant to get the macro and micro-nutrients through enhanced biological processes, increase nutrient solubility, alter soil salinity, sodicity and pH. (Alabadian *et al.*, 2009) [2]. Though they contain relatively low concentrations of nutrients and handling them is labour intensive, there has been a large increase in their use over inorganic fertilizers as a nutrient source (Kannan *et al.*, 2005) [9]. The long-term manurial studies conducted at many places have revealed the superiority of integrated nutrient supply systems in sustaining crop productivity at comparison to chemical fertilizer alone (Gaur, 1991) [6].

Boron (B) and zinc (Zn) are the essential plant micronutrients, and their importance for crop productivity is similar to that of major nutrients (Rattan *et al.* 2009; Padbhushan and Kumar 2014) [17, 15]. Widespread and extensive occurrence of B and Zn deficiency has been reported in the cultivable soils of Arunachal Pradesh (Debnath *et al.* 2015) [4]. It is therefore imperative to apply B and Zn to such soils in addition to major nutrients for obtaining maximum yields. Application of Zn to soil is the most satisfactory way to cure Zn deficiency (Das 2003). Studies on B and Zn fertilizer proved that the application of B and Zn greatly influenced growth, yield and quality of legume crops (Debnath *et al.* 2015) [4]. The deficiency symptoms of B and Zn, as well as low yield, have been recorded on many legume and other field crops, including vegetable crops grown in the north-eastern Hill region (Kumar *et al.* 2016) [11]. The reports on application of micronutrients on yield of legumes for piedmont soil of the north-eastern Hill region, particularly Arunachal Pradesh, are very meagre. The study was therefore conducted to assess the levels of B and Zn fertilization on growth and yield of cowpea grown in soil of East Siang district of Arunachal Pradesh.

Plant nutrients are the main source for improving the quality and quantity of cowpea. The non-availability of nutrients is a major constraint to crop productivity and soil fertility, and the imbalanced use of plant nutrients markedly affects crop growth and yield (Siddiqui *et al.*, 2015) [19]. Phosphorus fertilizers seem to be an important constraint in bumper harvest of the crop in most of the cowpea growing areas which are deficient in phosphorus. The supply of phosphorus to legumes is more important than that of nitrogen because, later fixed by symbiosis with Rhizobium bacteria. Phosphorus stimulates nodulation, early root development, plant growth, yield and quality of grains, etc. It gives a rapid and vigorous start to plants, strengthens straw and decreases lodging tendency. Phosphorus application to legumes not only benefits the current crop but also favourably affects the succeeding non-legume crop. It also improves crop quality and resistance against plant diseases. Availability of soil P is critical for growth and development of cowpea, and a poor P availability limits its productivity. Phosphorus deficiency is a critical nutrient-deficiency problem in the soils and may cause up to 29-45% yield losses in cowpea (Ahlawat *et al.*, 2007) [1]. Foliar spraying is a new technique for feeding crops, in which liquid forms of micronutrients are applied to leaves (Nasiri *et al.*, 2010). Using microelements in foliar form is more useful than using as application soil. Since use rates are less comparable with soil addition, the same application can be easily obtained, and the crop reacts with the nutrient application immediately (Zayed *et al.*, 2011) [27]. Soil organic matter (SOM) improves the structure, ability to hold water and nutrient cycling of soil (Yadav *et al.*, 2026a) [25]. Iron and zinc play a lot of different roles in crops, such as utilization, partitioning, and formation of photosynthetic assimilates (Sawan *et al.*, 2008) [18]. Iron is involved in many enzymatic activities, such as nitrate reductase, catalase (CAT), peroxidase, ferredoxin, superoxide dismutase (SOD) and

cytochromes. Hydrophilic gels or hydrogels are cross-linked polymers-either physically or chemically bound-that can absorb and retain large volumes of water without dissolving in the soil. Their hydrophilic nature, due to the presence of carboxylic groups, allows them to bind cations and hold water (Yadav *et al.*, 2026b) [26]. Kobraee *et al.* (2011) [10] reported that photosynthesis, symbiosis, nodulation, growth limitation, dry matter, plant nutrient disorder and production were a result of the lack of zinc and iron. Moreover, electron transport reactions require zinc and iron.

Materials and Methods

The field experiment was conducted at Narayan Bagh Research Farm, Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Bundelkhand University, Jhansi, U.P., situated in the Bundelkhand region of Uttar Pradesh at 25°31'07.1" N latitude and longitude of 78°33'47.4 E with 284 meters above mean sea level (MSL). According to NARP, Bundelkhand falls in Agro climatic zone VI (Bundelkhand Zone of UP). The soils of the district are characterized by their varying depth, topographic situations and colours. The two main soil groups are red and black, that generates four soil series locally known as rakar, parwa, kabar and mar. The soil texture varies from rocky, gravely, sandy, sandy loam to clay loam and has gentle to steep (0.5 to 10%) slope with low to medium WHC content and very low to high water holding capacity. Farming situations and cropping patterns vary as per soil type, water, vegetation and livestock availability

Jhansi possesses tropical and subtropical climate conditions. The average annual rainfall is 884.6 mm, with 90-95 percent of that raining during the southwest monsoon, which commences in June and reaches a peak in August and ends in October; two to three showers of winter rainfall also occur. The region faces extreme temperatures (cold winters and hot summers), coupled with drought and long dry spells that occur during the rainy season, and are a common feature of the climate in the region.

The treatments were; Control (T_0), RDF (T_1), P_1 (60 kg ha⁻¹) + Zn₁ (10 kg ha⁻¹) + Rhizobium + N (20 kg ha⁻¹), K (50 kg ha⁻¹) + FYM (5 t/ha⁻¹) + VC (2.5 t/ha⁻¹) (T_2), P_1 (60 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + Rhizobium + NK + FYM + VC (T_3), P_2 (80 kg ha⁻¹) + Zn₁ (10 kg ha⁻¹) + Rhizobium + NK + FYM + VC (T_4), P_2 (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + Rhizobium + NK + FYM + VC (T_5), P_1 (60 kg ha⁻¹) + Zn₁ (10 kg ha⁻¹) + PSB + NK + FYM + VC (T_6), P_1 (60 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK + FYM + VC (T_7), P_2 (80 kg ha⁻¹) + Zn₁ (10 kg ha⁻¹) + PSB + NK + FYM + VC (T_8) and P_2 (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK + FYM + VC (T_9). Different observations of the plant were taken during the Crop period. The height of plants was measured from ground level to the extreme growing tip using a meter scale. Observations were recorded at two stages: 45 and 60 DAS. The number of branches of selected plants was counted at two stages: 45 and 60 DAS; the number of pods plant⁻¹, pod length, no. of seeds pod⁻¹, of selected plants were counted at two stages: 45 and 60 DAS; test weight, seed yield, straw yield and biological yield of each plot were calculated.

Statistical analysis

The experimental data recorded for growth, yield, and other characters were subjected to statistical analysis by the "Analysis of Variance" technique suggested by Fisher (1936). The appropriate standard error for each of the factors was worked out. The significance of differences among treatment effects was tested by the "F" test. Critical difference (CD) was worked out wherever the difference was found significant at 5.0 or 1.0 percent

level of significance.

Results and Discussion

The data presented in Table 1 show the effect of biofertilizers, phosphorus, and zinc application on plant height (cm) of cowpea (*Vigna unguiculata* L.) was observed at different growth stages: 45 DAS (Days After Sowing) and 60 DAS. The results show significant differences among treatments. The application of biofertilizers, phosphorus, and zinc significantly influenced the plant height of cowpea at all growth stages. Among the treatments, T₉ (P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK + FYM + VC) recorded the maximum plant height at 45 DAS (47.13 cm) and 60 DAS (66.67 cm), showing a substantial improvement over the control (T₀), which recorded 41.53 cm and 59.47 cm, respectively.

The number of branches in cowpea (*Vigna unguiculata* L.) increased with the use of biofertilizers, phosphorus, and zinc at all stages of growth. The highest number of branches was recorded in T₉ (P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK + FYM + VC) with 5.73 branches at 45 DAS, and 13.87 at 60 DAS, which was much higher than the control (T₀) that had 4.87 and 11.00, respectively. Treatments that combined biofertilizers, phosphorus, and zinc (T₂ to T₈) performed better than the control (T₀). Among the biofertilizers, PSB and Rhizobium treatments (T₃ to T₉) gave better results than T₀ treatment. The differences

between treatments were statistically significant, as they were greater than the critical difference values. Overall, T₉ was the most effective treatment for increasing the number of branches in cowpea, as shown in Table 1.

Table 1 illustrates the effect of biofertilizers, phosphorus, and zinc on the number of pods per plant in cowpea (*Vigna unguiculata* L.). The highest pod count was recorded in T₉ (P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK + FYM + VC) with 7.93 at 45 DAS, and 19.53 at 60 DAS pods per plant, followed closely by T₅ (P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + Rhizobium + NK + FYM + VC) at 7.80 and 19.13 pods. In comparison, the control (T₀) produced only 5.13 pods at 45 DAS and 12.60 pods per plant at 60 DAS. Treatments combining biofertilizers, phosphorus, and zinc (T₂ to T₈) consistently resulted in more pods than the control (T₀). Among the biofertilizers, PSB and Rhizobium-based treatments indicated their beneficial effect on pod production.

Jayshree and Umesha (2021) ^[8] reported significant improvements in plant growth parameters—plant height, number of branches, nodules, dry weight, and crop growth rate—as well as yield-attributing traits such as pods per plant, seeds per pod, 100-seed weight, seed yield, and biological yield. Similar findings were reported by Harireddy and Dawson (2021) ^[7], Dhaliwal *et al.* (2022) ^[5], Umesha *et al.* (2021) ^[24], Debnath *et al.* (2018) ^[3] and Rathore *et al.* (2016) ^[16].

Table 1: Effect of Biofertilizers, Phosphorus and Zinc application on plant height, no. of branches and no. of pod plant⁻¹ of Cowpea

Treatment No.	Plant height (cm)		No. of branches		No. of pods/plant	
	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS
T ₀	41.53	59.47	4.87	11.00	5.13	12.60
T ₁	43.47	62.93	4.80	12.20	6.07	15.93
T ₂	44.93	63.47	4.93	12.67	6.47	17.00
T ₃	46.07	64.33	4.73	12.73	6.87	18.07
T ₄	46.33	65.07	5.13	13.13	7.13	18.40
T ₅	47.07	66.60	5.53	13.60	7.80	19.13
T ₆	45.80	64.20	4.67	12.73	6.47	17.80
T ₇	46.13	64.87	4.87	12.80	7.07	18.27
T ₈	46.87	65.47	5.40	13.20	7.60	18.73
T ₉	47.13	66.67	5.73	13.87	7.93	19.53
S.E.m±	0.70	0.79	0.20	0.21	0.25	0.18
C.D. (@5%)	2.08	2.33	0.58	0.63	0.75	0.53

Table 2 shows the effect of biofertilizers, phosphorus, and zinc on pod length in cowpea (*Vigna unguiculata* L.). The longest pods at 45 and 60 DAS were recorded in treatment T₉, where Vermicompost @ P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK + FYM + VC were combined, measuring an average of 22.80 cm at 45 DAS and 24.33 cm at 60 DAS. This was closely followed by T₅, showing pod lengths of 22.60 cm at 45 DAS and 23.07 cm at 60 DAS. The control treatment (T₀) had the shortest pods, averaging 19.47 and 19.40 cm. Generally, treatments integrating biofertilizers, phosphorus, and zinc (T₂ to T₈) resulted in significantly longer pods compared to the control (T₀). Among the biofertilizer combinations, PSB and Rhizobium-based treatments tended to promote longer pods than the control and RDF. These differences were statistically significant.

Table 2 demonstrates the influence of biofertilizers, phosphorus, and zinc on the number of seeds per pod in cowpea (*Vigna unguiculata* L.). Among the treatments, T₉, which included @ P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK + FYM + VC, recorded the highest seed count, averaging 9.40 seeds per pod. This was closely followed by T₅, the biofertilizers, phosphorus, and zinc treatment, with 9.20 seeds per pod. The control group produced the lowest number of seeds, averaging 6.47 per pod. Overall,

treatments that combined biofertilizers, phosphorus, and zinc (T₂ to T₈). Additionally, PSB/Rhizobium, phosphorus and zinc-based treatments tended to perform better than the control.

Table 2 illustrates the impact of biofertilizers, phosphorus, and zinc on the test weight of cowpea (*Vigna unguiculata* L.). The highest test weight was observed in treatment T₉: Vermicompost @ P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK + FYM + VC (77.31 g). This was followed by T₅, with a test weight of 76.83 grams. The control treatment (T₀) had the lowest test weight of 74.12 grams. Overall, treatments that integrated with biofertilizers, phosphorus, and zinc (T₂ to T₈) resulted in significantly heavier seeds compared to the control (T₀). Among the biofertilizer treatments, PSB/Rhizobium, phosphorus and zinc-based combinations generally produced higher test weights than control and RDF. Jayshree and Umesha (2021) ^[8] reported significant improvements in plant growth parameters—plant height, number of branches, nodules, dry weight, and crop growth rate—as well as yield-attributing traits such as pods per plant, seeds per pod, 100-seed weight, seed yield, and biological yield. Similar findings were reported by Harireddy and Dawson (2021) ^[7], Dhaliwal *et al.* (2022) ^[5] and Umesha *et al.* (2021) ^[24], Debnath *et al.* (2018) ^[3] and Rathore *et al.* (2016) ^[16].

The highest seed yield was recorded in treatment T₉ (P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK +FYM + VC) with 1246.33 kg/ha, followed by T₅ (P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + Rhizobium + NK +FYM + VC) at 1124.67 kg/ha. The control treatment (T₀) showed the lowest seed yield of 965.33 kg/ha. Treatments combining biofertilizers, phosphorus, and zinc (T₂ to T₈) consistently outperformed the control (T₀), indicating the positive effect of biofertilizers, phosphorus, and zinc on seed

production. Jayshree and Umesha (2021) ^[8] reported significant improvements in plant growth parameters—plant height, number of branches, nodules, dry weight and crop growth rate—as well as yield-attributing traits such as pods per plant, seeds per pod, 100-seed weight, seed yield and biological yield. Similar findings were reported by Yadav *et al.* (2022), Mohammed *et al.* (2021) ^[12], Singh *et al.* (2018) ^[22], Singh *et al.* (2017) ^[21] and Singh *et al.* (2014) ^[23].

Table 2: Effect of Biofertilizers, Phosphorus and Zinc application on pod length, no. of seed pod⁻¹ and test weight of Cowpea

Treatment No.	Pod length (cm) @ 45 DAS	Pod length (cm) @ 60 DAS	No. of seeds per pod	Test weight
T ₀	19.47	19.40	6.47	74.12
T ₁	20.60	22.47	7.67	75.61
T ₂	20.07	22.27	7.87	74.93
T ₃	21.40	22.53	8.13	76.07
T ₄	21.93	22.73	8.67	76.47
T ₅	22.60	23.07	9.20	76.83
T ₆	21.33	22.47	8.27	75.47
T ₇	21.47	22.67	8.53	76.20
T ₈	22.07	22.87	8.87	76.59
T ₉	22.80	24.33	9.40	77.31
S.E.m±	0.25	0.25	0.07	0.35
C.D. (@5%)	0.75	0.73	0.22	1.05

Treatment T₉: P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK +FYM + VC also produced the highest straw yield of 2093.33 kg/ha, followed by T₅ with 2020.67 kg/ha. The control treatment had the lowest straw yield of 1613.67 kg/ha. Biofertilizers, phosphorus, and zinc-treated plots showed a significant increase in straw yield compared to the control. Jayshree and Umesha (2021) ^[8] reported significant improvements in plant growth parameters—plant height, number of branches, nodules, dry weight, and crop growth rate—as well as yield-attributing traits such as pods per plant, seeds per pod, 100-seed weight, seed yield, and biological yield. Similar findings were reported by Yadav *et al.* (2022), Mohammed *et al.* (2021) ^[12], Singh *et al.* (2018) ^[22], Singh *et al.* (2017) ^[21] and Singh *et al.* (2014) ^[23].

Biological yield followed the same trend, with T₉: P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK +FYM + VC recording the

maximum yield of 3339.67 kg/ha, followed by T₅ with 3145.33 kg/ha. The control treatment had the lowest biological yield of 2579 kg/ha. The significant increase in biological yield under biofertilizer treatments highlights the benefit of integrating vermicompost, neem cake and biofertilizers. Jayshree and Umesha (2021) ^[8] reported significant improvements in plant growth parameters—plant height, number of branches, nodules, dry weight and crop growth rate—as well as yield-attributing traits such as pods per plant, seeds per pod, 100-seed weight, seed yield and biological yield. Similar findings were reported by Yadav *et al.* (2022), Mohammed *et al.* (2021) ^[12], Singh *et al.* (2018) ^[22], Singh *et al.* (2017) ^[21] and Singh *et al.* (2014) ^[23].

It is explicit from the data presented in Table 4.7 that application of biofertilizers, phosphorus, and zinc did not show any significant variation in harvest index of cowpea crop.

Table 3: Effect of Biofertilizers, Phosphorus and Zinc application on Yields of Cowpea

Treatment No.	Seed yield (kg)	Straw yield (kg)	Biological yield (kg)	Harvest index
T ₀	965.33	1613.67	2579.00	37.43
T ₁	1048.33	1922.33	2970.67	35.28
T ₂	980.67	1689.67	2670.33	36.73
T ₃	1036.33	1825.33	2861.67	36.21
T ₄	1086.67	1978.67	3065.33	36.00
T ₅	1124.67	2020.67	3145.33	35.73
T ₆	1035.67	1765.67	2801.33	36.95
T ₇	1047.67	1896.33	2944.00	35.58
T ₈	1099.33	2001.33	3100.67	35.43
T ₉	1246.33	2093.33	3339.67	38.47
S.E.m±	27.26	21.69	34.93	3.78
C.D. (@5%)	80.99	64.44	103.78	NS

Conclusion

On the basis on experimant concluded that growth parameters, yield attributes and yield of cowpea crop with the addition of T₉ (P₂ (80 kg ha⁻¹) + Zn₂ (20 kg ha⁻¹) + PSB + NK +FYM + VC) recorded the highest values.

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