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EFFECT OF BIO-FERTILIZERS AND PHOSPHORUS ON GROWTH AND YIELD OF *ZAID* COWPEA (*VIGNA UNGUICULATA* L.)

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ABSTRACT

A field experiment was conducted on Cowpea during *Zaid* season 2024 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Faculty of Agriculture, Sam Higginbottom University of Agriculture, Technology and Sciences. The experiment was laid out in a Randomized Block Design with 10 treatments and replicated thrice. The treatment consisted of 3 Bio-fertilizers (*Rhizobium*, VAM, PSB) along with 3 levels of Phosphorus (30, 40 and 50 kg/ha) with recommended doses of Nitrogen, Phosphorus and Potassium (20:40:20 N:P: K kg/ha). The experimental field soil was sandy loam in texture, neutral in reaction (pH 7.5), available medium organic carbon (0.598 %), low in available nitrogen (180.48 kg/ha), medium in available phosphorus (28.4 kg/ha), medium in available potassium (234.3 kg/ha) and medium electrical conductivity (0.431 ds m^{-1}). The result revealed application of PSB along with Phosphorus 40kg/ha showed higher growth attributes *viz.* plant height (52.10 cm), number of branches per plant (23.21), number of nodules per plant (33.33) and plant dry weight (11.57 g) and higher yield attributes *viz.* number of pods per plant (5.00), seed yield (819.32 kg/ha) and stover yield (1312.48 kg/ha) however, number of seeds per pod (11.67), seed index (13.13), harvest index (41.67) remained non-significant. The aforesaid treatment also recorded maximum gross return (76363.76 INR/ha), net return (56402.9 INR/ha) and B:C ratio (2.83) was observed with the application of PSB along with Phosphorus (40 kg/ha) *i.e.* Treatment 8. It is concluded that application of PSB along with Phosphorus (40 kg/ha) *i.e.* Treatment 8 recorded highest yield and economics in *Zaid* Cowpea crop.
Keywords : Cowpea, Economics, Growth parameters, Phosphorus, PSB, Rhizobium, VAM, Yield.

Introduction

The Cowpea (*Vigna unguiculata* L.) is a herbaceous legume, Family-Fabaceae commonly called as Black-eyed pea. It is a major crop in semi-arid locations due to its tolerance for sandy soil and little rainfall. It requires extremely little inputs because the plant's root nodules can fix atmospheric nitrogen, making it a desirable crop for resource-constrained farmers and well-suited for intercropping with other crops. Cowpea is noted for its drought resistance; the shadowing effect of its wide and droopy leaves keeps soils and soil moisture retained. It is a major source of protein in human diets with the grains containing about 23% protein (Berssani 1985). The green pod of Cowpea contains 51.40% water. 22.5% protein, 10.1% crude fibre, 56.29% soluble carbohydrate, 2.10% fat and 9% minerals (Rahman *et al.*, 1992). The per capita availability of pulses in India is 35.5g/day as against the minimum requirement of 70g/day/capita as advocated by the Indian Council of Medical Research. In India during 2022-23 cowpea grew about 13.3 m ha with an annual production of 8.06 m t and productivity of 596 kg/ha (GOI, 2023).

Phosphorus is among the essential macro-nutrients required for plant growth and development. Phosphorus stimulates the symbiotic nitrogen fixation because in presence of phosphorus bacterial cell becomes mobile which is pre requisite for migration of bacterial cell to root hair for nodulation Charel (2006). *Rhizobium* helps in symbiotic nitrogen fixation which is performed with the help of bacterium called Rhizobia as an important source to fulfil its major part of nitrogen requirement. *Vesicular arbuscular mycorrhiza* (VAM) fungi improve plant growth through phosphorus nutrition. VAM stimulate phosphorus, zinc and other nutrient and translocate them into the host root along with their own need Pandey *et al.* (2014). *Phosphate Solubilizing Bacteria* (PSB) in the rhizosphere of crop solubilize unavailable soil phosphorus and make available to plants. PSB converts insoluble phosphate into soluble forms

Materials and Methods

Experiment Site and Soil analysis

A field experiment was conducted at the Crop Research Farm, Department of Agronomy, Naini Agriculture Institute (NAI), Sam Haigginbottom University of Agriculture and Technology (SHUATS), Prayagraj, Uttar Pradesh during *Zaid* 2024. Located at 98 metres above mean sea level having 25°57'N latitude and 81°54'E longitude. About 5 km from Prayagraj city, this area is located on the Yamuna River's right bank by the Allahabad Rewa Road. The department supplied all the facilities needed for crop production. The experimental plot's soil was sandy loam in texture and had a nearly neutral pH of 7.5. The soil analysis showed organic carbon content (0.598%), available nitrogen (N) 180.48 kg/ha, available phosphorus (P) 28.4 kg/ha, available potassium (K) 234.3 kg/ha, and an electrical conductivity was 0.431 dS/m.

Treatment Details

The experiment followed a Randomized Block Design (RBD) with three replications and included 10 different treatment combinations. These included three different types of Bio-fertilizers (*Rhizobium,* VAM, PSB) as seed inoculation and different levels of phosphorus (30, 40, and 50 kg/ha) as basal application. Recommended doses of nitrogen, phosphorus, and potassium (20:40:20 N: P: K kg/ha) were also applied.

Treatment combinations	
T_1	*Rhizobium* + Phosphorus 30 kg/ha
T_2	*Rhizobium* + Phosphorus 40 kg/ha
T_3	*Rhizobium* + Phosphorus 50 kg/ha
T_4	VAM + Phosphorus 30 kg/ha
T_5	VAM + Phosphorus 40 kg/ha
T_6	VAM + Phosphorus 50 kg/ha
T_7	PSB + Phosphorus 30 kg/ha
T_8	PSB + Phosphorus 40 kg/ha
T_9	PSB + Phosphorus 50 kg/ha
T_{10}	Control (20:40:20) N:P:K kg/ha

Details of the Variety Under Study

The Cowpea (*Lobia*) variety *Ankur Gomati*, developed by Ankur Seeds Pvt Ltd., is a high-yielding crop with a duration of just 80 -100 days. Known for its large, attractive green pods, this variety can produce yield of up to 100–120 quintals per hectare. On 27th February 2024, seeds of *Gomati* variety were sown with a spacing of 30 cm between rows and 10 cm between plants.

Seed treatment & Fertilizer Application

Seeds are treated with three different levels of Bio-fertilizers (*Rhizobium*, VAM, PSB) one hour before sowing and left to dry under shade. Phosphorus was incorporated as a basal application prior to sowing to stimulate early root establishment and improve nutrient accessibility during the initial growth stages. The fertilizers were placed in 4–5 cm deep furrows at the time of sowing, facilitating efficient nutrient absorption and encouraging robust seedling development.

Data Collection and Statistical analysis

Plant growth attributes such as plant height (cm), dry weight (g/plant), number of branches per plant, and number of root nodules per plant were assessed from 15 DAS to 60 DAS at 15-day intervals. At harvest, yield attributes like the number of pods per plant, number of seeds per pod, Seed index (%), seed yield (kg/ha), stover yield (kg/ha), and harvest index (%) were recorded. All data were statistically analyzed using the analysis of variance (ANOVA) for the randomized block design, as outlined by Gomez and Gomez (1984). The F-value was computed at a 5% level of probability, and the critical difference was calculated for comparing treatment means.

Results and Discussion

Growth Attributes

The data on growth-attributing traits are summarized in Table 1. showed a steady increase in plant height, peaking at 60 DAS, along with root nodule numbers peaked at 60 DAS before declining as it showed plant growth even after 60 DAS. The highest values for plant height (52.23 cm), number of nodules per plant (33.33), number of branches per plant (23.21), and plant dry weight (11.57 g) were recorded in Treatment 8, which involved PSB along with phosphorus (40 kg/ha). These values were statistically at par with other treatments. Increased in plant height with the application of phosphorus plays an important role in nodule initiation and root proliferation that enhanced the plant height. These results are in conformity with those of Jha and Trivedi (2021).

Increased in number of nodules per plant with the application of PSB acts as P-solubilizer and nitrifying bacteria which may have fixed more nitrogen and increased absorption, they also contributed to improved root growth and dry pod production. Similar findings with those of Vadthe and Umesha (2022). Application of Phosphorus helps in Phosphorus availability, which plays an important role in nodules formation. Dekhane (2011); Nkaa *et al.,* 2014; Baboo and Mishra (2001).

Increased in number of branches per plant with the application of PSB as key microorganisms that helps in solubilization of fixed phosphorus through release of various organic acids such as formic acid, butyric acid etc. and make it available to plants Gaur (1991) in blackgram. Application of phosphorous promotes formation of new cells, cell elongation, plant vigour and hasten the leaf development, which helps in harvesting more solar energy, better utilization of nitrogen which in turn leads to higher plant growth in green gram. These results are in close agreement with those of Jat *et al.* (2013), Naik (2014), Chaudhari (2015) and Khan *et al.* (2017) in green gram.

Maximum plant dry weight is due to application of phosphorous shows its beneficial effect of P attributed towards root proliferation, nodulation and synthesis of protoplasm gave higher pace of dry matter accumulation. The results are in close conformity with the findings of Kumar *et al.* (2012), Singh and Singh (2012), Singh *et al.* (2013) and Singh *et al.* (2014).

Yield Attributes

The data on yield-attributing traits are summarized in Table 2. revealed that Treatment 8, which involved PSB along with phosphorus (40 kg/ha), produced the highest number of pods per plant (5.00), showing significant improvement over most other treatments, However T_1 & T_5 are observed at par with the highest. Number of seeds per pod was seen highest in T_8 (11.67) although not statistically significant. Seed Index was highest (13.13 g) in Treatment 6, though not statistically significant. The combined application of Bio-fertilizer inoculation and phosphorus positively influenced yield parameters. Significantly maximum number of pods/plants was found with the application of PSB might be due the increased availability of P which favored nodule formation, higher nitrogen fixation, dry matter accumulation. Same results were revealed by Perveen *et al.* (2002), Balachandran *et al.* 2005), Prasad *et al.* (2014) and Choudary *et al.* (2014) in greengram.

Grain Yield (kg/ha)

The data on grain yield is summarized in Table 2. Showed that significantly highest grain yield (819.32 kg/ha) was recorded under Treatment 8, which involved PSB along with phosphorus (40 kg/ha). However, yields from Treatments 2, 3, 5, 6, and 7 were statistically at par. The increased yield in Treatment 8 can be attributed to application of PSB due to increases the availability of phosphorus to plants through solubilization effect and translocation of nutrients through mycelium Chhonkar (2001). Application of Phosphorous may increase carbohydrate accumulation and their remobilization to reproductive parts of the plants, being the closest sink and hence, resulted in increased plant growth, flowering and fruiting. Similar result was reported by Khandelwal *et al*. (2012).

Stover Yield (kg/ha)

The data on stover yield is summarized in Table 2. showed significantly highest stover yield (1312.48 kg/ha) was recorded with Treatment 8, which involved PSB along with phosphorus (40 kg/ha). However, no treatments were statistically at par with it. Application of PSB may increase availability of photosynthates to the reproductive part during pod filling that increases the dry weight, similar results with the Gupta *et al.* (2014) in blackgram. Application of Phosphorous enhance root growth, which promotes plant height and dry matter accumulation, early growth of seedlings, and increases photosynthetic efficiency. Greater accumulation of photosynthates in vegetative parts results in superior vegetative growth and an increase in stover yield. similar results with Sepat *et al.* (2005).

Harvest Index (%)

The data on harvest index is summarized in Table 2. showed that the highest harvest index (41.67%) was recorded with Treatment 5, which involved VAM along with Phosphorus (40 kg/ha) statistically found to be non-significant.

Economics

The data on the economics of different treatments summarized in Table 2. showed that Treatment 8, involved PSB along with phosphorus (40 kg/ha) resulted in the highest net return (56402.9/ha) and benefit-cost ratio (2.83). In contrast, the lowest net return (40639.61/ha) and B:C ratio (1.19) were recorded in Treatment 9.

Conclusion

Based on one year of experimentation, the combined application of PSB as seed inoculation along with Phosphorus (40 kg/ha) as applied in Treatment 8 proved most effective in maximizing both yield and economic returns from *Zaid* Cowpea cultivation.

Table 1 : Effect of Bio-fertilizers and Phosphorus on Growth attributes of *Zaid* Cowpea.

	Treatment Combinations	Plant height (cm) 60 DAS	Number of nodules per plant 60 DAS	Number of branches per plant 60 DAS	Dry weight (g) 60 DAS
1.	Rhizobium + Phosphorus 30 kg/ha	42.00	32.33	17.87	11.47
2.	Rhizobium + Phosphorus 40 kg/ha	40.73	31.83	19.93	9.57
3.	Rhizobium + Phosphorus 50 kg/ha	51.93	32.83	23.10	9.12
4.	VAM + Phosphorus 30 kg/ha	43.13	30.50	20.53	9.82
5.	VAM + Phosphorus 40 kg/ha	49.57	33.17	17.47	8.88
6.	VAM + Phosphorus 50 kg/ha	49.93	30.83	17.53	11.47
7.	PSB + Phosphorus 30 kg/ha	48.33	31.17	14.73	10.37
8.	PSB + Phosphorus 40 kg/ha	52.23	33.33	23.21	11.57
9.	PSB + Phosphorus 50 kg/ha	47.53	32.17	18.27	9.47
10.	Control (20:40:20) NPK Kg/ha	38.07	30.17	22.02	9.68
	SEm(±)	2.97	0.687	1.251	0.489
	CD (p=0.05)	8.85	2.04	3.72	1.45

Table 2 : Effect of Bio-fertilizers and Phosphorus on Yield attributes, Yield and Economics of *Zaid* Cowpea.

	Treatment Combinations	Number of Pods per plant	Number of seeds per pod	Seed index (%)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)	Net Return (INR/ha)	B:C ratio
1.	Rhizobium + Phosphorus 30 kg/ha	3.60	10.73	12.76	678.27	1055.79	38.39	43969.0	2.29
2.	Rhizobium + Phosphorus 40 kg/ha	2.60	11.00	12.36	782.60	1140.27	40.73	52777.6	2.65
3.	Rhizobium + Phosphorus 50 kg/ha	3.33	10.33	12.23	793.23	1173.42	40.28	53050.6	2.56
4.	VAM + Phosphorus 30 kg/ha	3.20	11.00	12.68	699.52	1081.01	39.46	45887.9	2.39
5.	VAM + Phosphorus 40 kg/ha	4.33	11.60	12.91	764.25	1041.68	41.67	50885	2.55
6.	VAM + Phosphorus 50 kg/ha	3.47	10.73	13.13	768.11	1179.03	39.75	50757.1	2.45
7.	PSB + Phosphorus 30 kg/ha	2.67	10.97	12.25	749.76	1176.94	38.48	50621.4	2.64
8.	PSB + Phosphorus 40 kg/ha	5.00	11.67	12.37	819.32	1312.48	38.67	56402.9	2.83
9.	PSB + Phosphorus 50 kg/ha	2.53	8.73	12.51	657.97	1066.59	38.14	40639.6	1.96
10	Control (20:40:20) NPK Kg/ha	2.60	10.47	12.33	708.21	1089.37	40.79	46016.7	2.31
	SEm(±)	0.2304	0.485	0.276	29.09	44.78	2.67	-	-
	CD (p=0.05)	0.68	-	-	86.44	133.06	-	-	-

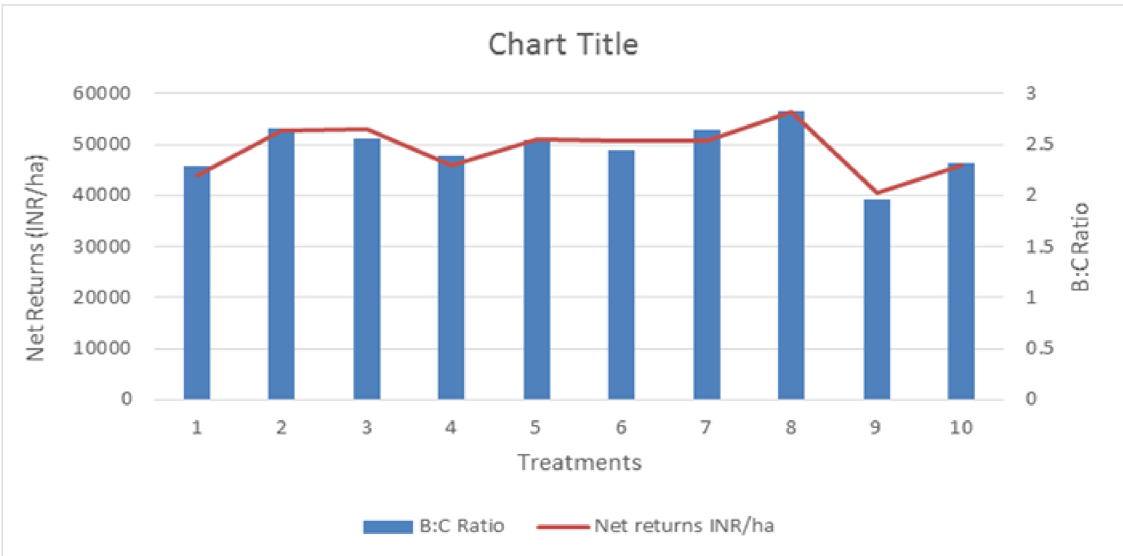

Fig. 1 : Influence of Bio-fertilizers and phosphorus on the economic returns of *Zaid* Cowpea (*Vigna unguiculata* L.) cultivation.

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