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Effect of phosphorous levels with bio-fertilizers and micro-nutrients on growth and yield of cowpea (*Vigna unguiculata L.*)

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Abstract
A field experiment was conducted during Zaid 2021 at CRF (Crop Research Farm), Department of Agronomy, SHUATS, and Prayagraj (U.P). The soil of the experimental field is sandy loam in texture, nearly neutral in soil reaction (pH 7.4). The treatments consisted of Phosphorus levels 30kg/ha P2O5 and 40kg/ha P2O5, Biofertilizers, PSB (15Kg/ha) and VAM (10Kg/ha) and Foliar application of Micro-nutrients of Zinc (2mg/it) and Iron (2mg/it) whose effect is observed in Cowpea (Var – Ankur Gomati). The experiment was laid out in Randomized Block Design with ten treatments replicated thrice. The treatment 7 with (40kg/ha P2O5 + PSB + FeSO4) also recorded significantly higher in plant height (90.73cm), number of branches (6.23), plant dry weight (25.30g). The treatment 7 with (40kg/ha P2O5 + PSB + FeSO4) also recorded significantly higher in yield attributes viz. Number of pods/pant (9.47); and Number of seeds/pod (10.49), test weight (128.21 g) and Protein content (34.53%). The treatment 7 with (40kg/ha P2O5 + PSB + FeSO4) also recorded significantly higher in Seed yield (1168.27 kg/ha). The maximum cost of cultivation (40225.00 INR/ha), gross return 93461.60 INR/ha), net return (53236.60 INR/ha) and B: C ratio (1.32).

Keywords: Cowpea, phosphorus, biofertilizers, micro-nutrients foliar application

Introduction
The Cowpea (Vigna unguiculata L.) is an annual herbaceous legume from the genus Vigna, belongs to family Fabaceae. Due to its tolerance for sandy soil and low rainfall, it is an important crop in the semiarid regions across Africa and Asia. It requires very few inputs, as the plant's root nodules are able to fix atmospheric nitrogen, making it a valuable crop for resource-poor farmers and well-suited to intercropping with other crops. Due to its tolerance for sandy soil and low rainfall, it is an important crop in the semiarid regions across Africa and Asia. It requires very few inputs, as the plant's root nodules are able to fix atmospheric nitrogen, making it a valuable crop for resource-poor farmers and well-suited to intercropping with other crops. In India it is cultivated mainly in UP, MP, Bihar, Punjab, Haryana, Rajasthan, HP, etc., where it is growth for both vegetable and pulse purposes and is a highly remunerative crop. The seeds are usually cooked and made into stews and curries, or ground into flour or paste. Most cowpeas are grown on the African continent, particularly in Nigeria and Niger, which account for 66% of world production.

Phosphorus application significantly increased grain and straw yield with the increase in P levels up to 40 kg P 2 O 5 /ha. The increase in grain yield was 19.95 per cent in 40 kg P2O5 /ha over control. This might be due to significantly increase in P availability and uptake resulted profuse nodulation leading to greater symbiotic N2 fixation which in turn has positive effect on photosynthesis then on yield/ha. Response of phosphorus was also reported by Chaudhari, *et al.* (2016) [2]. The higher removal of nutrients with this treatment might be due to better development of root and shoot with this treatment resulted in higher nutrient uptake. These results are in accordance with the results of those reported by Dekhane *et al.* (2011) [4] and Jat *et al.* (2015) [5]. Application of phosphorus might have resulted in increased 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.

PSB might have helped in reducing P fixation by its effect and also solubilized the unavailable form of P leading to more uptake of nutrient and reflected in better yield attributes. The findings of this investigation are in line with those of Bansal and Khandelwal.

Phosphate solubilizing bacteria (PSB) have the consistent capacity to increase the availability of phosphates to plants by mineralizing organic phosphorus compounds. It solubilizes insoluble inorganic phosphorus compounds by exerting organic acids, which is the primary mechanism of solubilizing of insoluble inorganic phosphates. Besides organic acids, production of chelating substances, mineral acids, siderophores and proton extrusion mechanism are also involved.

VAM greatly improve phosphate supply to the host plant which resulted in increase of nodulation and N2 fixation in legumes. Many tropical legumes are infact highly mycorrhizal dependant. The most interesting feature of the legumes is their ability to form mutualistic association with certain microbes. Two type of micro-organisms which are found associated with roots of these plants include fungi (mycorrhiza) and bacteria (Rhizobium). The present work was undertaken to study the response of Green gram (Vigna radiata) to VAM (Glomus mossae) inoculation on colonization, growth, nutrient uptake and yield with different levels of phosphate fertilizers in native soil.

Iron and zinc are playing an important role for boosting productivity of Pulses. Growth parameters were increased by zinc application regardless to its concentration and application method. Zinc application either through soil or foliar application also increases the Zn content of shoot. Application of zinc and iron either foliar spray or basal application are fortified the seed quality of mungbean. Bio fortified staple crops, when consumed regularly, will generate measureable improvements in human health and nutrition. Bio fortified crops are also a feasible means of reaching rural populations who may have limited access to diverse diets or other micronutrients level interventions.

Materials and Methods

The experiment was carried out during Zaid season of 2021 at the CRF (Crop Research Farm), Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The CRF is situated at 25º24'41.27" N latitude, 81°50'56" E longitude and 98 m altitude above the mean sea level (MSL). This area is situated on the right side of the Yamuna River by the side of Prayagraj - Rewa road about 12 km from the city. The experiment laid out in Randomized Block Design which consisting of ten treatments with **T1 -** CONTROL, T2-30kg/ha P2O5 + PSB + ZnSO4, T3-40kg/ha P2O5 + PSB + ZnSO4, T4-30kg/ha P2O5 + VAM + ZnSO4, T5-40kg/ha P2O5 + VAM + ZnSO4, T6-30kg/ha P2O 5 + PSB + FeSO4, T7-40kg/ha P2O 5 + PSB + FeSO4, T8 30kg/ha P2O 5 + VAM + FeSO4, T9-40kg/ha P2O5 + VAM + Fe SO4. The Experiment was laid out in Randomized Block Design, with ten treatments which are replicated thrice. Date of sowing was on 27th March 2021 with the seed rate of 7- 20 kg/ha. In the period from germination to harvest several plant growth parameters were recorded at frequent intervals along with it after harvest several yield parameters were recorded those parameters are growth parameters, plant height, no. of branches per plant and plant dry weight are recorded. The yield parameters like No. of pods per plant, No. of seeds per pod, Test weight (gm.) and seed yield (kg/ha) were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design.

Results

Yield attributes

Data in table 1 tabulated that Application of 40kg/ha P2O 5 + PSB + FeSO4 resulted maximum no. of pods per plant (9.47), more no. of seeds per pod (10.49), Test weight (128.21gm) and Seed yield (1168.27kg/ha) which was significantly higher. 30kg/ha+ P2O 5 + PSB + FeSO4 has recorded maximum no. of pods per plant (9.39),more no. of seeds per pod (10.30), Test weight (127.79 gm.) and Seed yield (1144.37 kg/ha) respectively which were statistically at par with 40kg/ha P2O 5 + PSB + FeSO4

Table 1: Effect of phosphorus levels with bio-fertilizers and micro-nutrients on yield attributes of cowpea.

Treatments	Number of pods/ plant	Number of seeds/pod	Test weight (gm.)	Seed yield (kg/ha)
Control	7.08	7.92	123.79	794.47
30kg/ha P_2O_5 + PSB + Zn	8.61	9.79	126.88	1037.30
40kg/ha P_2O_5 + PSB + Zn	9.26	10.07	127.42	1110.57
30kg/ha P_2O_5 + VAM + Zn	7.60	8.56	125.24	899.77
40kg/ha P_2O_5 + VAM + Zn	8.23	9.46	126.09	1007.10
30kg/ha P_2O_5 + PSB + Fe	9.39	10.30	127.79	1144.37
40kg/ha P_2O_5 + PSB + Fe	9.47	10.49	128.21	1168.27
30kg/ha P_2O_5 + VAM + Fe	7.35	8.36	124.53	857.67
40kg/ha P_2O_5 + VAM + Fe	7.83	8.79	125.56	943.47
F test	S	S	S	S
S. Em (±)	0.15	0.13	0.27	19.64
CD (P=0.05)	0.45	0.38	0.82	58.89

Yield and Yield attributes

Data in table 2 tabulated that Application of 40kg/ha P2O 5 + PSB + FeSO4 resulted highest plant height (90.73cm), more no. of branches/plant (6.23) and maximum plant dry weight (25.30 g/plant) which was significantly higher. 30kg/ha P2O 5 + PSB + FeSO4 has recorded plant height (89.37cm), more no. of branches/plant (5.97) and maximum plant dry weight (24.87 g/plant) respectively which were statistically at par with 40kg/ha P2O 5 + PSB + FeSO4.

Table 2: Effect of phosphorus levels with biofertilizers and micro-nutrients on yield and yield attributes of cowpea

Treatments	Plant height (cm) (85 DAS)	No. of branches per plant (85 DAS)	Dry weight (g/plant) (85 DAS)
Control	77.50	4.03	18.03
30kg/ha P_2O_5 + PSB + Zn	86.23	5.47	24.03
40kg/ha P_2O_5 + PSB + Zn	88.03	5.67	24.70
30kg/ha P_2O_5 + VAM + Zn	82.27	4.80	20.27
40kg/ha P_2O_5 + VAM + Zn	84.00	5.33	21.00
30kg/ha P_2O_5 + PSB + Fe	89.37	5.97	24.87
40kg/ha P_2O_5 + PSB + Fe	90.73	6.23	25.30
30kg/ha P_2O_5 + VAM + Fe	80.47	4.60	19.03
40kg/ha P_2O_5 + VAM + Fe	82.60	5.13	20.47
F-test	S	S	S
SEm±	1.47	0.16	0.51
CD (P=0.05)	4.41	0.48	1.54

Economics

Data in table 3 tabulated Experimental results revealed that application of 40kg/ha P2O 5 + PSB + FeSO4 recorded higher grain yield (1168.27 kg/ha), maximum Gross returns (93461.60 INR/ha), Net returns (53236.60 INR/ha) and Benefit cost ratio (1.32) and minimum gross returns (63557.60 INR), minimum net returns (25732.60 INR) and minimum benefit: cost ratio (0.68) were recorded with the treatment of control plot.

Table 3: Effect of phosphorus levels with bio-fertilizers and micro-nutrients on genomics of cowpea

Treatments	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
Control	63557.60	25732.60	0.68
30kg/ha P_2O_5 + PSB + $ZnSO_4$	82984.00	43314.00	1.09
40kg/ha P_2O_5 + PSB + $ZnSO_4$	88845.60	48550.60	1.20
30kg/ha P_2O_5 + VAM + $ZnSO_4$	71981.60	32871.60	0.84
40kg/ha P_2O_5 + VAM + $ZnSO_4$	80568.00	40923.60	1.03
30kg/ha P_2O_5 + PSB + $FeSO_4$	91549.60	51949.60	1.31
40kg/ha P_2O_5 + PSB + $FeSO_4$	93461.60	53236.60	1.32
30kg/ha P_2O_5 + VAM + $FeSO_4$	68613.60	29663.60	0.76
40kg/ha P_2O_5 + VAM + $FeSO_4$	75477.60	35902.60	0.90

Discussion

The maximum no. of pods per plant (9.47) and more no. of seeds per pod (10.49) in whereas treatment with application of T6 (30kg/ha P2O 5 + PSB + FeSO4) was recorded with (9.39) and application of T3(40kg/ha P2O5 + PSB + ZnSO4) was recorded with (9.26) were statistically at par with treatment T7(40kg/ha P2O 5 + PSB + FeSO4) the maximum number of pod per plant (49) were recorded in fertilizer at optimum application (60kg P2O 5ha1) and minimum number of per plant (30.75) were recorded in control treatment. This increase in the number of pod plant-1 with the application p205 might have resulted from more pronounced growth of the plant which in turn had increased number of pods per plant and significant increase in yield attributes with biofertilizers. Seeds/pod was not affected significantly by the application of phosphorus alone or in combination with PSB reported by Stamford *et al.*, (2013) [9] and Siag (1995) [7].

Maximum (129.21gm) test height in T7 (40kg/ha P2O 5 + PSB + FeSO4) which was superior over other treatments, whereas treatment with application of T6 (30kg/ha P2O 5 + PSB + FeSO4) was recorded with (127.79) and application of T3 (40kg/ha P2O5 + PSB + ZnSO4) was recorded with (127.42) were statistically at par with treatment T7 (40kg/ha P2O 5 + PSB + FeSO4). This might be the result of improved supply of phosphorus by Pseudomonas striata at the later stages of crop growth reported by Khan *et al*. (2007) [6] and Singh *et al*. (2014) [8]. Maximum (1168.27kg/ha) plant height in T7 (40kg/ha P2O 5 + PSB + FeSO4) Which was superior over other treatments, whereas treatment with application of T6 (30kg/ha P2O5 + PSB + FeSO4) was recorded with (1144.37kg/ha) and application of T3(40kg/ha P2O5 + PSB + ZnSO4) was recorded with (1110.57kg/ha) were statistically at par with treatment T7(40kg/ha P2O 5 + PSB + FeSO4). Phosphorus application significantly increased grain and straw yield with the increase in p levels up to 40kg P2O5/ha. The increase in grain yield was 19.95 per cent in 40kg P2O5/ha over control reported by Chaudhari *et al.*, (2016) [2] and The inoculation of seed with PSB increased seed yield in Mungbean. Inoculation of Mungbean with PSB increased all the yield attributing characters of Mungbean reported by Khan *et al.*, (2004) [6] maximum (90.73 cm) plant height recorded in T7 (40kg/ha P2O 5 + PSB + FeSO4), whereas treatment with application of T6(30kg/ha P2O 5 + PSB + FeSO4) was recorded with (89.37cm) and application of T3(40kg/ha P2O5 + PSB + ZnSO4) was recorded with (88.03cm) were statistically at par with treatment T7(40kg/ha P2O 5 + PSB + FeSO4).

The factors which are responsible for growth plant height was augmented significantly due to the soil showed that "p" content was slightly deficient, thus chickpea showed a positive response to its addition. These results are in conformity with those reported that 40, 57 and 69kg p2O5there is significant increase in plant height with P2O5 application During this study we examined that these results also resemble the findings reported an increase in plant height with p205 application ha-1respectively that analysed by Jain (2003) [10]. Maximum (6.23) branches per plant recorded in T7 (40kg/ha P2O 5 + PSB + FeSO4), whereas treatment with application of T6(30kg/ha P2O 5 + PSB + FeSO4) was recorded with (5.97), application of T3(40kg/ha P2O5 + PSB + ZnSO4) was recorded with (5.67) and application of T2(40kg/ha P2O5 + PSB + ZnSO4) was recorded with (5.47) were statistically at par with treatment T7(40kg/ha P2O 5 + PSB + FeSO4). The factors which are responsible for growth characters of Mung bean viz. plant height and branches per plant and nodules /plant were not affected by zinc and iron application but plant height, primary branches/ plant and nodules/plant were numerically better under iron treatment. It might be due to positive response and iron reported by Dubey *et al.* (2013) [13] Khalil. Maximum (25.30) Dry weight/plant recorded in T7 (40kg/ha P2O 5 + PSB + FeSO4), whereas treatment with application of T6(30kg/ha P2O 5 + PSB + FeSO4) was recorded with (24.87), application of T3(40kg/ha P2O5 + PSB + ZnSO4) was recorded with (24.70) and application of T2(40kg/ha P2O5 + PSB + ZnSO4) was recorded with (24.03) were statistically at par with treatment T7(40kg/ha P2O 5 + PSB + FeSO4).

Foliar application of nutrients help specially treatment of zinc sulphate and iron sulphate at flower initiation and bud initiation which might have also responsible for efficient translocation of photosynthate from source to sink, this cause higher number of pod formation and more dry weight plant reported by Dubey *et al.* (2013) [3], Jat *et al.* (2015) [5]. Maximum cost of cultivation (40225.00 INR/ha) Gross return (93461.60 INR/ha), Net return (53236.60 INR/ha) and Benefit cost ratio (1.32 %) recorded in T7 (40kg/ha P2O 5 + PSB + FeSO4), increased benefit cost ration and net income with increasing levels of phosphorus. Application of 80 kg P2O5 ha-1 + PSB recorded highest gross income of Rs. 72371 and net return of Rs. 50873. The net return Re-1investment (B: C) increased up to 80 kg P2O5 ha-1 + PSB recoding highest values of Rs. 2.37. This was attributed to greater increase in grain and straw yield as compared to cost of cultivation with increasing levels of phosphorus reported by Mitra *et al.* (2006) [11].

Fig 1: Effect of phosphorus levels with Biofertilizers and foliar application on *Zn* and *Fe* on growth and yield of cowpea

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