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EVALUATION OF THE IMPACT OF BIOFERTILIZER AND PHOSPHORUS MANAGEMENT ON GROWTH YIELD AND QUALITY OF SUMMER GREEN GRAM (*VIGNA RADIATA* L.)

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ABSTRACT

A field experiment on green gram was carried out at the Instruction Farm of Invertis University Bareilly, Uttar Pradesh, India during *summer* season 2024. The soil of the experimental field was sandy loam in texture, low in organic carbon and available nitrogen, but medium in available phosphorus and available potassium having slightly alkali pH (7.3) with an electrical conductivity of 0.312. The experiment was arranged in a randomized block design having 10 treatments *viz;* T_1- Control, T_2- VAM+ P_2O_5 20 kg/ ha, T_3- VAM+ P_2O_5 40 kg/ ha, T_4- VAM+ P_2O_5 60 kg/ ha, T_5 - PSB+ P_2O_5 20 kg/ ha, T_6- PSB+ P_2O_5 40 kg/ ha, T_7- PSB+ P_2O_5 60 kg/ ha, T_8- *Rhizobium* + P_2O_5 20 kg/ ha, T9- *Rhizobium* + P_2O_5 40 kg/ ha, T10- *Rhizobium* + P_2O_5 60 kg/ ha with three replication. The application results noted that among the biofertilizer and phosphorus management, application of *Rhizobium* + P_2O_5 60 kg/ ha had maximum plant height (52.49 cm), Number of branches/plants (12.95) and dry matter accumulation (13.98 g/plant) at harvest stage. However, significantly maximum pods/plant (14.2), pod length (8.3 cm), grains/pod (11.2), test weight (32.1 g), grain yield (12.0 q/ha), straw yield (25.6 q/ha), biological yield (39.2 q/ha), protein content (21.9 %) and protein yield (262.9 kg/ha) was recorded under the application of *Rhizobium* + P_2O_5 60 kg/ ha than other treatment combinations.
***Keywords*:** Biofertilizer, Phosphorus, *Rhizobium,* Vesicular Arbuscular Mycorrhiza (VAM) and Phosphate Solubilizing Bacteria (PSB).

Introduction

Green gram (*Vigna radiata* L.) is also known as mung bean or golden bean, is a significant pulse crop in tropical and subtropical region. Mung bean is a short duration legume crop, cultivated during the summer season that belongs to the Fabaceae family. It is a valuable crop due to its high protein content, short duration and adaptability to various agro-climatic conditions (Dhakal *et al.,* 2015). It ranks 3rd among all pulses that are grown in India after chickpea and pigeon pea. Pulses are an important component of Indian diet being a good source of protein. It contains 24.5% protein with large amount of lysine (460 mg/g N) and tryptophan (60 mg/g N), it also contains quantity of ascorbic acid and riboflavin (0.21 mg/100 g) (Azadi *et al*., 2013). The presence of some antinutritional factors such as tannins (366.6 mg/100 mg), phytic acid (441.5 mg/100 g), trypsin inhibitors, hemagglutinin, proteinase inhibitors and polyphenols (462.5 mg/100 g) were reported in mung bean, which affect the digestion and bioavailability of full nutrition. Globally an area about 150.05 lakh ha with a production of 158.72 lakh tonnes and productivity of 1058 kg/ha under. In India, green gram is grown over an area about 48.52 lakh ha with a production of 26.48 lakh tonnes and productivity of 546 kg/ha (GOI, 2022)[3]. Total coverage under green gram in Uttar

Pradesh 0.89 Lakh ha with a production 0.54 Lakh tonnes and the productivity 608 kg/ha. Biofertilizers are substances that contain microorganisms**,** which when added to the soil increase its fertility and promote plant growth such as bacteria, fungi and algae etc.

They can be used distinctly or in combination and have different modes of action. Leguminous crop root nodules support in fixing atmospheric nitrogen in the soil, which is biofertilizers available to plants. Biofertilizers boost nutrient availability and increase yield by 10 to 25% when applied to seed or soil without negatively affecting the soil or environment (Chirumella *et al*., 2023). It contains beneficial microorganisms, offer a sustainable solution to these challenges. These microbes, such as Rhizobium and phosphate-solubilizing bacteria (PSB), improve nutrient availability by fixing atmospheric nitrogen, solubilizing insoluble forms of phosphorus and improving soil health. Their application not only reduces the reliance on synthetic fertilizers but also promotes eco-friendly and cost-effective farming practices. In summer green gram cultivation, the role of biofertilizers is mainly significant due to the ability of crops to establish symbiotic relationships with Rhizobium, leading to improved nitrogen fixation. Plants require phosphorus, in addition to nitrogen. Phosphorus availability in Indian soils ranges from poor to medium. Phosphorus application to legumes improves not just the current crop but also future non-legume crops. It has also increased crop quality and resilience to disease. It is a component of ADP, ATP, nucleic acid, thiamine phosphate, flavin nucleotides, phospholipids, and phosphorylated sugar, among others. It stores and transforms energy. It is also required for cell division, protein synthesis, root development, blooming, fruiting, and seed production. (Shalu *et al*., 2023).

Material and Method

The field experiment was conducted at the Instruction Farm (at a latitude of 28° 29’ North and longitude of 79° 49’ East with an elevation of 252 m above mean sea level) of Invertis University Bareilly, Uttar Pradesh, India during *rabi* season 2024 on sandy loam soil. The soil of the experimental field was low in organic carbon (0.35 %) and available nitrogen (179.3 kg/ha), but medium in available phosphorus (12.5 kg/ha) and potassium (117.6 kg/ha) having slightly alkali pH (7.3) with an electric conductivity of 0.312. Experimental field was moist, well- drained with uniform topography. The experiment was arranged in a randomized block design having 10 treatments *viz;* T_1- Control, T_2- VAM+ P_2O_5 20 kg/ ha, T_3- VAM+ P_2O_5 40 kg/ ha, T_4- VAM+ P_2O_5 60 kg/ ha, T_5 - PSB+ P_2O_5 20 kg/ ha, T_6- PSB+ P_2O_5 40 kg/ ha, T_7- PSB+ P_2O_5 60 kg/ ha, T_8- *Rhizobium* + P_2O_5 20 kg/ ha, T9- *Rhizobium* + P_2O_5 40 kg/ ha, T10- *Rhizobium* + P_2O_5 60 kg/ ha with three replication. Plant height was recorded with the help of a meter scale, dry matter accumulation was recorded in each plot, two plants form the sample rows (second row from both north and west side of the plot) was cut from the ground surface with the help of sickle at all the stages of crop growth and sun dried for 2-3 days. After sun drying, these plants were dried at 65 ± 5^0C temperature at until a constant weight was achieved and the average weight was expressed in gram per plant. The yield attributes viz; Pods/plant, Pod length (cm) and Grains/pod were recorded according to standard procedure. After the harvesting of border rows the grain yield, stover yield and biological yield were recorded in kg/plot in each net plot and express as q/ha, protein content in grains was determined by modified- Kjeldahl method by using the formula as,

$$\text{Protein content (\%)} = \text{Nitrogen content in grain (\%)} \times 5.85 \text{ (correction factor)}$$

Protein yield of the grain was measured by multiplying the average protein content of grain with grain yield/ha and expressed as kg/ha. This gave the total protein yield/ha and as per given formula:

$$\text{Protein yield (kg/ha)} = \frac{\text{Protein content in grain (\%)} \times \text{grain yield (kg/ha)}}{100}$$

The mean of data was analyzed through Analysis of Variance (ANOVA) techniques for randomized block design and presented at 5 % level of significance (<P = 0.05).

Result and Discussion

Growth and development of green gram

The data is presenting table 1. The Impact of biofertilizer and phosphorus on various growth parameter *viz*; Plant height, number of branches/plant and dry matter accumulation (g/plant) at 20, 40 and 60 Days after sowing (DAS) and at harvest stage. The maximum plant height of 13.38, 35.62, 48.39 and 52.49 cm noted that with the application of *Rhizobium* + P_2O_5 60 kg/ ha at 20,40 and 60 DAS and at harvest stage, respectively. Which being significantly superior with T_1, T_2, T_5 and T_8 at 20 DAS and T_1, T_2 and T_5 at 40 DAS. However, *Rhizobium* + P_2O_5 60 kg/ ha *at par* with T_4, T_7 and T_{10} at 60 DAS, T_4 and T_7 at harvest. While, the lowest plant height 10.28, 22.48, 31.35 and

33.89 was recorded under control at 20, 40 and 60 DAS and at harvest stage, respectively. Number of branches/plants was significantly affected by different biofertilizer and phosphorus management. The result presented in table 1 showed that the minimum to maximum branches/plant of 2.43, 4.67, 8.24 and 8.64 to 3.25, 7.92, 12.32 and 12.95 under control and *Rhizobium* + P_2O_5 60 kg/ ha at 20, 40 and 60 DAS and at harvest stage, respectively. Which being statically *at par* with T_4, T_7 and T_9 at 20, 40 DAS and at harvest, T_4 and T_9 at 60 DAS. This might be due to its noticeable effect on root growth, which in turn strengthened the nutrient and moisture extraction. The increase depends upon the cell elongation and multiplication, which in turn depends upon Ribose Nucleic Acid (RNA) and Deoxyribose Nucleic Acid (DNA) in plant system. The phosphorus being one of the most important constituents of RNA and DNA regulate cell multiplication and elongation. Besides this, phosphorus forms esters, phosphatides and phospholipids which are essential constituents of plant cell. Luikham *et al.* (2005) observed marked improvement in plant height, number of branches per plant of green gram with increasing rates of phosphorus application. The above conclusions are likewise in agreement with those of Karwasra *et al.* (2006) and Biswas and Patra (2007). The result presented in table 1 showed that the minimum to maximum dry matter accumulation (g/plant) varies from 0.98, 2.98, 10.15 and 10.29 to 1.49, 4.95, 12.80 and 13.98 (g/plant) was recorded under control and *Rhizobium* + P_2O_5 60 kg/ ha. However, *Rhizobium* + P_2O_5 60 kg/ ha *at par* with T_4 and T_7 at 20 days after sowing and at harvesting stage. Although, T_4, T_6, T_7 and T_9 at par at 40 DAS except T_6 at 60 DAS. This could be related to the fact that P, being an energy bound molecule, plays a significant role in the energy transformation required to almost different metabolic processes *viz.,* respiration, photosynthesis, cell division and cell elongation, amino acids activation for synthesis of protein and carbohydrate metabolism etc. which ultimately increased all the growth attributes *viz.,* plant height and number of branches per plant, these were responsible for increase in the dry matter production per plant with raising levels of P up to 60 kg P_2O_5 per ha. Similar findings have been reported by others Luikham *et al.* (2005)[6] and Patel *et al.* (2013).

Yield attributes, yield and quality

The data is presenting in table 2. The Impact of biofertilizer and phosphorus on various yield attributes *viz*., pods/plant, pod length, grains/pod, test weight (g), grain yield (q/ha), straw yield (q/ha), biological yield (q/ha), protein content (%) and protein yield (kg/ha) have significant different. The significantly maximum pods/plant (14.2) and pod length (8.3cm) were noted under T_{10}, which being statically *at par* with T_4 and T_7. Application of *Rhizobium* + P_2O_5 60 kg/ ha had significantly maximum grains/pod (11.2) and test weight (32.1 g) which being statically *at par* with T_4, T_7 and T_9 in grains/pod and T_4, T_6, T_7 and T_9 in test weight. The minimum grains/pod (8.7) and test weight (25.5) noted under control. The significantly maximum grain yield of 12.0 q/ha, straw yield of 25.6 q/ha and biological yield of 39.2 q/ha were recorded under T_{10} being statically *at par* with T_4 and T_7 in grain yield and T_7 at straw yield and biological yield. The minimum grain yield (8.7 q/ha), straw yield (11.2 q/ha) and biological yield (39.2 q/ha) received under control. The increase in yield attributes by phosphorus, was due to raised production of photosynthates and their translocation from source to sink, which ultimately gave the higher values of yield attributing characters. Increase in yield attributing characters by phosphorus application has also been noticed by Luikham *et al.* (2005), Patil *et al.* (2011) and Neeraj and Ved Prakash (2014). The maximum protein content (21.90 %) was received under T_{10}, which being statically *at par* with T_4, T_6, T_7 and T_9. The minimum to maximum protein yield varies from 115.5 to 262.9 kg/ha under T_1 and T_{10}, which being statically at par with T_4 and T_7. The protein content in grain and protein yield increased significantly with raising doses of P up to 60 kg P_2O_5 per ha. The increase in protein content in seed was mainly due to significant increase in nitrogen content in grain with raising levels of P. Increase in protein content with raising doses of P has also been reported by Vikrant *et al*. (2005).

Conclusion

On the basis of experiment, it may be concluded that with the application of *Rhizobium* + P_2O_5 60 kg/ ha in green gram seems to be best as they improved the growth, yield attributes, yield and quality of green gram. Thus, application of 60 kg/ ha P_2O_5 along with *Rhizobium* provides a reliable, short- term and sustainable approach for increasing the yield in green gram.

Table 1: Impact of biofertilizer and phosphorus level on plant height (cm), number of branches/plant and dry matter accumulation (g/plant) of green gram at successive stage of crop growth.

Treatment	Plant Height (cm) at				Number of branches/plants				Dry matter accumulation (g/plant)			
	20 DAS	40 DAS	60 DAS	Harvest	20 DAS	40 DAS	60 DAS	Harvest	20 DAS	40 DAS	60 DAS	Harvest
T_1	10.28	22.48	31.35	33.89	2.43	4.67	8.24	8.64	0.98	2.98	10.15	10.29
T_2	11.72	31.45	40.38	43.03	2.77	6.23	10.11	10.58	1.18	4.11	11.11	11.39
T_3	12.41	34.38	43.96	47.06	2.98	6.89	10.98	11.51	1.29	4.50	11.98	12.64
T_4	12.98	35.12	46.55	50.05	3.15	7.53	11.77	12.38	1.38	4.83	12.48	13.48
T_5	11.88	32.58	41.43	44.30	2.87	6.54	10.52	11.01	1.21	4.29	11.68	12.05
T_6	12.66	34.75	44.32	47.52	3.02	7.12	11.22	11.78	1.32	4.62	12.12	12.81
T_7	13.16	35.41	47.41	51.03	3.18	7.85	12.03	12.65	1.41	4.88	12.57	13.61
T_8	12.15	33.55	42.54	45.54	2.92	6.71	10.77	11.29	1.26	4.42	11.82	12.47
T_9	12.75	34.88	45.98	49.34	3.09	7.34	11.53	12.12	1.35	4.76	12.36	13.06
T_{10}	13.38	35.62	48.39	52.49	3.25	7.92	12.32	12.95	1.45	4.95	12.80	13.98
SEm±	0.32	0.59	0.61	0.66	0.07	0.23	0.36	0.37	0.03	0.11	0.22	0.170
CD(P=0.05)	0.98	1.76	1.84	2.46	0.21	0.71	1.08	1.11	0.09	0.34	0.66	0.51

Table 2: Impact of biofertilizer and phosphorus level on yield attributes, yield and quality of green gram at successive stage of crop growth.

Treatments	Pods /plant	Pod length (cm)	Grains /pod	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Protein content (%)	Protein yield (kg/ha)
T_1	10.7	4.3	8.7	25.5	6.3	11.2	17.3	18.33	115.5
T_2	11.6	5.6	9.3	29.2	8.1	15.1	23.1	16.26	131.5
T_3	12.6	6.4	9.9	29.9	9.9	18.0	27.9	20.33	201.2
T_4	13.5	7.8	10.7	31.7	12.2	22.5	34.7	21.29	260.1
T_5	11.8	5.8	9.6	29.5	8.9	16.0	24.9	19.31	172.0
T_6	12.8	6.8	10.2	31.3	10.3	20.0	30.9	20.86	213.8
T_7	13.8	7.9	10.9	31.6	11.7	23.8	36.6	21.60	253.1
T_8	12.2	6.2	9.7	29.7	9.3	17.0	26.4	19.61	181.9
T_9	13.1	7.3	10.4	31.6	10.6	21.1	32.4	20.55	216.8
T_{10}	14.2	8.3	11.2	32.1	12.0	25.6	39.2	21.90	262.9
SEm±	0.29	0.16	0.26	0.49	0.37	0.63	0.92	0.50	5.21
CD(P=0.05)	0.9	0.5	0.8	1.5	1.1	1.9	2.7	1.5	15.6

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