Studies on the effect of liquid bio-inoculantRhizophos on the agronomic traits of green gram[*Vigna radiata* (L.) Wilczek]

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ABSTRACT

A study was conducted to assessthe effectof liquid bio-inoculants on the agronomic traits of green gram.Field experiments were conducted in the Instructional-North farm of Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu during the *rabi* season (2024) in a randomized block design. The experiment included five treatments [Absolute control,RDF,RDF + *Rhizobium leguminosarum* (TNAU14) in liquid formulation,RDF + phosphobacteria in liquid formulation,RDF + Rhizophos in liquid formulation. Seeds were treated in accordance with the details given above and foliar application was done @ 1ml Lit^{-1} on 15^{th},$30^{th}$and 45^{th} DAS. From the results, a significant increase in the plant height (30.03 cm) dry matter production (1633.67$kgha^{-1}$) and number of root nodules (65.70) at different growth stages were observed when compared to the absolute control. The yield parameters like pods $plant^{-1}$ andseeds pod^{-1} were also increased. The treatments with mixed liquid bio-inoculant Rhizophos (T5) registered the highest seed yield and haulm yield of 730 $kgha^{-1}$ and 1816.67 $kgha^{-1}$ respectively. The results suggest that, application of liquid rhizophos through seed treatment and foliar spray significantly influenced the agronomic traits of green gram and the yield.

Keywords:Bioinoculants, Foliar application, Green gram, Rhizophos, Seed treatment

1. INTRODUCTION

Indian soils are poor in nitrogen as well as phosphorous. COntinuos application of chemical fertilizers affects the soil quality both directly or indirecty. Tthe addition of phosphatic fertilizers (P_2O_5) causes it to get fixed and become inaccessible to plants (Bhabai*et al*.,2019).Biofertilizers are an eco-friendly approach to minimize the use of chemical fertilizers and enhancing the soil biological activity there by improving the crop yield. The microbial inoculants use unique biological processes to mobilize significant nutritional elements from the soil that are in non-usable form to crop plants (Selvakumar *et al.,*2009), besides improving the microbial population of the rhizosphere zone.Bioinoculants like *Rhizobium* and phosphobacteria (PSB) plays an important role in enhancing the availability of N and P through increase in biological fixation of atmospheric N and mobilizing the immobile phosphorus to plants (Gajera *et al*., 2014).

PSB (Phosphate Solubilizing Bacteria) helps in solubilizing and mobilizing inorganic phosphate in soil and making them available to plants (Teja *et al*.,2022). They do so by secreting certain organic acids like formic acid, fumaric acid propionic acid, etc., which lowers the soil pH and breaks down the bound phosphatemoieties (Patel et al., 2019). *Rhizobium* sp. may be credited with increased root proliferation, root cation exchange

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capacity, and grain yield in addition to enhanced nitrogen availability for uptake (Utpal and Bandopadhyay, 2004).

Mung bean, also known as green gram (*Vigna radiata* L.), and is an important pulse crop grown in India. It belongs to the family Fabaceae. Green gram is a warm season, short day and self-pollinated crop with epigeal germination. It is a good source of dietary protein, with high quality lysine and tryptophan (Yubaraj*et al.,* 2016). Green gram ranks thirdamong the different pulses grown in India interms of production and consumption, It has been estimated that green gram is being cultivated in 25 million hectares with a production record of 16.47 million tons and productivity of 652 kg ha^{-1} (Myaka*et al.,* 2022). Green gram is known for its versatility as it is grown for forage, seed and green manure. Because of the presence of root nodules, it fixes the atmospheric nitrogen which enriches the soil. Despite the poor nutrient status of Indian soils, inoculation of liquid bio-inoculants can cause a substantial increase in the microbiologically fixed nitrogen and phosphorus, which will improve the soil fertility and yield of the crop.

Based on these perspectives' experiments were conducted to understand the effect of liquid bio-inoculants on green gram productivity and nutrient use efficiency. The interactions of bio-inoculants with green gram plants have been studied earlier with single inoculum in carrier-based formulations preferably delivered through seed treatment. Here attempts are made to study the effect of mixed inoculum rhizophos (*Rhizobium* and PSB) on green gram delivered through seed treatment and foliar spray. The study also assessed the feasibility of usingliquid bioinoculants for increasing the yield, and for designing a more viable technology for integrated nutrient management for sustainable production.

2. MATERIAL AND METHODS

Field experiments were conducted in the Instructional-North farm of Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu during the *rabi* season of 2023. The location is geographically situated at 10°56'N Latitude, 76°44'E Longitude, and an altitude of 474 m above mean sea level. Soil characteristics of the experimental field were pH 8.4, EC 0.44 dsm^{-1}, and available N 312.2 kg ha^{-1}, P_2O_5 15.8 kg ha^{-1}, K_2O 45.61 kg $ha^{-1,}$ and organic carbon 1.81%.The study was conducted with the green gram variety CO 8 obtained from KrishiVigyan Kendra, Sulur, Coimbatore.

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The treatments included *Rhizobium leguminosarum* (TNAU 14)and PSB (*Bacillus megaterium* var. *phosphaticum*) strains in liquid formulations obtained fromTamil Nadu Agriculture University, Coimbatore. The experiment was laid out in Randomized Block Design (RBD), comprising fivetreatments and four replications. The treatment details are:

T1: Absolute control (without a Recommended dose of fertilizer),T2: With RDF (recommended dose of fertilizer),T3: RDF + *Rhizobium leguminosarum* (TNAU14) in liquid formulation,T4:RDF + phosphobacteria in liquid formulation, and T5: RDF + Rhizophos in liquid formulation.

The green gram seeds were treated with bio-inoculants at the rate of $10mlkg^{-1}$ as per the treatments. The treated seeds were shade-dried for 30 minutes before sowing. The seeds were sown with row-to-row spacing of 30cm and plant-to-plant spacing of 10cm. Before sowing soil, samples were collected from each experimental plot for analysing the nutrient status. The available nitrogen was estimated by alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus using 0.5M $NaHCO_3$ extractable colorimetric methods (Olsen et al. 1954), and available potassium by Jackson (1973). The fertilizer was applied as per the treatments, a full dose of nitrogen and phosphorus was applied as a basal dose.The data on growth and yield parameters were recorded periodically.The recorded data were statistically analysed using analysis of variance (ANOVA) as applied in Randomized block design (Gomez and Gomez 1984).

3. RESULTS AND DISCUSSION

Impact of liquid bio-inoculants on different growth parameters

Plant height (cm)

It is a measure of the plant's accumulation of dry matter over time and serves as an indicator of growth and development. The data on green gram height was impacted by the combination of biofertilizer formulations. Data revealed significantly higher plant height (30.03 cm) in T_5 which is RDF + Rhizophos in liquid over all the other treatments (Table 1). However, treatment (T_3) with RDF + *Rhizobium leguminosarum*TNAU14 in liquid (26 cm) was found to be statistically onpar with T_4 (RDF + Phosphobacteria in liquid) applied through seed treatment followed by foliar sprays (15, 30 and 45 DAS). This may be dueto the combined effect of phosphate solubilizing PSB and increased nitrogen availabilityby *Rhizobium leguminosarum*TNAU14. The results showed that the application of bio-inoculants facilitatenutrient absorption and increased availability of the major nutrients preferebaly N and Pduring crop growth, besides producing phytohormones which resulted inincreased plantheight. The results also conformedwith the findings of Verma*et al.* (2022).

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Dry matter production ($kgha^{-1}$)

In the present study, the drymatter production recorded a steady increase till 45 DAS and declined afterwards., Leaf shedding was observed due to a decline in dry matter outputup to

the harvest period. The results revealed that the treatment T_5(RDF + Rhizophos in liquid)marked higher dry matter production at 45 DAS (1633.67kg ha^{-1}) over all the other treatments (Table 1). However, treatment (T_3) was found to be statistically onpar with T_4 (RDF + Phosphobacteria in liquid). These results were correlated with the findings of Shravani *et al.* (2019). The increasein dry matter production up toflowering stage might be attributed to better source-sink allocation and afterward, the carbohydrates are re-directed towards pod development(Singh *et* al.2018).

Nodulation pattern

Foliar application of liquid rhizophos significantly increased the number of nodules $plant^{-1}$ and treatment T_5(RDF + Rhizophos in liquid) registeredmaximum root nodules $plant^{-1}$(65.7) overall the other treatments (Table 1),followed by treatments T_3(RDF + *Rhizobium leguminosarum* (TNAU14) in liquid formulation) and T_4 (RDF + phosphobacteria in liquid formulation) which were statistically at par with each other. Application of biofertilizers such as PSB and *Rhizobium leguminosarum*TNAU14 resulted in increased phosphorous solubilization and nitrogen fixation, respectively,Phosphorus increases nodule development, which thereby boosts nitrogen fixation and ultimately promotes the productivity. These results were also concluded byDhakal *et al.*(2015) on green gram, in which they observed higher growth and yield parameters by using bio-inoculants over control.

Table 1. Effect of RDF, *Rhizobium,* PSB, and Rhizophos on growth attributes of green gram at 45DAS

Treatment	Plant height (cm)	Dry matter production ($kgha^{-1}$)	Nodules $plant^{-1}$
T_1	18.64	1137.00	37.20
T_2	22.50	1300.00	44.26
T_3	26.30	1471.00	57.60
T_4	26.10	1463.33	51.60

T_5	30.03	1633.67	65.70
SEd	**1.52**	**70.15**	**1.05**
CD (P=0.05)	**3.18**	**146.55**	**2.19**

Yield attributes and yield(kgha^{-1})

Among the various treatments significant improvement in podsplant^{-1} (17), seedspod^{-1} (10.5), seed yield (730 kgha^{-1}), and haulm yield (1816.67 kgha^{-1}) were observed in T_5(RDF + Rhizophos in liquid)as compared to other treatment values (table 2). It was followed by T_3 (RDF + *Rhizobium leguminosarum* (TNAU14) in liquid formulation)and T_4 (RDF + phosphobacteria in liquid formulation)which were statistically on par with each other. The observed increase in the yield attributes and yieldmight be due to the enhanced phosphate availability by PSB in conjunction with rhizobium-mediated nitrogen fixation.Organic acids produced by PSBaidin chelates formation, which increases the P availability, accumulation, and absorption,thereby improving the yield and yield attributes. These results were in conformity with Singh*et al.* (2022).

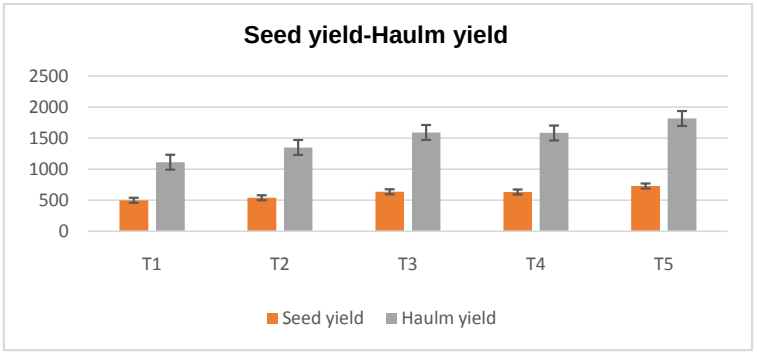
It was observed that there was a high correlation between DMP and the number. of root nodules plant^{-1} (Fig:1) and dry matter production (Fig: 2). The correlation between grain yield and root nodules plant^{-1} and dry matter were 92% and 97%, respectively. The application of liquid rhizophosboth through seeds and foliar spray resulted in better root nodulation in green gram, hence improving the dry matter and grain yield.

Table2. Effectof RDF, *Rhizobium,* PSB and Rhizophos on yield attributes of greengram.

Treatment	Podsplant^{-1}	Seedspod^{-1}	Seed yield (kg ha^{-1})	Haulm yield (kgha^{-1})
T_1	15.2	9.1	500.00	1112.50
T_2	17.1	10.6	540.00	1349.97
T_3	19.1	12.3	636.67	1591.67
T_4	19.0	12.1	633.33	1583.00
T_5	17.0	13.8	730.00	1816.67

SEd	**0.90**	**0.63**	**36.7**	**75.2**
CD (P=0.05)	**1.89**	**1.33**	**76.8**	**157.1**

Fig: 1 Effect of liquid bioinoculants on yield and number of root nodules of green gramat 45DAS



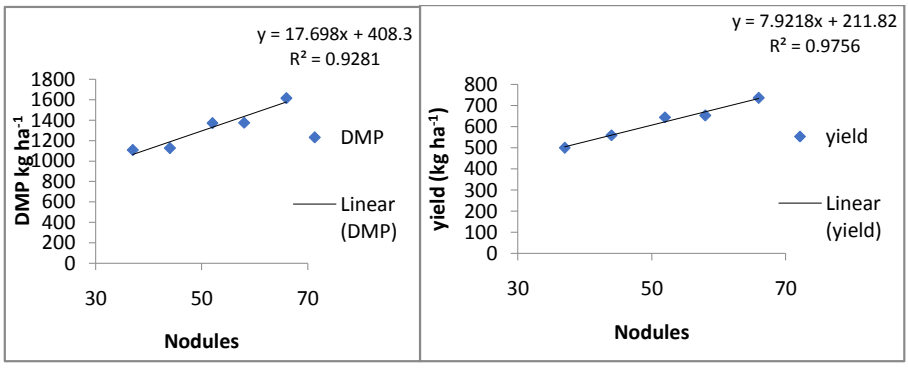


Fig 2: Relationship between grain yield, DMP and root nodules of green gram as influenced by liquid rhizophos

4. CONCLUSION

The impact of liquid bio-inoculantson severalgrowth and yield parameters areassessed inthe present investigation., The mixed inoculum rhizophos as liquid formulation delivered through seed treatment and folair spray, enhanced the growth and yield attributes of green gram, it was observed that there was an increase in the grain yield of 46% over controlTherefore,

these results highlight the significance of bioinoculantsin integrated nutrient management and sustaining soil health as well as pulses productivity.

REFERENCES

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1.Verma, R., Singh, M., Dawson, J., Muddassir, P., & Khan, I. (2022). Effect of bio-fertilizers and organic manures on growth and yield of greengram (Vignaradiata L.). *The Pharma Innovation Journal*, *11*(4), 1599-602.

2. Ali, M. M., Ghazal, R. A., & Al-juthery, H. W. (2023, July). Effect of RhizobactereinBiofertilizer, Nano-NPK and Nano-Micro Complete on Some Parameters of Growth and Yield of Bean and Number of Bacteria in the Rhizosphere. In *IOP Conference Series: Earth and Environmental Science* (vol. 1213, no. 1, p. 012096). IOP Publishing.

3.Dhakal, Y., Meena, R. S., & Kumar, S. (2016). Effect of INM on nodulation, yield, quality and available nutrient status in soil after harvest of greengram. Legume Research-An International Journal, 39(4), 590-594.

4.Singh, K. K., Gupta, S. K., Das, S., Srivastava, R. K., & Singh, A. K. (2022). Effect of bio-fertilizer on yield and economics of summer green gram (Vigna radiata L.). The Pharma. Innov. J, 11(4), 188-191.

5.Teja, M. S., Kishore, A., Sharma, J. D., Kumar, S. P., Reddy, K. S., & Pramod, T. (2022). Different levels of phosphorus and phosphorus solubilizing bacteria (PSB) influence growth, yield and economics of green gram [Vigna radiata L.]. *Journal of Food Legumes*, *35*(3), 180-183.

6.Singh, R., Singh, P., Singh, V., & Yadav, R. A. (2018). Effect of phosphorus and PSB on yield attributes, quality and economics of summer greengram (Vignaradiata L.). *Journal of pharmacognosy and phytochemistry*, *7*(2), 404-408.

7.Shravani, K., Triveni, S., Latha, P. C., &Ramulu, V. (2019). Biofertilizers formulations and their effect on morphological characters in greengram(V*ignaradiata L.*). *Journal of Pharmacognosy and Phytochemistry*, *8*(3), 2460-2465.