

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

## ABSTRACT

A study was conducted to assess the effect of liquid bio-inoculants on the agronomic traits of green gram. Field experiments were conducted on 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<sup>-1</sup> on 15<sup>th</sup>, 30<sup>th</sup> and 45<sup>th</sup> DAS. From the results, a significant increase in the plant height (30.03 cm) dry matter production (1633.67 kg ha<sup>-1</sup>) 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<sup>-1</sup> and seeds pod<sup>-1</sup> were also increased. The treatments with mixed liquid bio-inoculant Rhizophos (T5) registered the highest seed yield and haulm yield of 730 kg ha<sup>-1</sup> and 1816.67 kg ha<sup>-1</sup> 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, **dry matter, yield, nodules**

## 1. INTRODUCTION

Indian soils are poor in nitrogen as well as phosphorous. **Continuous** application of chemical fertilizers affects the soil quality both directly or indirectly. **The** addition of phosphatic fertilizers (P<sub>2</sub>O<sub>5</sub>) causes it to get fixed and become inaccessible to plants (Bhabaiet *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 phosphate moieties (Patel *et al.*, 2019).

*Rhizobium* sp. may be credited with increased root proliferation, root cation exchange 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 (Dhakal *et al.*, 2016). Green gram ranks third among the different pulses grown in India in terms 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<sup>-1</sup> (Teja *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 using liquid 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<sup>-1</sup>, and available N 312.2 kg ha<sup>-1</sup>, P<sub>2</sub>O<sub>5</sub> 15.8 kg ha<sup>-1</sup>, K<sub>2</sub>O 45.61 kg ha<sup>-1</sup>, and organic carbon 1.81%. The study was conducted using high-yielding green gram variety CO 8 (COGG 923 x VC 8040A).

The treatments included *Rhizobium leguminosarum* (TNAU 14) and PSB (*Bacillus megaterium* var. *phosphaticum*) strains in liquid formulations obtained from Tamil Nadu

Agriculture University, Coimbatore. The experiment was laid out in Randomized Block Design (RBD), comprising five treatments 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 10 ml kg<sup>-1</sup> 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<sub>3</sub> 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<sub>5</sub> which is RDF + Rhizophos in liquid over all the other treatments (Table 1). However, treatment (T<sub>3</sub>) with RDF + *Rhizobium leguminosarum*TNAU14 in liquid (26 cm) was found to be statistically on par with T<sub>4</sub> (RDF + Phosphobacteria in liquid) applied through seed treatment followed by foliar sprays (15, 30 and 45 DAS). This may be due to the combined effect of phosphate solubilizing PSB and increased nitrogen availability by *Rhizobium leguminosarum*TNAU14. The results showed that the application of bio-inoculants facilitate nutrient absorption and increased availability of the major nutrients preferably N and P during crop growth, like PSB secretes organic acids, which effectively solubilize phosphate aiding in increased nitrogen fixation, dry matter buildup, increased uptake of nutrients resulting in a positive effect on growth, these results were similar with Bhabaiet al.(2019).

### Dry matter production (kg ha<sup>-1</sup>)

In the present study, the dry matter production recorded a steady increase till 45 DAS and declined afterwards., Leaf shedding was observed due to a decline in dry matter output up to the harvest period. The results revealed that the treatment T<sub>5</sub> (RDF + Rhizophos in liquid) marked higher dry matter production at 45 DAS (1633.67 kg ha<sup>-1</sup>) over all the other treatments (Table 1). However, treatment (T<sub>3</sub>) was found to be statistically on par with T<sub>4</sub> (RDF + Phosphobacteria in liquid). These results were correlated with the findings of Shravani *et al.* (2019). The increase in dry matter production up to flowering 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<sup>-1</sup> and treatment T<sub>5</sub> (RDF + Rhizophos in liquid) registered maximum root nodules plant<sup>-1</sup>(65.7) over all the other treatments (Table 1), followed by treatments T<sub>3</sub> (RDF + *Rhizobium leguminosarum* (TNAU14) in liquid formulation) and T<sub>4</sub> (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 by Dhakal *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 (kg ha <sup>-1</sup> )	Nodules plant <sup>-1</sup>
T <sub>1</sub>	18.64	1137.00	37.20
T <sub>2</sub>	22.50	1300.00	44.26
T <sub>3</sub>	26.30	1471.00	57.60
T <sub>4</sub>	26.10	1463.33	51.60

<b>T<sub>5</sub></b>	30.03	1633.67	65.70
<b>SEd</b>	<b>1.52</b>	<b>70.15</b>	<b>1.05</b>
<b>CD (P=0.05)</b>	<b>3.18</b>	<b>146.55</b>	<b>2.19</b>

### Yield attributes and yield (kg ha<sup>-1</sup>)

Among the various treatments significant improvement in pods plant<sup>-1</sup> (17), seeds pod<sup>-1</sup> (10.5), seed yield (730 kg ha<sup>-1</sup>), and haulm yield (1816.67 kg ha<sup>-1</sup>) were observed in T<sub>5</sub> (RDF + Rhizophos in liquid) as compared to other treatment values (table 2). It was followed by T<sub>3</sub> (RDF + *Rhizobium leguminosarum* (TNAU14) in liquid formulation) and T<sub>4</sub> (RDF + phosphobacteria in liquid formulation) which were statistically on par with each other. The observed increase in the yield attributes and yield might be due to the enhanced phosphate availability by PSB in conjunction with rhizobium-mediated nitrogen fixation. Organic acids produced by PSB aid in 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).

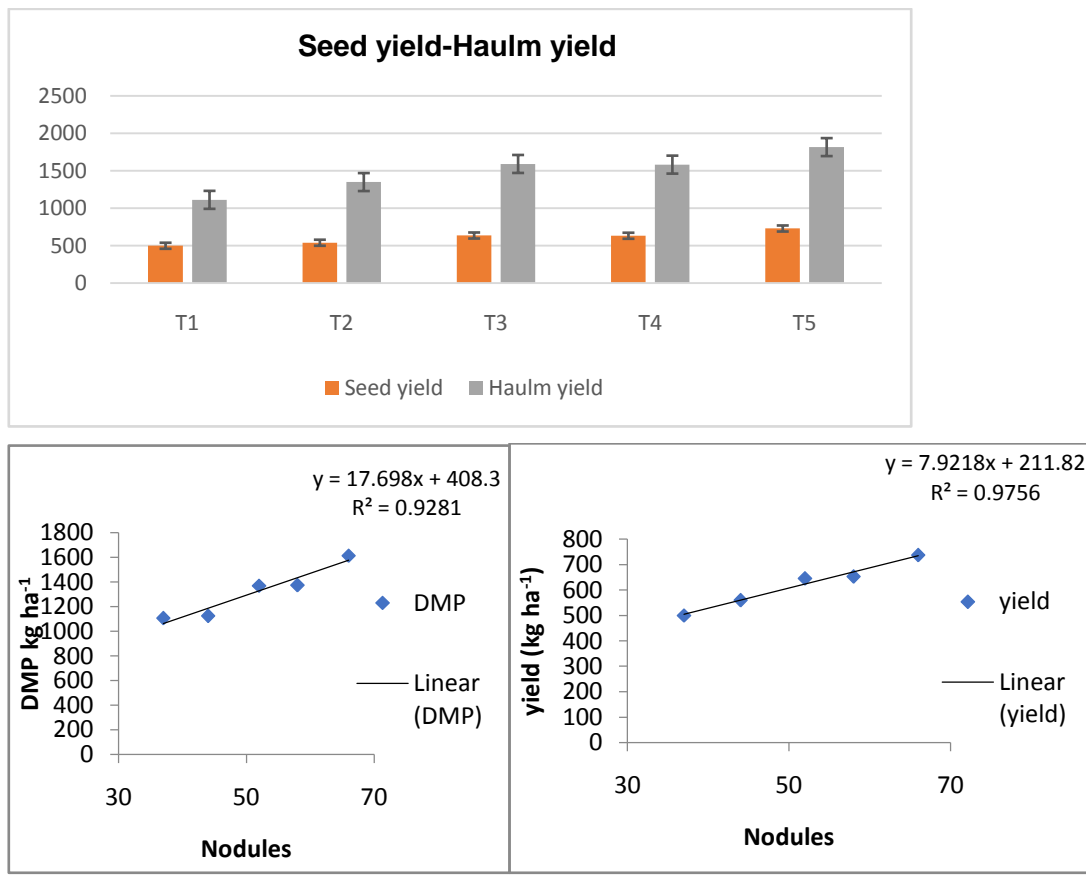
It was observed that there was a high correlation between DMP and the number of root nodules plant<sup>-1</sup> (Fig: 1) and dry matter production (Fig: 2). The correlation between grain yield and root nodules plant<sup>-1</sup> and dry matter were 92% and 97%, respectively. The application of liquid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

**Table 2. Effect of RDF, *Rhizobium*, PSB and Rhizophos on yield attributes of green gram.**

Treatment	Pods plant <sup>-1</sup>	Seeds pod <sup>-1</sup>	Seed yield (kg ha <sup>-1</sup> )	Haulm yield (kg ha <sup>-1</sup> )
T <sub>1</sub>	15.2	9.1	500.00	1112.50
T <sub>2</sub>	17.1	10.6	540.00	1349.97
T <sub>3</sub>	19.1	12.3	636.67	1591.67
T <sub>4</sub>	19.0	12.1	633.33	1583.00
T <sub>5</sub>	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 gram at 45 DAS**



**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-inoculants on several growth and yield parameters are assessed in the present investigation., The mixed inoculum rhizophos as liquid formulation delivered through seed treatment and foliar 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 control

Therefore, these results highlight the significance of bioinoculants in integrated nutrient management and sustaining soil health as well as pulses productivity.

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