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Effect of Co-inoculants Rhizophos on the Growth and Yield of Black Gram [*Vigna mungo* (L.) Hepper]

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Authors' contributions

This work was carried out in collaboration among all authors. Authors CS, MS, ST did the conceptualization. Authors CS, MS, ST, PDK did the methodology. Authors CS, MS, KUK, ST, PDK did the writing—original draft, data curation and visualization; All authors have read and agreed to the published version of the manuscript.

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ABSTRACT

Field experiment was conducted to investigate effect of co-inoculants Rhizophos in liquid formulation on the agronomic traits of black gram (*Vigna mungo* L.). The treatments such as RDF (Recommended dose of fertilizer) + rhizophos in liquid formulation (T_5), RDF + phosphobacteria in liquid formulation (T_4), RDF + *Rhizobium leguminosarum* (TNAU14) in liquid formulation (T_3), RDF

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(T_2) and absolute control (T_1) were imposed in a Randomized Block Design with four replication each. Seeds were treated accordingly with the treatments and foliar application was done at 1ml.L^{-1} on 30, 45 and 60 DAS. Among the treatments, foliar spray of Rhizophos @ 1 ml.L^{-1} exhibited profound effect in improving the growth and yield attributes. The result demonstrates that RDF + rhizophos in liquid formulation recorded the highest yield of (750 kg.ha^{-1}) over the control (483 kg.ha^{-1}). The results showed that, application of co-inoculant rhizophos through seed treatment and foliar spray significantly influenced the agronomics traits and yield of black gram over individual treatment and recommended dosage alone.

Keywords: Foliar spray; bio-inoculant; Black gram; yield; phosphobacteria; rhizophos; seed treatment.

1. INTRODUCTION

Pluses are the main source of protein in the vegetarian diet of our country. Among the pulses, black gram is one of the dominant pluses usually grown as a fallow crop in southern part of Tamil Nadu. Black gram (*Vigna mungo* L.) a widely cultivated legume that is native to India and a significant pulses crop, is a member of the Fabaceae family and plays a significant role in global food and nutritional security. It is a crop with a short growth period that goes well as a solo or an intercrop in all the seasons. Black gram is popularly known “Urad dal” and it’s is one of the most highly valued pulses among all the pulses [1]. Indian is the biggest producer and user of black grams in the world [2]. The high nutritional value and short span of growth cycle, makes it suitable for a diverse ecological conditions. It can be grown as an intercrop along with sugarcane, cotton, sorghum, maize and pigeon pea as well as a fodder and green manure crop [2].

Although pulses can fix atmospheric nitrogen (N), previous studies suggest that using inorganic N fertilizer can assist increased production. Since N is an essential component of protein and other macromolecules such as nucleic acid, and chlorophyll therefore, it is regarded as an integral nutrient for enhancing the nutrient quality of black gram. Hence, optimal vegetative development, yield and quality of pulses, especially mung bean, depend on a sufficient supply of N. Conversely, overuse of N is not only unfeasible but also slow crop maturity and prolongs the growth period. Further excessive amount of N lead to physiological problems [3].

Due to their inherent ability to fix atmospheric nitrogen in symbiotic association with rhizobia, this legume-rhizobia association is crucial for preserving the soil fertility and other eco-system services. The Gram-negative soil bacterium fixes atmospheric N in specialized structures called root nodules and facilitates N uptake and assimilation. The effect of Rhizobia’s association with the rhizosphere on plant growth proved to be consistent [4].

Through increasing the biological fixation of atmospheric N and releasing the immobile phosphorus into the plants, bio-inoculant such as *Rhizobium* spp. and phosphobacteria (PSB) play a significant role in improving the availability of N and Phosphorus [5].

Experiments were carried out to investigate the impact of liquid bio-inoculants (both single and co-inoculants) on black gram productivity and nutrient utilization efficiency. Previous research on the interactions of bioinoculants with black gram plants implied single inoculum in carrier-based formulations that were effectively applied through seed treatment. Here, efforts are being made to investigate the impact of a co-inoculants *Rhizobium leguminosarum* TNAU 14 + *Bacillus megaterium* var phosphaticum (Rhizophos) applied through foliar spray and seed treatment on Black gram. The study also evaluated the viability utilizing liquid bioinoculants as part of integrated nutrient management system to boost pulse productivity and sustainable environment.

2. MATERIALS AND METHODS

A field experiment was carried out during *Rabi* season of January 2024 at the instructional farm (North), Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu. The experimental field is geographically located in Tamil Nadu at 10°56’N latitude, 76°44’E longitude and altitude 474 m above mean sea level. (10056’ N latitude and 76044’ E longitude; altitude 474 m above mean sea level). The soil (0-15 cm) at the experimental site was clay loam in texture, having pH 8.0 and Electrical conductivity (EC) 32 ds.m^{-1}, organic carbon

1.68%, available N, P and K 309.4, 18.2 and 40.37 kg.ha^{-1}, respectively. The place under study falls in the western agro-climatic zone of Tamil Nadu. The climate is tropical semi-arid slightly temperate with altitude.

The treatments included *Rhizobium leguminosarum* (TNAU 14) and PSB strains in liquid formulation obtained from – Tamil Nadu Agriculture University, Coimbatore. The experimental was laid out in a Randomized block design with four replications with individual plots of size 4 x 3 m, comprising five treatments Absolute control (T_1), RDF (Recommended Dose of Fertilizer) (T_2), RDF + *Rhizobium leguminosarum* (TNAU14) in liquid formulation (T_3), RDF + phosphobacteria in liquid formulation (T_4) and RDF + rhizophos in liquid formulation (T_5) in Black gram.

The recommended dose of 25:50:25 kg of N: P_2O_5: K_2O ha^{-1} was applied to all plots except absolute control in the form of urea (46% N), Single super phosphate (16% P_2O_5), and Muriate of potassium (60% K_2O) respectively. The foliar spray of bio-inoculant was given at 30th, 45th and 60th DAS and the VBN 11 variety was used as test variety. Sowing was done on 11th January 2024 at a seed rate of 20 kg ha^{-1}. VBN 11 varieties of black gram seeds were treated with co-inoculants (*Rhizobium* broth, PSB broth and rhizophos broth) at the rate of 10ml kg^{-1} according to the recommended treatment and the seeds were shade dried. The dried seed were sown by dibble method, with a 30 cm x 10 cm seed spacing with two seeds per hill. On 3rd day after sowing pendimethalin 30% E.C 1.0 kg ha^{-1} and Pendimethalin + Imazethapyr (pre-mix) - Valor 32% EC 1.0 kg ha^{-1} as a pre-emergence herbicide was sprayed using knapsack sprayer fitted with flat fan nozzle using 500 liters of water for spraying one ha to the treatments respectively. On 15th and 30th day after sowing hand weeding was done. Gap filling was done after two weeks of planting to maintain the plant population.

The observation was recorded on growth and growth parameters such as plant height, number of branches per plant and Dry matter production kg ha^{-1} was recorded periodically. The yield parameter of number of pods per plant, number of seed pod per plant, seed yield and stover yield were also recorded. The observed data was statistically analyzed based on procedure given by [6].

3. RESULTS AND DISCUSSION

3.1 Impact of co-inoculant on Different Growth Parameters

Growth parameters of black gram such as plant height (cm), number of branches per plant, dry matter production (kg ha^{-1}) as influenced by foliar application of bio-inoculant was present in the Table 1 revealed that treatment RDF + rhizophos in liquid formulation (T_5) has recorded significantly higher plant height of 34.83 cm at 60 days after sowing (DAS). However, treatment T_3 (RDF + *Rhizobium leguminosarum* (TNAU14) in liquid formulation) (33.37 cm) and T_4 (RDF + phosphobacteria in liquid formulation) (31.37 cm) was found to be statistically on par with each other respectively. Application of treatment T_5 (RDF + rhizophos in liquid formulation) recorded higher number of branches per plant (4.50), which is followed by treatment T_3 (RDF + *Rhizobium leguminosarum* (TNAU14) in liquid formulation) (4.37) was found to be statistically on par with treatment T_4 (RDF + phosphobacteria in liquid formulation) (4.20) compared to treatment T_1 (Absolute control) (3.20) at harvest. Among the treatment dry matter production (1270 kg ha^{-1}) in treatment T_5 (RDF + rhizophos in liquid formulation) and lowest (590 kg ha^{-1}) was recorded in treatment T_1 (Absolute control). Similarly, were also reported in maximum number of root nodules plant^{-1} (63.30) in treatment T_5 (RDF + rhizophos in liquid formulation), which is followed by treatment T_3 (RDF + *Rhizobium leguminosarum* (TNAU14) in liquid formulation) (55.25) and T_4 (RDF + phosphobacteria in liquid formulation) (52.40) which were statistically on par with each other. The bio-inoculant were applied through seed treatment followed by three consecutive foliar sprays (30, 45 and 60 DAS). The higher growth in T_5 (RDF + Rhizophos liquid formulation) is a result of applying RDF, which gives the plants rapid access to nutrients, as well as applying biofertilizers like Rhizobium and PSB, which help to maintain the availability of both organic and inorganic nutrients for longer periods of time. This allowed the plants to absorb enough nutrients from the soil to grow well which thereby increased the growth parameters like plant height, dry matter production, number of branches per plant [7]. The increase in growth attributes in the present study may be primarily explained by *Rhizobium*'s ability to fix atmospheric N and make it available to plants. Biofertilizers enhance the uptake of nutrient. Phosphate Solubilizing Bacteria are essential

microbes that help in the release of different organic acids, such as butyric and formic acids, which solubilize fixed phosphorus and make it available to plants. PSB were found to enhance plant uptake of the mineral and as a result, boost plant growth. These results are conformity with Gautam et al. [8].

3.2 Impact of co-inoculants on Yield attributes and Yield (kg ha^{-1})

Yield attributes such as number of pods per plant, number of seeds per pod was significantly affected due to the application of bio-inoculant (Table 2). Significantly higher number of pods plant^{-1} (29.00) and number of seeds pod^{-1} (5.90) was recorded in treatment T_5 (RDF + rhizophos in liquid formulation) while minimum number of pods plant^{-1} (18.00) and minimum number of seeds pod^{-1} (5.47) in treatment T_1 (Absolute control) respectively. This is mainly due to the combined application of *Rhizobium* and PSB. These results are conformity with Gautam et al. [8].

Grain yield and stover yield was significantly influenced by application of bio-inoculant treatments (Table 2). A significantly higher grain yield (750 kg ha^{-1}) was observed in the treatment T_5 (RDF + rhizophos in liquid formulation) and the lower grain yield (483 kg ha^{-1}) was recorded in the treatment T_1 (Absolute control). The treatment influenced by bio-inoculant has recorded significantly higher stover yield i.e. treatment T_5 (RDF + rhizophos in liquid formulation) (2432 kg ha^{-1}) over the treatment T_1 (Absolute control) (1408 kg ha^{-1}). This is due to the inoculated organism's supply of nutrients, which may have increased their efficiency like N fixation by *Rhizobium* and P-solubilization by PSB. These results are in conformity with Rudresh et al. [9], Rajeshkumar et al. [10].

Table 1. Effect of RDF, *Rhizobium,* PSB, and Rhizophos on growth attributes of Black gram at 60 DAS

Treatments	Plant height (cm)	Number of branches plant^{-1} at harvest	DMP (kg ha^{-1})	Number of root nodules plant^{-1}
T_1 - Absolute control	27.47	3.20	590	35.08
T_2 - RDF (Recommended dose of fertilizer)	29.20	3.80	810	41.37
T_3 - RDF+ *Rhizobium leguminosarum* (TNAU14) in liquid formulation	33.37	4.37	1037	55.25
T_4 - RDF+ phosphobacteria in liquid formulation	31.37	4.20	1030	52.40
T_5 - RDF + rhizophos in liquid formulation	34.83	4.50	1270	63.30
SEm (±)	2.02	0.25	60.43	3.10
CD (0.05)	4.22	0.53	126.26	6.47

SEm - Standard Error of Mean
CD – Critical difference

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

Treatment	Number of pods per plants	Number of seeds per pod	Seed Yield (kg ha^{-1})	Stover Yield (kg ha^{-1})
T_1 - Absolute control	18.00	5.47	483	1408
T_2 - RDF (Recommended dose of fertilizer)	21.70	5.60	560	1748
T_3 - RDF+ *Rhizobium leguminosarum* (TNAU14) in liquid formulation	26.00	5.80	670	2092
T_4 - RDF+ phosphobacteria in liquid formulation	24.60	5.77	664	2088
T_5 - RDF + rhizophos in liquid formulation	29.00	5.90	750	2432
SEm (±)	1.52	0.36	35.17	124.599
CD (P=0.05)	3.19	0.77	73.48	260.29

SEm - Standard Error of Mean
CD – Critical difference

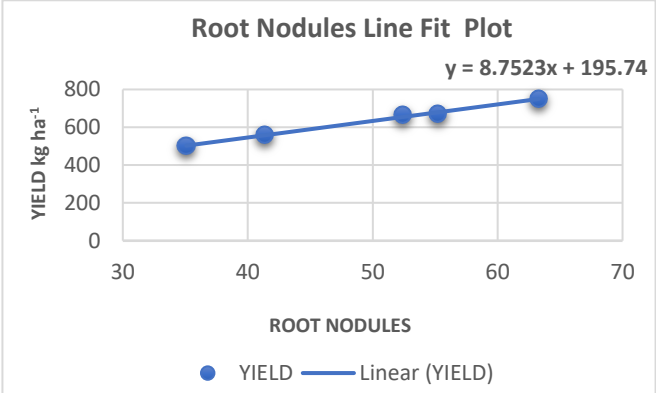

Fig. 1. Effect of RDF, Rhizobium, PSB and Rhizophos on association of nodules with yield of Black gram

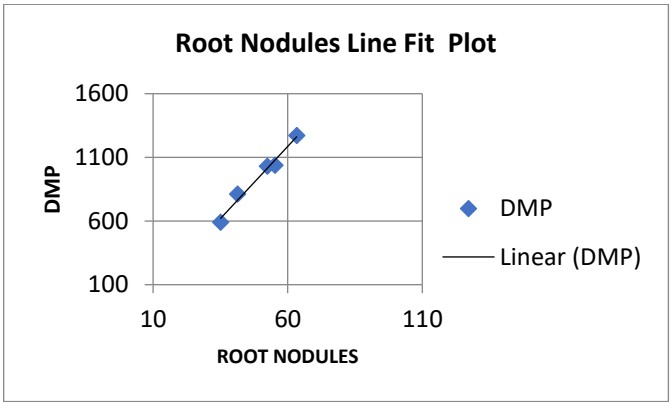

Fig. 2. Effect of RDF, Rhizobium, PSB and Rhizophos on association of nodules with DMP of Black gram

4. CONCLUSION

The present study concluded that the application of liquid co-inoculant Rhizophos (combination of *Rhizobium* and PSB) applied through seed treatment and foliar spray increased the plant growth and influenced the yield attributes. The plants treated with rhizophos showed (55.3) per cent yield increase over the control. Based on the findings, it could be concluded that bio-inoculants are available technology for improving soil health and plant growth, Hence it can be recommended as a part of integrated nutrient management system for sustaining environment stability and sustainable production of black gram.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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