

Effect of Plant Growth Promoting Rhizobacteria (PGPR) and Chemical Fertilizer on the Growth and Yield of Binamoog-8

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Abstract: Plant Growth Promoting Rhizobacteria (PGPR) are beneficial soil born bacteria that colonize plant roots, enhancing plant health and growth, and enhance stress tolerance. The present study was conducted to evaluate comparative effects of Plant Growth Promoting Rhizobacteria (PGPR) and chemical fertilizer on the yield and yield attributing characteristics of Mung bean (i.e. Binamoog-8). The field experiment was conducted at High Ganges River Floodplain of Bangladesh using six treatments viz. T₁: Control, T₂: 100% recommended dose of chemical fertilizers (RCF), T₃: 50% RCF + Bacterial Strain CD1, T₄: 50% RCF + Bacterial Strain CD2A, T₅: 50% RCF + Bacterial Strain CD2B, T₆: 50% RCF+ Bacterial mixed culture of CD1, CD2A, and CD2B. Results showed significant increase in pod number and yield with inoculated treatments over uninoculated control treatment. The maximum number of pods plant⁻¹ (16), seed yield (1.93 t ha⁻¹) recorded in the treatment T₄ (50% CF + CD2A) while the minimum pods plant⁻¹ (13), seeds pod⁻¹ (1.38 t ha⁻¹) were recorded from control. Among six treatments, overall, the treatment T₄ (i.e 50% CF + CD2A) showed the best performance. These findings suggested that integrating PGPR inoculation with 50% recommended doses of chemical fertilizer could optimize the growth, yield of Binamoog-8. Thus, offers a sustainable strategy for reducing the dependence of chemical fertilizer without hampering productivity. Thus, our findings concluded that the strain CD2A could be used along with 50% recommended dose of chemical fertilizers offerings a sustainable strategy for reducing the dependence of chemical fertilizer without hampering Mung bean production.

Keywords: Bacterial inoculation; Plant growth; Chemical fertilization; Sustainable agriculture.

INTRODUCTION

Mung bean is an edible grain legume crop that is mostly attractive for growers in South Asia due to its short life span and its great performance in adverse climatic conditions (Hanumantha Rao et al 2016). Per gram of the whole bean, it contains a significant amount of protein (24.6%), carbohydrates (59.91%), calcium (76 mg), iron (8.51 mg), β-carotene (49.3 mg), and a few other essential micronutrients. And it can be readily digested. Domestic animals can also be fed certain sections of stems and leaves. It is also used as green manure, which improves soil fertility and productivity (Dahiya et al. 2015). Naturally,

through biological nitrogen fixation, the Mung bean plant can fix atmospheric nitrogen (63-342 kg ha⁻¹) in soil per season, which increases soil fertility (Afzal et al. 2004).

Free living bacteria known as Plant Growth Promoting Rhizobacteria (PGPR) colonize plant roots and stimulate the growth of plants. By using their own metabolism (fixing nitrogen, generating hormones, or solubilizing phosphates), by directly influencing the plant metabolism (increasing the uptake of water and minerals), improving root development, raising the plant's enzymatic activity, "helping" other beneficial microorganisms to increase their action on the plant, or by suppressing plant pathogens

(Perez-Montano et al, 2014. Vocciante et al, 2022, Bhanse, et al, 2022). By enhancing plant health, stress tolerance, and pollution remediation, PGPR may promote plant growth in the face of abiotic stress. More information and understanding of the bacterial characteristics that promote plant growth may inspire and encourage the creation of innovative PGPR-based solutions in highly variable climatic and climatological contexts (Oleńska et al, 2020). In recognition of their advantages for the ecology and economy, biofertilizers containing PGPR strains are gaining more popularity recently. It is anticipated that the worldwide market for plant growth stimulants, such as bio-fertilizers, will expand by 12% a year (Mosttafiz et al, 2012). Since Mung bean is a common household item and has proven to be a critical nutrient-dense herb, focus must be paid to increase the yield in order to feed the expanding population. The application of fertilizer has an enormous effect on crop yield. Although chemical fertilizers have been found to be the most successful, bioformulations exhibit as prospective alternatives because they are economically viable and not harmful to the agro-ecosystem. Plant Growth Promoting Rhizobacteria (PGPR) are increasingly being used in sustainable agriculture for boosting crop sustainability (Kumar et al., 2016). Since it would significantly reduce the demand of chemical fertilizers and pesticides, the use of Plant Growth Promoting Rhizobacteria (PGPR) as inoculants in agricultural activities is highly encouraged. For the purpose of isolating various bacterial strains and investigating their function in promoting plant growth, the gradual incorporation of PGPR is becoming progressively more accepted. Studies showed that multiple bacterial genera, including *Azotobacter*, *Pseudomonas*, *Rhizobium*, and *Bacillus*, showed encouraging outcomes (Teaumroong et al 2010) as PGPR.

MATERIALS AND METHODS

Experimental site

This field research, to the study of the effect of PGPR and chemical fertilizer on the yield of Mung bean, was conducted at BINA Sub-station, Ishurdi (24°07'23.6"N 89°04'50.0"E) during the Kharif season of 2022.



Figure 1: Experimental site (Source: Google map)

Description of soil

The use of chemical fertilizers, undoubtedly disturb the most prevalent soil microbial species, both the functional and structural diversity of the soil microbial communities. Moreover, alteration in diversity and activity of microbes was observed due to the overuse of chemical fertilization. Even though there is ample proof that chemical fertilizers have an impact on the soil microflora, the scant research that is now accessible largely shows a varied pattern. Due to their direct impacts on organisms and indirect effects caused by unfavorable environmental changes, fertilizers can have either short-term or long-term effects on the soil microflora (Seymour, 2005).

Fertilizer application is a crucial management strategy in agricultural production that influences the microbes in the soil (Berthrong 2013, Wang et al 2015) and enhances crop development and yield (Shang et al 2014, Yu et al 2019) but regular application of chemical fertilizers currently results in a number of environmental hazardous issues (Chen et al., 2016; Liu et al., 2014; Yang et al., 2019). In contrast, bioorganic fertilizer not only advances soil fertility through the introduction of organic materials and beneficial microorganisms (Lazcano et al., 2013; Wei et al., 2017), but it also cuts out many of the negative environmental impacts triggered on by chemical fertilizers. The farmers of Bangladesh frequently cultivate Mung bean without the use of fertilizers results in lower Mung bean production. Thus, there is a great deal of opportunity for enhancing Mung bean production by PGPR inoculation and proper fertilization. Thus, the current experiment was carried out to investigate the effects of chemical fertilizer and PGPR strains on Mung bean yield performance under field conditions.

The soil of the experimental field belongs to the Agro Ecological Zone-11 (High Ganges River Floodplain). The region is characterized by a mix of plain, low-lying areas and elevated landforms. The major portion of Ishurdi Upazila lies in the vast Gangetic floodplain, featuring fertile alluvial soil deposited by the rivers (SRDI, 2000; Brammer, 1996). A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment for fertility analysis.

Description of the Mung bean variety

The Binamoog-8 is a summer Mung bean variety released in 2010. It is obtained from seeds of MB-149 which were irradiated with 400 Gy of gamma ray. Maturity period ranges from 64-67 days. Maximum grain yield is about 2.0 t ha⁻¹ (av. 1.8 t ha⁻¹). Seed is medium size with green shiny color. Seed contains higher protein (23%). Plants are short and tolerant to yellow mosaic virus (YMV) disease. This variety is suitable for cultivation in pulse growing areas of Bangladesh.

Climate

According to the Koppen climate classification (Beck et al., 2018), Ishurdi has a humid sub-tropical or tropical savanna climate. The weather is influenced by Indian monsoon (BMD, 2023). Much of the yearly rainfall is received from the south west monsoon. Generally, monsoon hits this region in the 2nd week of June and retreats at the end of October. (Ahmed, 2007).

Preparation of the field

The plot selected for the experiment was ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed and the large clods were broken into smaller pieces to obtain a desirable tilth of soil for sowing of seeds. Finally, the land was leveled and the experimental plot was partitioned into the unit plots in accordance with the experimental design.

Layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The total number of plots was 18 and each measuring 3m × 2m (6 m²). The treatment combination of the experiment was assigned at random into 18 plots of each at 3 replications.

Application of chemical fertilizers

The half dose of chemical fertilizers (BARC, 2018) such as Urea, Triple Super Phosphate and Muriate of Potash were applied at the time of final land preparation.

PGPR strains, their inoculation and seed sowing

The bacterial strains used in this study were isolated from decomposed cow dung using serial dilution techniques and stored at 4°C for experimental purpose. Isolated strains were gram positive and showed phosphate solubilizing capacity and indole acetic acid production capacity at laboratory conditions in previous study. On the basis of phosphate solubilizing capacity, three strains and their mixer were used as different treatments for this experiment. Peat based inoculum were prepared from isolated strains and were used for this study. Required seeds were coated with molasses first and then bacterium inoculum were putted on seeds. Seeds were then gently mixed for making a coat on the seed surface. Inoculated mung bean seeds were sown on the 22 March 2022 at early morning.

Cultural and management practices

Various intercultural operations such as thinning of plants, weeding and spraying of insecticides were accomplished whenever required to keep the plants healthy and the field

weed free. Special care was taken to protect the crop from birds especially after sowing and germination stages. The field was irrigated twice-one at 15 days and the other at 30 days after sowing.

Harvesting

The crop was harvested at maturity on 30 May 2022 & 20 June 2022. The harvested crop of each individual plot was bundled separately. Five plants were taken separately for taking the data on following parameters. Grain yields were recorded plot wise separately and the yields were expressed in t ha⁻¹.

Plant height: The plant height was measured 1 mm above the ground level to the top of the canopy of 5 plants randomly from each plot and averaged. It was done at the maturity stage of the crop.

Number of branches plant⁻¹: No. of branches were counted from five plants at maturity stage from each plot and averaged.

Number of pods plant⁻¹: The matured pods were collected by hand picking. Pods of 5 plants were counted at maturity stage from each plot and averaged.

Pod length (cm): Pod length was measured at maturity stage. 5 pods randomly collected from each plot and averaged.

Number of seeds pod⁻¹: The number of seeds from five selected pods from each plot were counted and averaged.

Hundred seed weight: The hundred seeds of Mung bean were counted randomly and then weighed plot wise.

Grain yield: Grains obtained from the center of each individual plot was dried, weighed carefully and then converted into t ha⁻¹ as yield.

Statistical analysis

The data obtained from the experiment were analyzed statistically to find out the difference among the treatments. The mean values of all the characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the differences among pairs of treatment means was estimated by the Least Significant Difference (LSD) test at 5% and 1% level of probability and DMRT was calculated (Gomez and Gomez, 1984).

Inoculated plants showed the higher plant height over chemical fertilizers but it was not significantly different. The maximum (47.40 cm) was observed in the treatment containing the bacterial strain CD2B and 50% recommended dose of chemical fertilizer (Table 1).

RESULTS AND DISCUSSIONS

Results showed significant increase in pod number and yield with inoculated treatments over uninoculated control treatment but non-significant effects on vegetative growth.

Table 1. Effect of Plant Growth Promoting Rhizobacteria (PGPR) and chemical fertilizer on the vegetative growth of Binamoog-8

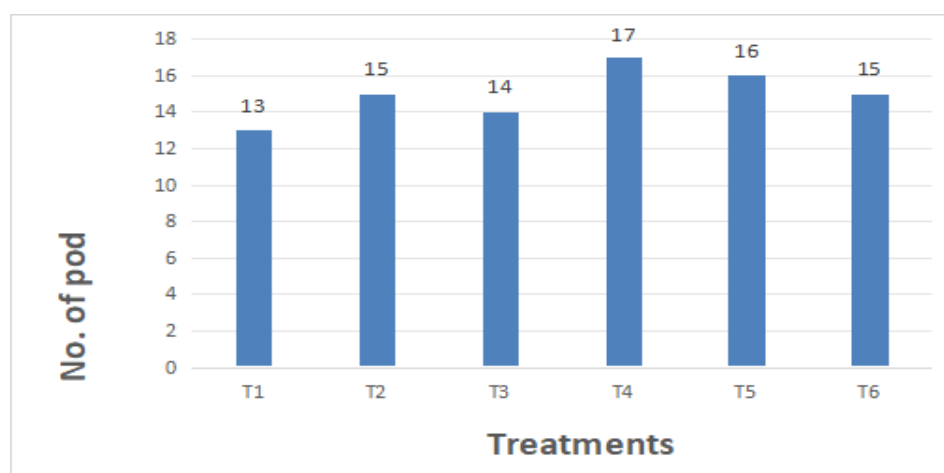
Treatments	Plant height (cm)	Number of branch plant ⁻¹
T ₁ : Control	46.33	3
T ₂ : 100% CF	45.13	3
T ₃ : 50% CF + CD1	44.13	3
T ₄ : 50% CF + CD2A	44.67	3
T ₅ : 50% CF + CD2B	47.40	3
T ₆ : 50% CF + Mixed (CD1, CD2A & CD2B)	47.13	3
CV	3.00	33.12
Level of significance	NS	NS

Note: NS: Non-significant

Table 2. Effect of Plant Growth Promoting Rhizobacteria (PGPR) and chemical fertilizer on the yield contributing characteristics of Binamoog-8

Treatments	No. of pod	Pod length (cm)	Number of seed pod ⁻¹	Yield (t ha ⁻¹)	100 seed wt. (g)
T ₁ : Control	13c	8.40	10	1.38c	4.02
T ₂ : 100% CF	15ab	8.38	11	1.80ab	4.04
T ₃ : 50%CF + CD1	14bc	8.19	11	1.55abc	4.16
T ₄ : 50% CF + CD2A	17a	8.31	11	1.93a	4.11
T ₅ : 50% CF + CD2B	16ab	8.20	11	1.80ab	4.20
T ₆ : 50%CF + Mixed (CD1, CD2A, and CD2B)	15ab	8.27	11	1.47bc	3.77
CV	4.08	3.83	7.32	8.08	4.12
Level of significance	*	NS	NS	*	NS

Notes: NS = Non-significant, * indicate significant at 5% level of probability

**Figure 2:** Effect of PGPR and chemical fertilizer on the no. of pod of Binamoog-8

The branch number of plant is an important characteristic of plant growth. The number of branch per plant was not significantly influenced by produced by different treatments. The similar number of branch per plant was found in all treatments. Different yield and yield

contributing characters of Binamoog-8 were significantly influenced by different treatments (Table 2).

The maximum number of pods plant⁻¹ (16 nos plant⁻¹), yield (1.93 t ha⁻¹) recorded in the treatment T₄ (50% RCF+ strain

2A) while the minimum pods plant⁻¹ (13) and yield (1.38 t ha⁻¹) were recorded from control.

Among six treatments the treatment T₄ (i.e 50% RCF + strain 2A) showed overall the best performance. Probably PGPR strains coupled with recommended doses of fertilizer triggered the vegetative and reproductive growth of Mung

bean that resulted in higher growth of the plant. This finding is also supported by Dost et al. (2004); Malik et al. (2006); Nadeem et al. (2004). The result indicated that Plant Growth Promoting Rhizobacteria (PGPR) inoculation along with 50% recommended doses of chemical fertilizer enhanced growth and yield of Mung bean.

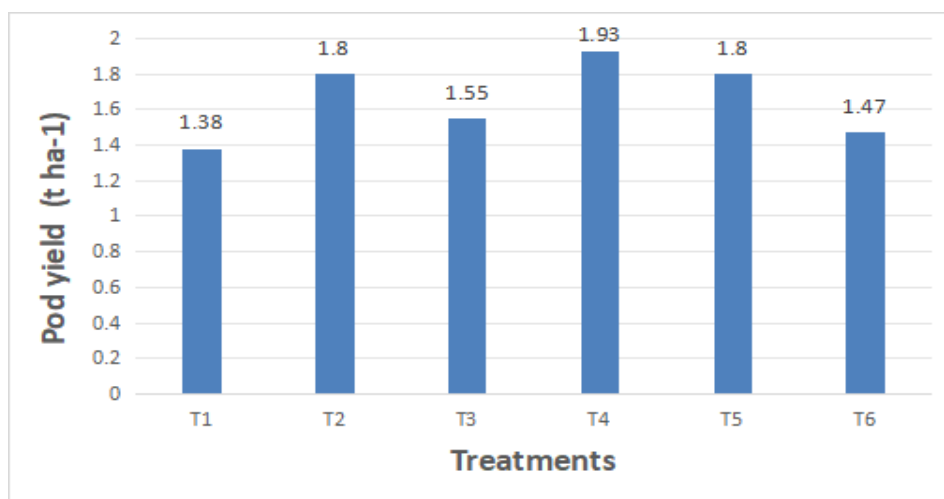


Figure 3: Effect PGPR and chemical fertilizer on the yield of Binamoog-8

Kapoor et al. (2023) also supported the idea that integrated nutrient management (75% or 50% RDF + Biofertilizer) leads to better long-term soil fertility compared to 100% chemical fertilizers. Chauhan et al. (2024) concluded that PGPR inoculation alongside 50% recommended doses of chemical fertilizer can effectively sustain growth, echoing the nutrient-uptake efficiency improvements. Most of isolates significantly increased plant height, root length, and dry matter production of shoot and root of Mung bean plant (Gangwar, 2013). PGPR affect plant growth through mechanisms such as N₂-fixation, plant growth regulators production (Vessey, 2003), water and nutrient uptake enhancement (Dey et al., 2004), soil-borne plant pathogens inhibition (Sindhu et al., 2002), and so on. The use of PGPR for inoculation of seedlings, seeds or soil helps in the mobilization of nutrients through biological activity and increases the population of micro flora, leading to improved soil health (Ipsita and Singh, 2014). The use of PGPR can reduce reliance on chemicals and support environmentally friendly and sustainable farming (Prasad et al., 2015). The maximum number of pods plant⁻¹ (16 nos plant⁻¹), yield (1.93 t ha⁻¹) recorded in the treatment T₄ (50% RCF + strain 2A) while the minimum pods plant⁻¹ (1.38 t ha⁻¹) were recorded from control. Among six treatments the treatment T₄ (i.e 50% RCF + strain2A) showed the best overall performance. Therefore, PGPR strains coupled with recommended doses of fertilizer triggered the vegetative and reproductive growth of Mung bean that resulted in higher growth of the plant. This finding is also supported by Dost et al. (2004); Malik et al. (2006); Nadeem et al. (2004).

CONCLUSION

This study showed that inoculation of Plant Growth Promoting Rhizobacteria (PGPR) along with 50% chemical fertilizer significantly affected Mung bean growth and yield attributing characteristics. Therefore, with a view to ensuring higher Mung bean production while maintaining soil health, increasing productivity, and enhancing soil sustainability, the inoculation of Plant Growth Promoting Rhizobacteria (PGPR) along with 50% recommended doses of chemical fertilizer can be suggested to the farmers for getting the better yield.

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Conflict of Interest

There is no conflict of interest declared by the authors.

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