Effect of Biofertilizer and Fertility Levels on Growth Characters of Mungbean under Mid Hills of Himachal Pradesh, India

ABSTRACT

Biofertilizers are tiny living organisms that can enrich the quality of the soil. These organisms positively imapact, making them healthier and more productive. One of the great things about biofertilizers is that they are environmentally friendly. Unlike some chemical fertilizers, they do not harm the environment. This makes them a good choice for sustainable farming practices. Another advantage of using biofertilizers is that they are cost-effective. One of their most important roles is maintaining the soil's long-term fertility. Over time, chemical fertilizers can deplete the soil of its natural nutrients. Biofertilizers, on the other hand, work in harmony with the soil, helping to keep it healthy and productive for years to come. So, if you want to increase your soil's productivity and do so in an environmentally friendly and cost-effective way, using biofertilizers is smart and intelligent. The present investigation, titled Effect of Biofertilizer and Fertility Levels on Growth Characters of Mungbean under Mid-hills of Himachal Pradesh was conducted during the *kharif* season of 2022 at the Chamelti Agriculture Farm, MS Swaminathan School of Agriculture, Shoolini University, Solan, Himachal Pradesh. The soil of the experimental site was sandy loam in texture, slightly alkaline in reaction with EC in a safe range, medium in organic carbon, available nitrogen, and potassium and high in available phosphorus. The field experiment was laid out in randomized block design comprising ten treatments *viz*. (T_1) control, (T_2) 100% RDF, (T_3) 75% RDF + seed treatment with liquid biofertilizer, (T_4) 100% RDF + seed treatment with liquid biofertilizer, (T_5) 75% RDF + seed treatment with solid biofertilizer, (T_6) 100% RDF + seed treatment with solid biofertilizer, (T_7) 75% RDF + soil application with liquid biofertilizer, (T_8) 100% RDF + soil application with liquid biofertilizer, (T_9) 75% RDF + soil application with solid biofertilizer and (T_{10}) 100% RDF + soil application with solid biofertilizer with three replications. The recommended dose of nitrogen, phosphorus and potassium (20:40:20 kg ha^{-1}) through urea, SSP and MOP at the sowing. Biofertilizers applied for seed are 10 ml kg^{-1} of seed, and for the soil application, take 10 g of solid biofertilizer for 1 kg^{-1} of $ha^{-1}$of seed and mix with 100 kg of FYM. Pusa Baisakhi variety of mungbean was used for sowing. Other crop management practices were followed as per the recommendation of the area.

Significantly higher growth characteristics (plant height, no. of branches, no. of trifoliate leaves and dry matter accumulation) were observed with (T_8) 100% RDF + soil application of liquid biofertilizer.

They were on par with (T_{10}) 100% RDF + soil application of solid biofertilizer over the rest of the treatments. The treatments (T_6) 100% RDF + seed treatment with solid biofertilizer were statistically similar to (T_4) 100% RDF + seed treatment with liquid biofertilizer, followed by treatments T_7, T_3 and T_2. Thus, the study suggests that mungbean can be successfully grown under the Mid-hills of Himachal Pradesh on (T_8) 100% RDF + soil application of liquid biofertilizer.

Keywords: Biofertilizer, mungbean, growth, fertility

1. INTRODUCTION

One of the significant significant agricultural researchers is finding ways to reduce reliance on costly agrochemicals and chemical fertilizers. These chemicals have detrimental effects on both the environment and human health. Chemical fertilizers are primarily used to replenish the nitrogen content in the soil, but they come with significant drawbacks. They are also expensive when used in large quantities and pose a severe environmental threat due to their contamination. This challenge reflects the urgent need for alternative, more sustainable approaches to agriculture. It underscores the importance of finding eco-friendly, cost-effective solutions that benefit our environment and human well-being (Dai *et al.*, 2004). Biofertilizers, play a vital role in enhancing plant nutrition. They then uniquely convert atmospheric nitrogen into a form that plants can readily use. Moreover, they are both cost-effective and environmentally sustainable sources of essential nutrients, complementing chemical fertilizers. These help to reduce the dependency on chemical fertilizers, contributing to the cause of sustainable agriculture (Rana *et al*., 2013). Regarding biofertilizers, we refer to microbial inoculants containing potent strains of microorganisms capable of solubilizing phosphate and fixing nitrogen in the soil. These microorganisms, found in biofertilizers, are organic products of living cells. They remarkably convert essential elements from inaccessible sources into forms that plants can easily absorb and utilize. To amplify their beneficial impact, biofertilizers are often incorporated into the soil, enriching it with a more significant population of these microorganisms. This acceleration of microbial processes significantly enhances the availability of nutrients, providing the plant can efficiently incorporate then to boost growth (Vessey, 2003).

Mungbean, a legume plant, establishes a symbiotic relationship with Rhizobia, allowing it to fix atmospheric nitrogen. This process contributes a substantial amount of biomass and nitrogen to the soil. This nitrogen fixation fulfils its own nitrogen needs and benefits subsequent crops. This ability to fix nitrogen is crucial in maintaining the soil's nitrogen balance and enhancing its physical and biological properties. Mungbean can serve as a valuable cover crop before or after cereal crops in rotation, making it an asset for soil enhancement. Using synthetic fertilizers has brought about a concerning situation, resulting in air, water, and soil pollution. This pollution not only affects the immediate environment but also has broader consequences. Contaminated soil and water sources harm microorganisms and eco-friendly insects, which are natural allies in maintaining crop health. This, in turn, leaves crops vulnerable to diseases and ultimately reduces soil fertility.

In contrast, biofertilizers emerge as a sustainable and environmentally friendly solution. They offer economic viability and contribute positively to the ecosystem over time. Small and average-sized farmers find them particularly beneficial compared to chemical fertilizers, as they can be both efficient and cost-effective (Mishra *et al*., 2013). Biofertilizers are microorganisms, such as bacteria, fungi and algal strains, that function differently from chemical fertilizers. Their crucial role lies in improving soil fertility by converting atmospheric nitrogen into a usable form and enhancing the quality of nutrients available in the soil. This natural approach increases crop yields without the environmental harm associated with chemical fertilizers, which disrupts the soil balance.

Agriculture holds immense importance in the Indian economy, driving growth and development. Adopting eco-friendly practices like biofertilisers becomes even more critical, as they not only benefit farmers but also become even more crucial, as they benefit farmers safeguard the environment upon which agriculture relies. Family and the Fabaceae family in India. These tiny, green seeds are remarkably rich in protein content. Mungbean is a crop that thrives in a relatively short growing season and is well-suited to warmer and drier climates. This legume is cultivated throughout India due to its adaptability and widespread popularity. Mung beans are also cost-effective and serve as a valuable source of protein, making them a staple in many diets. In light of these attributes, our experiment aimed to enhance the productivity of this crop. We sought to achieve this goal by applying eco-friendly biofertilizers (Dixit, 2013).

2. MATERIALS AND METHODS

The fieldwork was done in the *kharif* season of 2022 at Shoolini University Chamelti Agriculture Farm, which is part of the MS Swaminathan School of Agriculture and is situated at a latitude 30^0 85’67.30 N and longitude 77^0 13’20.38 E and an elevation of 1284 meters above mean sea level (AMSL). The field experiment was laid out in randomised block design comprising ten treatments *viz*. (T_1) control, (T_2) 100% RDF, (T_3) 75% RDF + seed treatment with liquid biofertilizer, (T_4) 100% RDF + seed treatment with liquid biofertilizer, (T_5) 75% RDF + seed treatment with solid biofertilizer, (T_6) 100% RDF + seed treatment with solid biofertilizer, (T_7) 75% RDF + soil application with liquid biofertilizer, (T_8) 100% RDF + soil application with liquid biofertilizer, (T_9) 75% RDF + soil application with solid biofertilizer and (T_{10}) 100% RDF + soil application with solid biofertilizer with three replications. The soil of the experimental field was sandy loam in texture, slightly alkaline in reaction with EC in safer range, medium in organic carbon, available nitrogen, potassium and high in available phosphorus (Table 1). Recommended dose of nitrogen, phosphorus and potassium (20:40:20 kg ha^{-1}) through urea, SSP and MOP at sowing time. The mungbean variety Pusa baisakhi was sown on 16th June 2022 at a row spacing of 30 × 10 cm using a seed rate of 12 kg $ha^{-1,}$ and a recommended dose of nitrogen, phosphorus and potassium (20:40:20 kg ha^{-1}) was applied through urea, SSP and MOP at the time of sowing. All the data were subjected to analysis of variance (ANOVA) as per the standard procedures. The comparison of treatment means was made by critical difference (RBD) at p=0.05.

Table 1. Properties of soil

Soil type	pH	EC (dS m^{-1})	OC (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available k (kg ha^{-1})
Sandy loam	6.69	0.20	0.52	298.01	27.12	260.09

3. RESULTS AND DISCUSSIONS

3.1 Plant height (cm)

The results of the study reveal significant differences among all the treatments. On plant height (Table 2), plants treated with (T_8) 100% RDF + soil application of liquid biofertilizer exhibited significantly higher plant height (23.99 cm) over the rest of the treatments at 30 DAS. This performance was at par with applying (T_{10}) 100% RDF + soil application of solid biofertilizer (17.16 cm). Furthermore, the treatments (T_6) 100% RDF + seed treatment with solid biofertilizer were statistically similar to (T_4) 100% RDF + seed treatment with liquid biofertilizer, followed by treatments T_7, T_3 and T_2. However, the lowest plant height was observed under (T_1) control (17.16 cm), and the same trend was followed at 60 DAS and harvest. This might be due to the combined application of biofertilizer with fertilizer, increased availability of significant nutrients to plants due to enhanced early root growth and cell multiplication, leading to more absorption of other nutrients from deeper soil layers, ultimately resulting in increased plant growth attributes. The synergistic effect of *Rhizobium*, PSB and KSB, as discussed above, might have increased the plant height in the present investigation due to increased nitrogenous activity and available phosphorus status of soil. Yadav *et al.* (2017), Shihab *et al.* (2023) and Meena *et al.* (2015) reported a similar finding.

The application of NPK with biofertilizer has boosted the availability of essential nutrients to plants. This is achieved by stimulating early root growth and cell multiplication, which enhances the absorption of additional nutrients from deeper soil layers (Pandey *et al*., 2019).

3.2 Number of branches plant^{-1}

Data on the number of branches plant^{-1} at 60 DAS and at the time of harvest showed a significant difference in Table 3. At 60 DAS, a significantly higher number of branches (7.53 plant^{-1}) was observed with the treatment (T_8) 100% RDF + soil application of liquid biofertilizer which was statistically at par with the application of (T_{10}) 100% RDF + soil application of solid biofertilizer (7.27 plant^{-1}). Moreover, treatments (T_6) 100% RDF + seed treatment with solid biofertilizer was found statistically at par with (T_4) 100% RDF + seed treatment with liquid biofertilizer followed by treatment T_7, T_3 and T_2. However, the lowest number of branches (4.93 plant^{-1}) was observed under (T_1) control. A similar trend was noted at the harvest stage. This might be due to an increase in the number of branches plant^{-1}, which may be attributed to robust vegetative expansion, facilitated by the provision of nitrogen through fertilizers and inoculants, which ultimately increase the total branches. These discoveries align harmoniously with the earlier findings of Hussain *et al*. (2011), Charles *et al.* (2023) and Jat *et al*. (2012), as they, reported a substantial increase in the total number of branches with biofertilizer applications.

3.3 Number of trifoliate leaves plant^{-1}

Data on the number of trifoliate leaves at 30, 60 and harvest are shown in Table 4.

The outcomes show a significant distinction between all treatments. At 30 DAS, a significantly higher number of trifoliate leaves (4.85) was observed with the application of (T_8) 100% RDF + soil application of liquid biofertilizer which was statistically at par with the treatment of (T_{10}) 100% RDF + soil application of solid biofertilizer (4.49). Moreover, treatments (T_6) 100% RDF + seed treatment with solid biofertilizer was found statistically at par with (T_4) 100% RDF + seed treatment with liquid biofertilizer followed by treatment T_7, T_3 and T_2. However, the lowest number of trifoliate leaves (2.80) was observed under (T_1) control. A similar trend was noted under 60 DAS and at harvest. This may be attributed to the beneficial impact of dual inoculation of biofertilizer with fertilizer on the plants, which involves supplementing them with additional nitrogen from the atmosphere and converting insoluble phosphorus into an accessible form. This increased availability of phosphorus promotes nitrogen fixation and the rate of photosynthesis, ultimately resulting in improved growth and eventually leading to an increase in trifoliate leaves Rajkhowa *et al*. (2003) and Patel *et al*. (2003).

3.4 Dry matter accumulation plant^{-1} (g)

Dry matter accumulation is a vital index indicating the crop's photosynthetic efficiency, ultimately influencing crop yield. The data on the effect of biofertilizer and fertility levels of mungbean on the dry matter accumulation recorded at 30, 60 DAS and harvest Table 5. At 30 DAS, significantly higher dry matter accumulation was observed (5.90 g) under (T_8) 100% RDF + soil application of liquid biofertiliser, which was statistically at par with treatment (T_{10}) 100% RDF + soil application of solid biofertiliser (5.74 g).

Moreover, treatment (T_6) 100% RDF + seed treatment with solid biofertiliser was found statistically at par with (T_4) 100% RDF + seed treatment with liquid biofertiliser- followed by treatment T_7, T_3 and T_2. However, the lowest dry matter accumulation (4.19) was observed under (T_1) control. A similar trend was noted under 60 DAS and at harvest. This biofertiliser may be due to biofertiliser with fertilizer because biofertiliser with fertilizer has played a pivotal role in facilitating the crops's efficient utilization. This, in turn, has led to robust vegetative growth in mungbean, leading to the maximum potential of solar radiation. Consequently, this solar energy has had favourable impact on the rate of photosynthesis, resulting in a greater significant accumulation of photosynthates and, ultimately, a substantial increase in dry matter accumulation Rajkhowa *et al.* (2003) and Qian *et al*. (2023).

Conclusions

When the soil was treated with liquid biofertiliser, biofertiliser showed a significant increase in the growth parameter of the plant mungbean (*Vigna radiata*). It is concluded that applying 100% RDF + soil application with liquid biofertiliser is the most efficient nutrient management to obtain better growth in the Mid-hills of Himachal Pradesh.

Table 2. Plant height (cm) of mungbean as influenced by biofertiliser and fertility levels at periodic intervals

Treatments	Plant height (cm)		
	30 DAS	**60 DAS**	**At harvest**
T_1: Control	17.16	41.74	44.69
T_2: 100% RDF	22.22	50.46	52.70
T_3: 75% RDF + Seed treatment with liquid biofertilizer	22.25	50.50	53.50
T_4: 100% RDF + Seed treatment with liquid biofertilizer	22.55	54.52	60.85
T_5: 75% RDF + Seed treatment with solid biofertilizer	19.69	50.01	52.01
T_6: 100% RDF + Seed treatment with solid biofertilizer	22.37	54.40	57.43
T_7: 75% RDF + Soil application of liquid biofertilizer	21.27	50.54	53.74
T_8: 100% RDF + Soil application with liquid biofertilizer	23.99	58.82	65.82
T_9: 75% RDF + Soil application of solid biofertilizer	20.37	50.42	52.47
T_{10}: 100% RDF + Soil application of solid biofertilizer	22.74	56.79	61.45
SEm±	0.39	1.34	1.64
LSD (p= 0.05)	1.16	3.97	4.86

Table 3. Number of total branches plant^{-1} of mungbean as influenced by biofertilizer and fertility levels at periodic intervals

Treatments	No of branches plant^{-1}	
	60 DAS	At harvest
T_1: Control	4.93	5.19
T_2: 100% RDF	6.04	6.17
T_3: 75% RDF + Seed treatment with liquid biofertilizer	6.06	6.21
T_4: 100% RDF + Seed treatment with liquid biofertilizer	6.77	6.99
T_5: 75% RDF + Seed treatment with solid biofertilizer	5.92	5.98
T_6: 100% RDF + Seed treatment with solid biofertilizer	6.70	6.78
T_7: 75% RDF + Soil application of liquid biofertilizer	6.08	6.22
T_8: 100% RDF + Soil application with liquid biofertilizer	7.53	7.76
T_9: 75% RDF + Soil application of solid biofertilizer	5.96	6.00
T_{10}: 100% RDF + Soil application of solid biofertilizer	7.27	7.50
SEm±	0.23	0.25
LSD (p= 0.05)	0.67	0.75

Table 4. Number of trifoliate leaves plant^{-1} of mungbean as influenced by biofertilizer and fertility levels at periodic intervals

Treatments	Trifoliate leaves plant^{-1}		
	30 DAS	**60 DAS**	**At harvest**
T_1: Control	2.80	7.24	7.12
T_2: 100% RDF	3.50	8.76	8.61
T_3: 75% RDF + Seed treatment with liquid biofertilizer	3.52	8.79	8.63
T_4: 100% RDF + Seed treatment with liquid biofertilizer	4.17	9.66	9.48
T_5: 75% RDF + Seed treatment with solid biofertilizer	3.07	8.41	8.39
T_6: 100% RDF + Seed treatment with solid biofertilizer	4.12	9.57	9.43
T_7: 75% RDF + Soil application of liquid biofertilizer	3.53	8.80	8.64
T_8: 100% RDF + Soil application with liquid biofertilizer	4.85	10.68	10.60
T_9: 75% RDF + Soil application of solid biofertilizer	3.42	8.63	8.47
T_{10}: 100% RDF + Soil application of solid biofertilizer	4.49	10.57	10.36
SEm ±	0.21	0.27	0.28
LSD (p= 0.05)	0.62	0.81	0.83

Table 5. Dry matter accumulation plant^{-1} (g) of mungbean as influenced by biofertilizer and fertility levels at periodic intervals

Treatments	Dry matter accumulation plant^{-1} (g)		
	30 DAS	**60 DAS**	**At harvest**
T_{1}: Control	4.19	8.24	10.94
T_{2}: 100% RDF	4.76	9.00	11.13
T_{3}: 75% RDF + Seed treatment with liquid biofertilizer	4.77	9.03	11.15
T_{4}: 100% RDF + Seed treatment with liquid biofertilizer	5.29	9.75	12.01
T_{5}: 75% RDF + Seed treatment with solid biofertilizer	4.44	8.38	11.06
T_{6}: 100% RDF + Seed treatment with solid biofertilizer	5.18	9.10	11.96
T_{7}: 75% RDF + Soil application of liquid biofertilizer	4.78	9.05	11.17
T_{8}: 100% RDF + Soil application with liquid biofertilizer	5.90	10.67	12.98
T_{9}: 75% RDF + Soil application of solid biofertilizer	4.51	8.41	11.05
T_{10}: 100% RDF + Soil application of solid biofertilizer	5.74	10.31	12.22
SEm±	0.20	0.23	0.28
LSD (*p*= 0.05)	0.58	0.68	0.83

References

1) Charles, Wesley, J. and Dawson, J. Influence of Biofertilizers and Gibberellic Acid on Growth and Yield of Blackgram (*Vigna mungo* L.). International Journal of Environment and Climate Change. 2023; 13(9):329-35.
2) Dai, J., Becquer, T., Rouiller, J.H., Reversat, G., Bernhard-Reversat, F. and Lavelle, P. Influence of heavy metals on C and N mineralisation and microbial biomass in Zn-, Pb-, Cu-, and Cd contaminated soils. Applied Soil Ecology, 2004; 25: 99-109.
3) Dixit, S. Impact of Bio-fertilization on morphological parameters of *Vigna mungo* (L.) Hepper: International Journal of Research in Plant Science. 2013; 3(1): 10-13.
4) El-Nagdy, G.A., Dalia M.A.N., Eman A., El-Kady. and Gelan, S.A. El-Yamanee. Response of flax plant (*Linum usitatissimum* L.) to treatments with mineral and biofertilizers from nitrogen and phosphorus. Journal American of Science 2010; 6: 207-217.
5) Ghanshyam, R.K. and Jat, R.K. Productivity and soil fertility as affected by organic manures and inorganic fertilizers in green gram (*Vigna radiata*)-Wheat (*Triticum aestivum*) system. Indian Journal of Agronomy. 2010; 55(1); 16-21.
6) Hussain, N.M., Medhi. and Kant R.H. Response of Nitrogen and Phosphorus on growth and yield attributes of black gram (*Vigna mungo* L.). Agricultural Science Research Journal. 2011; 2: 41–45.
7) Hussein, M.M.M. Response of some flax genotypes to biofertilizer and nitrogen fertilization. Zagazig Journal Agricultural Research. 2007; 34: 815-844.
8) Jat, S.L., Prasad, K. and Parihar, C.M. Effect of organic manuring on productivity and economics of summer mungbean (*Vigna radiata*). Annals of Agricultural Research New series. 2012; (1 & 2): 17-20.
9) Meena, R.S., Dhaka, Y., Bohra, J.S., Singh, S.P., Singh, M.K., Sanodiya, P. and Meena, H. Influence of Bioinorganic Combinations on Yield, Quality and Economics of Mung Bean. American Journal of Experimental Agriculture. 2015; 8(3): 159-166.
10) Mishra, D.J., Singh, R., Mishra, U.K. and Shahi, S. Kumar. Role of Bio-Fertilizer in Organic Agriculture: A Review; Research Journal of Recent Sciences. 2013; 2:239-41.
11) Pandey, O.P., Shahi, S.K., Dubey, A.N. and Maurya. S.K. Effect of integrated nutrient management of growth and yield attributes of green gram (*Vigna radiata* L.). Journal of

Pharmacognosy and Phytochemistry. 2019; 8 (3):2347- 2352.

12) Patel, J.J., Mevada, K.D. and Chotaliya, R.L. Response of summer mungbean to sowing dates and level of fertilizers. Indian Journal of Pulse Research. 2003; 16(2): 122-124.

13) Qian, L., Zakriya, M., Pervez, M., Waqar, I., Song, Z., Younis, U., Ahmed, N., Azeem, M., Alarfaj, A.A. and Hussain, M.I. Assessing the synergistic effect of acidified carbon, inorganic fertilizer, and biofertilizer on fenugreek antioxidant levels, and quality traits. Journal of King Saud University-Science. 2023; 1; 35(7):102848.

14) Rajkhowa, D.J., Saikia, M. and Rajkhowa, K.M. Effect of vermicompost with and without fertilization of green gram. Legume Research. 2003; 25: 295-296.

15) Rana, R. R. and Kapoor, P. Biofertilizers and Their Role in Agriculture. Popular Kheti. 2013; 1(1):56-61.

16) Shihab, M.A. and Alkurtany, A.K. Evaluation Effect of Inoculum Prepared from Local Bacterial Isolates of Rhizobium and Nitrogen Fertilization on some Growth Traits of Mung Bean Plant in Gypsiferous Soil. Kirkuk University Journal for Agricultural Sciences. 2023; 23:212-26.

17) Vessey, J.K. Plant growth promoting rhizobacteria as biofertilizers. Plant Soil. 2003; 255: 571-586.

18) Yadav, M., Yadav, S.S., Kumar, S., Yadav, K.H. and Tripura, P. Effect of Phosphorus and Bio-fertilizers on Yield, Nutrient Content and Uptake of Urban [*Vigna mungo* (L.) Hepper]. International Journal of Current Microbiology and Applied Science. 2017; 6(5): 2144-2151 2144.