Original Research Article

Effect of Biofertilizer and Fertility Levels on Growth Characters of Mungbeanunder Mid Hills of Himachal Pradesh

ABSTRACT

Biofertilizers tiny living organisms that can enrich the quality of the soil. These organisms have a positive impact on plant growth, making them healthier and more productive.One of the great things about biofertilizers is that they are environmentally friendly. Unlike some chemical fertilizers, they don't 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 long-term fertility of the soil. 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're looking to increase the productivity of your soil and do so in an environmentally friendly and cost-effective way, using biofertilizers is a smart choice. Present investigation titled Effect of Biofertilizer and Fertility Levels on Growth Characters of Mungbean under Mid-hills of Himachal Pradesh was conducted during *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 in reaction with EC in safe range, medium in organic carbon, available nitrogen, 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. Recommended dose of nitrogen, phosphorus and potassium (20:40:20 kg ha^{-1}) through urea, SSP and MOP at time of sowing. Biofertilizers applied for seed treatment is 10 ml kg^{-1} of seedand for the soil application take 10 g of solid biofertilizer for 1 kg $ha^{-1}$of seed and mixed 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 application of (T_8) 100% RDF + soil application of liquid biofertilizer and was on par with (T_{10}) 100% RDF + soil application of solid biofertilizer over 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, study suggests that mungbean can be successfully grown under Mid-hills of Himachal Pradesh on (T_8) 100% RDF + soil application of liquid biofertilizer.

Keywords: Biofertilizer, mungbean, growth, fertility

1.INTRODUCTION

At present, one of the major challengesfaced by agricultural researchers is finding ways to reduce the 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 not only expensive when used in large quantities but also pose a serious threat to the environment 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 and cost-effective solutions that can benefit both our environment and human well-being(Dai *et al.*, 2004).Biofertilizers, play a vital role in enhancing plant nutrition. They have the unique capability to 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 the use of chemical fertilizers.These help to reduce the dependency on chemical fertilizers, contributing to the cause of sustainable agriculture (Rana *et al.*,2013)When we talk about biofertilizers, we are essentially referring 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 have the remarkable ability to 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 greater population of these microorganisms. This acceleration of microbial processes serves to significantly enhance the availability of nutrients, ensuring that plants can efficiently assimilate them for increase the 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 not only fulfills its own nitrogen needs but also benefits subsequent crops. This ability to fix nitrogen plays a crucial role 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.The use of synthetic fertilizers has brought about a concerning situation, resulting in the pollution of our air, water, and soil. 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 the fertility of the soil.

In contrast, biofertilizers emerge as a sustainable and environmental friendly solution. They offer economic viability and contribute positively to the ecosystem over an extended period. 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 essentially microorganisms, such as bacteria, fungi and algal strains, that function differently from chemical fertilizers. Their key 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 results in increased crop yields without the environmental harm associated with chemical fertilizers, which disrupt the soil balance.

Agriculture holds immense importance in the Indian economy, driving growth and development. The adoption of eco-friendly practices like biofertilizers becomes even more critical, as they not only benefit farmers but also safeguard the environment upon which agriculture relies.In India, Mungbean, also known as moong or green gram, belongs to the Fabaceae family. These small, 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. Mungbean are not only cost-effective but also serve as a valuable source of protein, making them a staple in many diets.In light of these attributes, the aim of our experiment was to enhance the productivity of this crop. We sought to achieve this goal through the application of 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 the 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 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 soil of 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 time of sowing. The mungbean variety Pusa baisakhi was sown on 16th June, 2022 at a row spacing of 30 × 10 cm using seed rate of 12 kg ha^{-1} and Recommended dose of nitrogen, phosphorus and potassium (20:40:20 kg ha^{-1}) were 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 that 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 rest of the treatments at 30 DAS. This performance was at par with the application of (T_{10}) 100% RDF + soil application of solidbiofertilizer (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 same trend was followed at 60 DAS and at harvest.This might be due to the combined application ofbiofertilizer with fertilizer increased availability of major nutrients to plant due to enhanced early root growth and cell multiplication leading to more absorption of other nutrients from deeper layers of soil 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 present investigation due to increased nitrogenous activity and available phosphorus status of soil. Similar finding was reported by Yadav *et al*. (2017), Meena *et al.* (2015).

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

3.2Number of branches plant^{-1}

Data on the number of branches plant^{-1}at 60 DAS and at the time of harvest showed significant difference in Table 3. At 60 DAS, 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 application of (T_{10}) 100% RDF + soil application of solid biofertilizer (7.27plant^{-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 (4.93plant^{-1}) was observed under (T_1) control. Similar trend was noted under at harvest stage.This might be due to increase in number of branches plant$^{\mathbf{-1}}$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 presented by Hussain *et al*. (2011) and Jat *et al*. (2012)as they, reported substantial increase in total number of branches with biofertilizer application.

3.3 Number of trifoliate leaves plant^{-1}

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

The outcomes show a significant distinction between all treatments. At 30 DAS, 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. Similar trend was noted under 60 DAS and at harvest.This may be due to 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 ultimately leads to 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 an important index indicating the photosynthetic efficiency of the crop which ultimately influences the 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 at 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 biofertilizer which was statistically at par with treatment (T_{10}) 100% RDF + soil application of solid biofertilizer (5.74 g).

Moreover, treatment (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 dry matter accumulation (4.19) was observed under (T_1) control. Similar trend was noted under 60 DAS and at harvest.This might be due tothe presence of biofertilizer with fertilizer appears to have played a pivotal role in facilitating the crop's efficient utilization of the available nutrients. This in turn, has led to robust vegetative growth in mungbean, leads the maximum potential of solar radiation. Consequently, this utilization of solar energy has had a favorable impact on the rate of photosynthesis, resulting in a greater accumulation of photosynthates and ultimately, a substantial increase in dry matter accumulation Rajkhowa *et al.*(2003).

Conclusions

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

Table 2. Plant height (cm) of mungbean as influenced by biofertilizer 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$\pm$	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

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