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Studies on direct and residual effect of organic, inorganic and biofertilizers on growth of Mungbean

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Abstract
A field experiment entitled "Studies on Direct and Residual Effect of Organic, Inorganic and Biofertilizers on Mungbean" was conducted during the Kharif season of 2024 at Rama University, Kanpur, to evaluate the individual and interactive effects of fertilizers on growth, yield, soil fertility, and economics. The soil was sandy loam, neutral in pH, with high organic carbon and low to medium fertility. The experiment included 18 treatment combinations of three inorganic fertilizer levels (50%, 75%, and 100% RDF), two organic manure levels (control and FYM @ 5 t/ha), and three biofertilizers (Rhizobium, LNM-16, and Rhizobium + LNM-16), laid out in a factorial randomized block design with three replications using Pant Mung 5 variety. Application of 100% RDF significantly improved plant height, dry matter accumulation, growth indices, yield attributes, grain and biological yield, protein yield, and economic returns. FYM @ 5 t/ha enhanced chlorophyll content, nodule number, leaf area index, and nutrient uptake. Rhizobium + LNM-16 biofertilizer inoculation recorded maximum growth, yield, nutrient absorption, and profitability. While 1000-grain weight and protein content remained unaffected, grain yield and nutrient uptake increased significantly with integrated nutrient management. The mungbean-mustard cropping system showed higher productivity, profitability, and residual nutrient availability under 100% RDF, FYM @ 5 t/ha, and Rhizobium + LNM-16 treatments. Hence, integrated use of 100% RDF, FYM, and dual biofertilizer inoculation is recommended for sustainable mungbean cultivation and improved soil health. However, further multi-season research is necessary for broader recommendations.

Keywords: Mungbean, *Vigna radiata*, organic fertilizers, inorganic fertilizers

Introduction
India is the world's largest producer of pulses. A staple of the Indian cuisine, pulses provide over 30% of the daily required amount of protein. With a productivity of 817 kg/ha, India, the world's greatest producer and consumer of pulses, generated 23.2 million tons of pulses from 29.34 million hectares of land (Agriculture statistics 23-2024). There is almost little chance of expanding the land used for pulse growing in India.

One of the most significant and widely grown pulse crops is the green gram (*Vigna radiata* L.), sometimes referred to as the mung bean. Its excellent nutritional content, digestibility, and non-flatulent nature provide it an advantage over other pulses (Anjum *et al.*, 2016) [3]. Mungbean holds a significant position in a nutritious diet due to its high nutritional value (20-25% protein, 0.5-0.8% fat, 0.8-1.0% fiber, and 2.5-4.0% ash). With a production and productivity of 2.01 million tons and 467 kg/ha, respectively, mung beans are grown on over 20.35 lakh hectares in India, accounting for 9.41% of all pulse production (Agriculture statistics 23-2024).

As a pulse crop, mungbean uses less fertilizer and can fix around 35 kg/ha of atmospheric nitrogen through Rhizobium bacteria. Since it occurs in pulse crops following nodulation, fertilizers are necessary to provide these crops with nutrients during the early stages of development so that seedlings may establish themselves healthily (Maurya *et al*. 2023 and Pal *et al*. 2024) [9, 12]. Fertilizer is a vital source of nutrients, but excessive and ongoing use of chemical fertilizers lowers crop yields and has a number of negative effects on the environment and soil health. To reduce these negative effects of chemical fertilizers, integrated nutrient management of all available sources should be used (Pal *et al*. 2023) [11].

One of these crucial sources is organic manures, which provide major nutrients as well as organic matter, minerals, vitamins, and micronutrients. Compost and farm yard manures (FYM) are examples of organic manures that have long been used as inputs to maintain soil fertility and improve the physical, chemical, and biological characteristics of soil, which has led to yield stability (Ranpariya *et al.*, 2017) [13]. In addition to improving the physical and biological qualities of soil, FYM increases the efficiency of nutrient use when combined with inorganic fertilizer (Shete *et al.*, 2010; Sharif *et al.*, 2023) [15, 14].

In addition to organic manures, microbial fertilizers, or biofertilizers, also help manage nutrients in an environmentally friendly way (Mia and Shamsuddin, 2010) [10]. Along with a number of other benefits, these help legume crops grow their roots more effectively and improve the plant's capacity to fix nitrogen. In addition to partially replacing mineral fertilizers, FYM and biofertilizers are crucial for increasing the soil's organic matter content, which raises soil productivity and yield (Sutaria*et al.*, 2010) [16].

Methods and Materials

A field experiment was conducted during Kharif season of 2024-25 on loamy sand of in the rural area of Kanpur district of Mandhana, located 10 km from Kanpur in Uttar Pradesh to Studies on Direct and Residual Effect of Organic, Inorganic and Biofertilizers on Mungbean. The soil was normal in pH of 7.65, electrical conductivity (EC) of 0.27 dSm-1, organic carbon content of 0.41%, and available nutrients including nitrogen (N), phosphorus (P), and potassium (K) at levels of 217.0, 19.5, and 149.50 kg ha-1, respectively. The experiment was laid out during Rabi season of 2024-25.The experiment included 18 treatment combinations of three inorganic fertilizer levels (50%, 75%, and 100% RDF), two organic manure levels (control and FYM @ 5 t/ha), and three biofertilizers (Rhizobium, LNM-16, and Rhizobium + LNM-16), laid out in a factorial randomized block design with three replications using Pant Mung 5 variety. Data were gathered on five plants chosen from each plot.

Results

Growth Characters

1. Plant height (cm)

Table 1 presents the data on plant heights in mungbean as impacted by various inorganic fertilizers, organic manure, and biofertilizers at different phases of crop growth.

Generally speaking, as crop age rose, plant height climbed steadily and reached its maximum value at the maturity stage. The difference in nutrient treatments by different inorganic fertilizers, organic manure, and biofertilizers at different crop growth phases had a substantial impact on plant height. When 100% RDF was applied to inorganic fertilizers, the tallest plants—36.3, 83.0, and 90.5 cm—were seen at 30 and 60 DAS and harvest phases of crop growth. At 30 and 60 DAS and harvest phases of crop growth, respectively, 50% RDF was applied to the shortest plants, measuring 29.7, 77.1, and 83.9 cm. When FYM @ 5 t/ha was applied, the plants were noticeably taller than the control, measuring 34.6, 80.1, and 87.3 cm at 30 and 60 DAS and harvest phases of crop development, respectively. Rhizobium + LNM-16 seed inoculation produced the tallest plants, measuring 34.6, 80.7, and 84.6 cm at 30 and 60 DAS and harvest stages of crop development, respectively. The treatment that just applied LNM-16 and Rhizobium, however, was statistically equivalent to one another. In terms of plant height, there was no significant interaction between inorganic fertilizers and organic manure, inorganic fertilizers and biofertilizers, organic manure and biofertilizers, and inorganic fertilizers and organic manure and biofertilizers. Similar result reported by Abrol *et al*, (2017) [1], Bairwa *et al*, (2014) [5].

2. Dry matter accumulation

Table 2 displays information on the dry matter accumulation per mungbean plant as impacted by various inorganic fertilizers, organic manure, and biofertilizers during different phases of crop growth.

The outcome demonstrates that as crop age rose, the amount of dry matter accumulated by individual plants increased steadily and peaked at maturity. At every stage of crop growth, the planted crop showed more dry matter accumulation per plant. The use of different inorganic fertilizers, organic manure, and biofertilizers at all phases of crop growth had a substantial impact on the dry matter accumulation per plant in mungbean. The application of 100% RDF produced the greatest dry matter of any inorganic fertilizer, weighing 14.63 and 15.02 grams per plant at 60 DAS and harvest phases of crop development, respectively. At 30 DAS, however, this treatment gathered about the same amount of plant dry matter as 75% and 50% RDF. 50% RDF treatment resulted in the lowest dry matter at every stage of crop growth, with the exception of 30 DAS. Applying FYM @ 5 t/ha to organic manures resulted in noticeably larger dry matter accumulations than the control, with 4.96, 14.29, and 14.82 g per plant at 30 and 60 DAS and harvest stages, respectively. In comparison to Rhizobium and LNM-16, the seed infected with Rhizobium+LNM-16 collected the largest dry matter, weighing 4.99, 14.16, and 14.69 g per plant at 30 DAS, 60 DAS, and harvest stages, respectively. Regarding dry matter accumulation by plant, the interaction effects of inorganic fertilizers and organic manure, inorganic fertilizers and biofertilizers, organic manure and biofertilizers, and inorganic fertilizers and organic manure and biofertilizers were not statistically significant. Similar result reported by Azadi *et al*, (2013) [4], Bhavya *et al*, (2018) [6].

3. Number of nodules

Table 3 shows the information on the number of nodules per plant as impacted by various inorganic fertilizers, organic manure, and biofertilizers.

As crop age rose, the number of nodules per plant increased as well, reaching a maximum at 45 DAS and a minimum at 30 DAS. Different inorganic fertilizers, organic manure, and biofertilizers had a substantial impact on the number of nodules. At both phases of crop growth, the number of nodules per plant dropped as the amount of inorganic fertilizer increased. When 50% RDF was applied, there were noticeably more nodules—29.6 and 42.3 at 30 and 45 DAS, respectively—than when 75% and 100% RDF were used. However, using 100% RDF resulted in the least amount of nodules, which were 23.3 and 34.3 at 30 and 45 DAS, respectively. When FYM @ 5 t per hectare was applied to organic manure, a noticeably greater number of nodules per plant—27.0 and 39.4 at 30 and 45 DAS, respectively—than with control was observed. Compared to seed inoculation with LNM-16 and Rhizobium, mungbean seeds infected with Rhizobium+LNM-16 showed a considerably larger number of nodules, 26.7 and 39.7 at 30 and 45 DAS, respectively. At 30 DAS, it was statistically equivalent to inoculating seeds with Rhizobium. Seed infected with LNM-16 showed the smallest number of nodules, 25.5 and 36.6 at 30 and 45 DAS, respectively, which remained statistically equivalent to Rhizobium. Regarding the number of nodules per plant, the interaction effects of inorganic fertilizers and organic manure, inorganic fertilizers and biofertilizers, organic manure and biofertilizers, and inorganic fertilizers, organic manure, and biofertilizers were not statistically significant. Similar result reported by Dhakal *et al*, (2015) [7], Ezung *et al*, (2020) [8].

Table 1: Plant height of mungbean as influenced by different inorganic fertilizers, organic manures and biofertilizers

Treatment	30 DAS	60 DAS	Harvest
50%RDF	29.7	77.1	83.9
75%RDF	33.2	77.8	85.0
100%RDF	36.3	83.0	90.5
S.Em±	0.7	0.4	0.6
CD at 5%	1.9	1.2	1.7
Control	31.5	78.5	85.7
FYM5t/ha	34.6	80.1	87.3
S.Em±	0.5	0.4	0.5
CD at 5%	1.5	1.0	1.4
Rhizobium	32.2	78.8	82.4
LNM-16	32.3	79.5	82.6
Rhizobium+LNM-16	34.6	80.7	84.6
S.Em±	0.7	0.4	0.6
CD at 5%	1.9	1.2	1.7

Table 2: Plant dry matter accumulation of mungbean as influenced by different inorganic fertilizers, organic manures and biofertilizers

Treatment	30 DAS	60 DAS	Harvest
50%RDF	4.70	13.55	13.96
75%RDF	4.83	13.87	14.66
100%RDF	4.94	14.63	15.02
S.Em±	0.05	0.07	0.07
CD at 5%	0.13	0.21	0.20
Control	4.69	13.75	14.26
FYM5t/ha	4.96	14.29	14.82
S.Em±	0.04	0.06	0.06
CD at 5%	0.11	0.17	0.16
Rhizobium	4.75	14.01	14.48
LNM-16	4.73	13.88	14.46
Rhizobium+LNM-16	4.99	14.16	14.69
S.Em±	0.05	0.07	0.07
CD at 5%	0.13	0.21	0.20

Table 3: Number of nodules in munbean as influenced by different inorganic fertilizers, organic manures and biofertilizers

Treatment	Number of nodules	
	30 DAS	45 DAS
Inorganic Fertilizers		
50%RDF	29.6	42.3
75%RDF	25.2	37.7
100%RDF	23.3	34.3
S.Em±	0.3	0.3
CD at 5%	0.9	0.9
Organic Manures		
Control	25.1	36.2
FYM5tper ha	27.0	39.4
S.Em±	0.3	0.3
CD at 5%	0.7	0.7
Biofertilizers		
Rhizobium	26.0	37.4
LNM-16	25.5	36.6
Rhizobium+LNM-16	26.7	39.7
S.Em±	0.3	0.3
CD at5%	0.9	0.9

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