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Effect of Different Sources of Nutrients on Growth, Yield and Quality of Mung Bean (*Vigna radiata* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A pot experiment was conducted in the experimental research farm of Department of Soil Science, SAS, Nagaland University, and Medziphema campus, Nagaland in the period of June to September 2022 to make a study on "Effect of different sources of nutrients on growth, yield and quality of mung bean (*Vigna radiata* L.). The experiment was laid out in Complete Randomized Design (CRD) with 12 treatments and 3 replications. The study revealed that the incorporation of different sources of nutrients significantly influenced that the plant growth, yield attributes and quality parameters i.e., NPK and protein content, Nutrient uptake, and availability of nutrients in soil after harvest of green gram. The crop growth attributes such as plant height, number of leaves plant^{-1} and number of branches plant^{-1} were significantly influenced by its application. The highest seed yield of 11.67 g pot^{-1}and stover yield of 37.88 g pot^{-1} recorded with the treatment of 100% RDF+PSB+FYM was significantly superior over all treatments. The quality of green gram was improved by 100% RDF+PSB+FYM in the presence of different sources of nutrients. The highest nutrient content and highest nutrient uptake by green gram was also recorded highest with the treatment 100%

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RDF+PSB+FYM. The available nutrients (NPK), cation exchange capacity, organic carbon, soil respiration, microbial biomass carbon in soil was also found to be more due to the treatment of 100% RDF+PSB+FYM.

Keywords: Mung bean; NPK fertilizer; FYM; PSB; growth; yield; quality; soil properties.

1. INTRODUCTION

Green gram, also known as mung bean or *Vigna radiata*, is a small, green, and cylindrical-shaped legume that is widely cultivated in various parts of the world, including India, China, and Southeast Asia. It is a highly nutritious and versatile crop that is used for both food and fodder purposes. The plant is known for its tolerance to different climatic conditions, and it is often grown in rotation with other crops to enhance soil fertility.

India is the largest producer of green gram and accounts 54 per cent of the world production and covers 65 per cent of the world acreage. Area under pulses in India is about 23.09 million hectares with total production of 17.20 million tones and productivity of 744 kg/ha, in this green gram crop is grown on an area is about 3.43 million hectares with total production of 1.8 million tonnes with productivity of 587 kg/ha [1].

Green gram is an important leguminous crop that requires adequate nutrients for optimal growth and yield. The three primary macronutrients required for plant growth are nitrogen (N), phosphorus (P), and potassium (K), collectively known as NPK. the source of NPK nutrients can significantly affect the growth, yield, and quality of green gram. Different sources of each macronutrient can have varying effects on crop performance. Therefore, it is important for farmers to carefully manage the application of NPK nutrients to ensure optimal growth, yield, and quality of green gram.

Nitrogen is a critical nutrient for the growth and development of green gram, and its availability can significantly affect yield and quality. Different sources of nitrogen fertilizer, including urea, ammonium sulphate and calcium ammonium nitrate, can have varying effects on green gram growth and yield. Studies have shown that the application of nitrogen fertilizer can significantly increase the yield of green gram [2].

Phosphorus is another essential nutrient for the growth and development of green gram. Different sources of phosphorus fertilizer, including single superphosphate and triple superphosphate, can have varying effects on green gram growth and yield. Research has shown that the application of phosphorus fertilizer can increase the yield and quality of green gram. Potassium is also an important nutrient for the growth and development of green gram. Different sources of potassium fertilizer, including muriate of potash and sulphate of potash, can have varying effects on green gram growth and yield. Studies have shown that the application of potassium fertilizer can increase the yield and quality of green gram [3].

Phosphate-solubilizing bacteria (PSB) biofertilizers are known to enhance the availability of phosphorus (P) in soil by solubilizing insoluble forms of P. This can lead to increased growth, yield, and quality of green gram, an important leguminous crop. PSB biofertilizers, including Bacillus spp., Pseudomonas spp., and Rhizobium spp., can significantly enhance the growth, yield, and quality of green gram. The application of these biofertilizers can increase the availability of P and N, leading to improved crop performance. Therefore, it is important for farmers to consider the use of PSB biofertilizers as a sustainable and environmentally friendly alternative to chemical fertilizers. Rhizobium spp. are nitrogen-fixing bacteria that can form symbiotic associations with leguminous plants, including green gram. Research has shown that the application of Rhizobium spp. biofertilizer can increase the growth, yield, and quality of green gram [4].

Farmyard manure (FYM) is a popular organic fertilizer used in agriculture. It is rich in essential nutrients like nitrogen (N), phosphorus (P), and potassium (K), and is known to improve soil health, leading to increased growth, yield, and quality of crops. FYM from different sources, including cow dung, poultry manure, and sheep manure, can significantly improve the growth, yield, and quality of green gram. The application of these organic fertilizers can improve soil health, leading to improved crop performance. Therefore, it is important for farmers to consider the use of FYM as a sustainable and environmentally friendly alternative to chemical fertilizers. Cow dung FYM is one of the most commonly used sources of organic fertilizer in agriculture. It is rich in nutrients like N, P, and K, as well as micronutrients like zinc, copper, and iron. Research has shown that the application of cow dung FYM can significantly improve the growth, yield, and quality of green gram [5].

The concept of integrated nutrient management has greater significance in the recent years because of continuous increase in agricultural production and productivity requires high amount of plant nutrients and the production of these nutrients are not adequate in India as per its demand. Secondly, the high input cost and indiscriminate use of fertilizers for intensive agriculture results in net economic loss as well as soil health deterioration. The importance of combating environmental degradation on one hand and quality concern of the produce on the other has lead to change in the system of nutrient management in crops.

Green gram plays an important role in the economy of Nagaland. It is an important source of protein for the people of the state and is also an important cash crop for farmers. Green gram is mainly cultivated in the rainfed areas of the state, and its cultivation provides employment opportunities for farmers throughout the year. Green gram is one of the major pulse crops grown in Nagaland. According to the Directorate of Economics and Statistics, Nagaland, the total area under green gram cultivation in the state during the 2020-2021 season was 500 hectares with a production of 500 metric tonnes ha^{-1}. The productivity of green gram in Nagaland is around 1014 kg ha^{-1} [6] .

2. MATERIALS AND METHODS

The research-based pot experiment entitled “Effect of different sources of nutrients on growth, yield and quality of mung bean (*Vigna radiata* L.)” was performed in the experimental research farm of Department of Soil Science, SAS, Medziphema campus, Nagaland University, during kharif season of 2022. The materials used in the experiment and methodology details have been described in this chapter.

2.1 Site of Experiment

The experiment was performed in the experimental research farm of Department of Soil Science, SAS, Medziphema campus, Nagaland University. It is situated at an altitude of 305m above mean sea level with the geographical location of 25^0 45’ 43” N latitude and 93^o 53’ 04” E longitudes at an elevation of 310m above mean sea level.

2.2 Climatic Condition

The hills of medziphema lies in the sub-humid tropical region with high relative humidity (70-80%) and having moderate to high rainfall (2000-3000mm). The mean temperature ranges from 21^{0}C to 30^{0}C during summer and rarely goes below 8^{0}C in winter season.

2.3 Characteristics of the Experimental Soil

The texture of the soil used for the experiment was sandy loam in nature. The composite soil sample used for the experiment was collected from the Horticultural farm, SAS, Nagaland University. The soil collected from the surface soil (0-15cm depth) using soil auger was used for filling the pots. The soil sample was then analyzed for the physico-chemical properties.

2.4 Experimental Details

2.4.1 Design and experimental details

The experiment was laid out with CRD (Complete Randomized Design). There were 12 treatments with 3 replications. So, the total number of pots taken was equal to 36. The pots were arranged in three blocks in which each block contains 12 pots.

Table 1. Treatment details

Treatments	Details
T_1	T_1: control
T_2	T_2: 100%RDF
T_3	T_3: 100%RDF+PSB
T_4	T_4: 100%RDF+FYM
T_5	T_5: 100%RDF+PSB+FYM
T_6	T_6: 75%RDF+PSB
T_7	T_7: 75%RDF+FYM
T_8	T_8: 75%RDF+PSB+FYM
T_9	T_9: 50%RDF+PSB
T_{10}	T_{10}: 50%RDF+FYM
T_{11}	T_{11}: 50%RDF+PSB+FYM
T_{12}	T_{12}: 125%RDF

(Recommended dose of fertilizer=20:40:20: N: P_2O_5: K_2O)
(Recommended dose of Phosphorous Solubilising Bacteria =12 kg ha^{-1})
(Recommended dose of FYM= 2 t ha^{-1})

Design and layout:

Crop	: Mung Bean
Variety	: IU421
Experimental design	: CRD (Complete Randomized Design)
Number of replications	: 03
Number of treatments	: 12
Total number of pots	: 36
Weight of soil in each pot	: 10kg

Treatment details: There was 12 treatments

3. RESULTS AND DISCUSSION

The research-based pot experiment entitled "Effect of different sources of nutrients on growth, yield and quality of mung bean (*Vigna radiata* L.)" was performed in the experimental research farm of Department of Soil Science, SAS, medziphema campus, Nagaland university, during the kharif season of 2022.

3.1 Growth Parameters

3.1.1 Plant height (cm)

The data recorded in Table 2. It is evident from the data that the plant height increased significantly at different stage of crop growth over the control. At 25 DAS plant height was ranged from 15.53cm to 23.73cm. The maximum plant height was recorded with the treatment T_5{100%RDF+PSB+FYM} (23.73) which was at par with treatments T_{12} (23.03cm), T_4 (22.86cm), T_3 (22.50cm), T_2 (22cm), respectively. The lowest plant height was recorded with the T_1 control (15.53cm).

At 50 DAS plant height was found ranged from 36.73cm to 55.33cm. The plant height was recorded the maximum (55.33cm) with T_5 {100%RDF+PSB+FYM} which was at par with treatments T_{12} (54.16cm), T_4 (53.83cm), T_3 (53.50cm), T_2 (53.16cm), T_8 (52.60cm) respectively. The lowest plant height was recorded with the T_1 control (36.73cm).

At harvest plant height was ranged from 40.66cm to 63.46cm. The plant height was recorded the maximum (63.46cm) with T_5 {100%RDF+PSB+FYM} which was at par with treatments T_{12} (63.10cm), T_4 (62.80cm), T_3 (62.53cm), T_2 (62.26cm), T_8 (61.90cm), T_7 (60.80cm), T_6 (60.16cm), T_{11} (60.70cm), T_{10} (60.03cm), T_9 (59.50cm) respectively. The lowest plant height was recorded with the T_1 control (40.66cm).

It indicated from the data that application of NPK, FYM and bio-fertilizer in combinations significantly increased the plant height as compared to control. Amongst all the treatments, application of treatment T_5 (100%RDF+PSB+FYM) recorded the highest plant height. Balance application of NPK, FYM and PSB enhance the cell division, cell multiplication and tissue differentiation, which ultimately increase the plant height. Similar findings were notified by Singh et al. [7], Abraham et al., [8] and Barkha et al. [9].

3.1.2 Number of branches plant^{-1}

The data recorded in Table 2. It is evident from the data that the number of branches plant^{-1} increased significantly at different stage of crop growth over control. At 25 DAS number of branches plant^{-1} was ranged from 2.33 to 6.33. The number of branches plant^{-1} was recorded the maximum (6.33) with T_5 {100%RDF+PSB+FYM} which was at par with treatments T_{12} (6), T_4 (5.66), T_3 (5.33), respectively. The lowest number of branches plant^{-1}was recorded with the T_1 control (2.33).

At 50 DAS number of branches plant^{-1} was found from 8.33 to 12.33. The number of branches plant^{-1} was recorded the maximum (12.33) with T_5{100%RDF+PSB+FYM} which was at par with treatments T_{12} (12), T_4 (11.66), T_3 (11.33), T_2 (11), T_8 (10.66), respectively. The lowest number of branches plant^{-1} was recorded with the T_1 control (8.33).

At harvest number of branches plant^{-1} was found from 10.33 to 20. The number of branches plant^{-1} was recorded the maximum (20) was T_5 {100%RDF+PSB+FYM} which was at par with treatments T_{12} (19.66) respectively. The lowest number of branches plant^{-1} was recorded with the T_1 control (10.33).

It was noted from the data that the effect of NPK, FYM and PSB levels on number of branches plant^{-1} was significantly increased. Treatment T_5 (100%RDF+PSB+FYM) recorded significantly higher number of branches plant^{-1}. This might be due to higher uptake of nutrients by plants. When balance nutrients are applied in soil, then availability increases and therefore, leads to proper growth and development. Similar findings were notified by Bhattacharya et al. [10] and Patel et al. [11].

3.2 Yield and Yield Attributes

3.2.1 Pod length cm^{-1}

The data recorded in Table 3 revealed that increasing levels of RDF significantly increased the pod length over the control. The pod length cm^{-1} was recorded the maximum (9.03cm) with T_5 {100%RDF+PSB+FYM} which was at par treatments T_{12} (8.60 cm), T_4 (8.53 cm), respectively. The lowest pod length cm^{-1} was recorded with the T_1 (5.46 cm) without any application of nutrients in control.

It was concluded from the result that application of nutrients @100%RDF+PSB+FYM, provides the highest pod length per cm in comparison to other treatments. This may be due to the with higher level of nutrients 100%RDF+PSB+FYM increases the nodulation in the roots of green gram with the help of nutrients which produces profuse root. This leads to enhanced availability of phosphorus. Similar findings were notified by Gadi et al., [12] and Akter et al.,[13].

3.2.2 Number of pods $plant^{-1}$

The data recorded in Table 3 revealed that increasing levels of RDF significantly increased the number of pods $plant^{-1}$ over the control. The number of pods $plant^{-1}$ was recorded the maximum (10.33) with T_5 {100%RDF+ PSB+FYM} which was at par treatment T_{12} (10), T_4 (9.67), T_3 (9.33), T_2 (9), respectively. The lowest number of pods $plant^{-1}$ was recorded with the T_1 (3.66) without any application of nutrients in control.

It was clearly identified from the result that application of NPK, FYM and PSB bio-fertilizer provides the highest number of pods per plant in comparison to other treatments. This is due to application of PSB increases the phosphorus availability through solubilising the insoluble phosphate present in the soil. As phosphorus plays an important role in nutritional status of plant by increasing the nitrogen fixing ability as well as photosynthetic activity. Also phosphorus acts as a beneficiary element which helps to increase the root growth and there by enhancement in renewable of nitrogen by the crop. Similar findings were notified by Ali et al., [14].

3.2.3 Number of seeds pod^{-1}

The data recorded in Table 3 revealed that increasing levels of RDF significantly increased the number of seeds pod^{-1} over the control. The number of seeds pod^{-1} was recorded the maximum (12.33) with T_5 {100%RDF+ PSB+FYM} which was at par treatment T_{12} (12), T_4 (11.66), respectively. The lowest number of seeds pod^{-1} was recorded with the T_1 (7) without any application of nutrients in control.

Table 2. Effect of different sources of nutrients on growth attributes of green gram

Treatments	Plant height (cm)			Number of branches $plant^{-1}$		
	25 DAS	50 DAS	AT harvest	25 DAS	50 DAS	AT Harvest
T_1: control	15.53	36.73	40.66	2.33	8.33	10.33
T_2: 100%RDF	22.00	53.16	62.26	5.00	11.00	18.00
T_3: 100%RDF+PSB	22.50	53.50	62.53	5.33	11.33	18.33
T_4: 100%RDF+FYM	22.86	53.83	62.80	5.66	11.66	19.00
T_5: 100%RDF+PSB+FYM	23.73	55.33	63.46	6.33	12.33	20.00
T_6: 75%RDF+PSB	20.20	51.26	60.16	4.00	10.00	17.00
T_7: 75%RDF+FYM	20.70	51.60	60.80	4.33	10.33	17.33
T_8: 75%RDF+PSB+FYM	21.83	52.60	61.90	4.66	10.66	17.66
T_9: 50%RDF+PSB	19.93	50.80	59.50	3.00	9.00	16.00
T_{10}: 50%RDF+FYM	20.03	51.06	60.03	3.33	9.33	16.33
T_{11}: 50%RDF+PSB+FYM	20.60	51.70	60.70	3.66	9.66	16.66
T_{12}: 125%RDF	23.03	54.16	63.10	6.00	12.00	19.66
SEm±	0.623	1.124	1.735	0.36	0.569	0.255
CD (P = 0.05)	1.828	3.30	5.094	1.057	1.671	0.748

It was evident from the result that application of treatment T_5 100%RDF+PSB+FYM recorded significantly highest number of seeds pod^{-1}. It is because application of FYM to green gram improves overall fertility status of the soil. The favorable effect of higher dose of fertilizers on sink component could be attributed to better development of the plants in terms of plant height and dry matter production leading to increasing bearing capacity due to optimum growth. Similar findings were notified by Bera et al. [15] and Muindi et al. [16].

3.2.4 Seed yield g pot^{-1}

The data recorded in Table 3 revealed that increasing levels of RDF significantly increased theseed yield pot^{-1} over the control. The seed yield g pot^{-1} was recorded the maximum (11.67) with T_5 {100%RDF+PSB+FYM} which was at par treatment T_{12} (10.89) respectively. The seed yield g pot^{-1} was recorded with the T_1 (5.04) without any application of nutrients in control.

It was evident from the result that seed yield was significantly influenced due to different nutrient management levels. Amongst all the nutrient management treatments, application of 100%RDF+PSB+FYM gave significantly highest. Increase in grain yield with combined use of organic and inorganic fertilizer might be due to improvement in overall fertility status of the soil and vigorous plant growth might have produced more photosynthesis. Efficient partitioning of accumulated photosynthesis enhanced yield attributes which ultimately increased the seed yield. Similar findings were notified by Padbhushan et al., [17] and Rao et al., [18].

3.2.5 Stover yield g pot^{-1}

The data recorded in Table 3 revealed that increasing levels of RDF significantly increased the stover yield pot^{-1} over the control. The stover yield g pot^{-1} was recorded the maximum (37.88) with T_5 {100%RDF+PSB+FYM} which was at par treatment T_{12} (36.89) respectively. The stover yield g pot^{-1} was recorded with the T_1 (31.04) without any application of nutrients in control.

It was evident from the result that with the increasing levels of nutrients application, stover yield increased significantly. But it can be clearly identified from the data, stover yield increases with the increasing level of nutrients. This may be due to increasing level of biomass, nodule number and chlorophyll content as phosphorus plays an important role in extensive root development and nourishment of water and nutrients from deeper layer of soil. Similar findings were notified by Bhat et al., [19] and Yadav et al., [20].

3.2.6 Harvest index

The data recorded in Table 3 revealed that increasing levels of RDF significantly increased the harvest index over the control. The harvest index was recorded the maximum (23.54) with T_5 {100%RDF+PSB+FYM} which was at par treatment T_{12} (22.79), T_4 (21.81), T_3 (21.60), respectively. The harvest index was recorded with the T_1 (13.97) without any application of nutrients in control.

It was evident from the result that integration of organic and inorganic source of nutrients significantly increased harvest index as compared to control. It was also found that integration of organic manure, bio-fertilizer, and chemical fertilizer T_5 (100%RDF+PSB+FYM) significantly superior as compared to all the other treatments. Similar findings were notified by Dhakal et al., [21] and Shakila devi et al. [22].

3.3 Nutrient (N, P, K) Content

3.3.1 Nitrogen content (%) in seed and stover

The nitrogen content of the seed and stover shown in Table 4. The maximum N content in seed was found in treatment T_5 {100% RDF+PSB+FYM} (3.96), and the lowest was found in treatment T_1 control (2.42), which was at par with the treatment T_{12} (3.82).

The maximum nitrogen content in stover was recorded as in treatment T_5 {100% RDF+PSB+FYM} (2.89) and followed by T_{12} (2.75), T_4 (2.61), which was at par with the treatment T5 and lowest was recorded in control T_1 is 1.77.

In seed and stover of the green gram at a particular level of nutrient application, 100% RDF+PSB+FYM recorded highest nitrogen content over all other treatments. It shows that PSB plays a significant role in increasing the nitrogen content in both seed and stover of green gram. So, it can be concluded that phosphorus promotes profuse root growth which helps to absorb the nutrients from deeper layers. PSB helps to solubilize the unavailable phosphate in the soil by secreting the organic acid with the help of chelating. This finding is in conformity with the findings of Pandey et al., [23]

Table 3. Effect of different sources of nutrients on yield attributes of green gram

Treatments	Pod length per cm	No. of pods per plant	No. of seeds per pod	Seed yield (g pot^{-1})	Stover yield (g pot-^{1})	Harvest index (%)
T_1: control	5.46	3.66	7.00	5.04	31.04	13.97
T_2: 100%RDF	8.00	9.00	11.00	9.43	35.43	21.01
T_3: 100%RDF+PSB	8.30	9.33	11.33	9.91	35.90	21.60
T_4: 100%RDF+FYM	8.53	9.67	11.66	10.05	36.03	21.81
T_5: 100%RDF+PSB+FYM	9.03	10.33	12.33	11.67	37.88	23.54
T_6: 75%RDF+PSB	7.00	8.00	10.00	8.36	34.36	19.55
T_7: 75%RDF+FYM	7.26	8.33	10.33	8.59	34.59	19.88
T_8: 75%RDF+PSB+FYM	7.70	8.66	10.66	9.05	35.06	20.51
T_9: 50%RDF+PSB	6.00	7.00	9.00	6.23	32.26	16.16
T_{10}: 50%RDF+FYM	6.30	7.33	9.33	6.71	32.71	17.02
T_{11}: 50%RDF+PSB+FYM	6.60	7.66	9.66	7.68	33.68	18.56
T_{12}: 125%RDF	8.60	10.00	12.00	10.89	36.89	22.79
SEm±	0.211	0.544	0.304	0.366	0.355	0.758
CD (P = 0.05)	0.62	1.598	0.893	1.076	1.042	2.225

3.3.2 Phosphorus content (%) in seed and stover

The phosphorus content of the seed and stover shown in Table 4. The maximum phosphorus content in seed was found to be (1.85) in T_5 {100% RDF+PSB+FYM} and the lowest was found to be (1.39) in control T_1, which was at par with the treatment T_{12} (1.79).

The maximum phosphorus content in stover was identified in treatment T_5 {100% RDF+PSB+FYM} (0.79) and followed by T_{12} (0.78), T_3 (0.77), T_4 (0.76), T_2 (0.74), T_8 (0.722), T_6 (0.710), and lowest was recorded in control T_1 is (0.57).

It was clearly identified from the result that at a particular level of nutrient application integration of organic and inorganic source of nutrients recorded highest phosphorus content in stover and seed when compared to over all other treatments. PSB helps to solubilise the unavailable phosphate in the soil by secreting the organic acid with the help of chelating. It shows that PSB plays a significant role in increasing the phosphorus content in both seed and stover of green gram. This finding is in conformity with the findings of Singh et al., [7].

3.3.3 Potassium content (%) in seed and stover

The potassium content of the seed and stover shown in Table 4. The maximum potassium content in seed was found to be (1.95) in T_5, and the lowest was found to be (1.54) in control T_1, which was at par with the treatment T_{12} (1.92), T_4 (1.89).

The maximum potassium content in stover was identified in treatment T_5 {100% RDF+PSB+FYM} (1.72) and followed by T_{12} (1.69), T_4 (1.66), T_3 (1.64), and lowest was recorded in control T_1 is (1.31).

It was evident from the result that application of 100% RDF+PSB+FYM recorded highest potassium content over all other treatments. This may be the reason for more nutrient availability which ultimately helps in better utilization and absorption of plant nutrient by crop with the increased root nodulation through better root development. This finding is in conformity with the findings of Rekha et al., [24].

3.4 Nutrient Uptake (N, P, and k) by Green Gram Seed and Stover

3.4.1 Nitrogen uptake g pot^{-1}

The data pertaining to the different sources of nutrients on N uptake by seed and stover is presented in the Table 5. From the data it is observed that N uptake by stover and seed increased significantly over the control. The maximum N uptake in seed was found in treatment T_5 {100% RDF+PSB+FYM} (0.46), and the lowest was found in treatment T_1 control (0.12), which was at par with the treatment T_{12} (0.41).

Table 4. Effect of different sources of nutrients on Nutrient content of seed and stover of green gram

Treatments	Nutrient content of seed (%)			Nutrient content of stover (%)		
	N	P	K	N	P	K
T_1: control	2.427	1.396	1.310	1.773	0.572	1.540
T_2: 100%RDF	3.500	1.693	1.630	2.427	0.740	1.860
T_3: 100%RDF+PSB	3.640	1.771	1.640	2.520	0.772	1.870
T_4: 100%RDF+FYM	3.687	1.725	1.663	2.613	0.763	1.893
T_5: 100%RDF+PSB+FYM	3.967	1.859	1.720	2.893	0.795	1.950
T_6: 75%RDF+PSB	3.313	1.617	1.593	2.287	0.710	1.823
T_7: 75%RDF+FYM	3.360	1.571	1.603	2.333	0.684	1.833
T_8: 75%RDF+PSB+FYM	3.407	1.649	1.620	2.380	0.722	1.850
T_9: 50%RDF+PSB	3.127	1.485	1.550	2.100	0.640	1.780
T_{10}: 50%RDF+FYM	3.220	1.459	1.567	2.193	0.620	1.797
T_{11}: 50%RDF+PSB+FYM	3.267	1.539	1.587	2.240	0.670	1.817
T_{12}: 125%RDF	3.827	1.795	1.693	2.753	0.782	1.923
SEm±	0.086	0.030	0.029	0.109	0.032	0.022
CD (P = 0.05)	0.253	0.088	0.085	0.319	0.094	0.065

The maximum nitrogen uptake in stover was recorded as in treatment T_5 {100% RDF+PSB+FYM} (1.10) and followed by T_{12} (1.01), which was at par with the treatment T_5 and lowest was recorded in control T_1 is 0.55.

It was evident from the result that, with application of 100% RDF+PSB+FYM significantly increased the nitrogen uptake over lower levels of nutrient application. From the above analysis we can conclude that application of 100% RDF+PSB+FYM significantly increase the nitrogen uptake in seed and stover of green gram. The similar finding was reported by Pandey et al., [23].

3.4.2 Phosphorus uptake g pot^{-1}

The data recorded to the different sources of nutrients on Phosphorus uptake by seed and stover is presented in the Table 5. From the data it is observed that Phosphorus uptake by seed and stover increased significantly over the control. The maximum P uptake in seed was found in treatment T_5 {100% RDF+PSB+FYM} (0.217), and the lowest was found in treatment T_1 control (0.071), which was at par with the treatment T_{12} (0.196).

The maximum Phosphorus uptake in stover was recorded as in treatment T_5 {100% RDF+PSB+FYM} (0.302) and followed by T_{12} (0.289), T_3 (0.277), T_4 (0.275), which was at par with the treatment T_5 and lowest was recorded in control T_1 is 0.178.

In seed and stover of the green gram at a particular level of nutrient application, 100% RDF+PSB+FYM recorded highest phosphorus uptake over all other treatments. It shows that PSB plays a significant role in increasing the phosphorus content in both seed and stover of green gram. From the above analysis we can conclude that application of 100% RDF+PSB+FYM significantly increase the phosphorus uptake in seed and stover of green gram. The similar finding was reported by Singh et al., [7].

3.4.3 Potassium uptake g pot^{-1}

The data identified to the different sources of nutrients on Potassium uptake by seed and stover is presented in the Table 5. From the data it is observed that Potassium uptake by seed and stover increased significantly over the control. The maximum K uptake in seed was found in treatment T_5 {100% RDF+PSB+FYM} (0.201), and the lowest was found in treatment T_1 control (0.066), which was at par with the treatment T_{12} (0.184).

The maximum potassium uptake in stover was recorded as in treatment T_5

{100% RDF+PSB+FYM} (0.738) and followed by T_{12} (0.710), which was at par with the treatment T_5 and lowest was recorded in control T_1 is (0.478).

It was evident from the that application of 100% RDF+PSB+FYM significantly increased the potassium uptake over lower levels of nutrient application. From the above analysis we can conclude that application of 100% RDF+PSB+FYM significantly increase the potassium uptake in seed and stover of green gram The similar finding was reported by Rekha et al., [24].

3.4.4 Total nitrogen uptake g pot^{-1}

The data pertaining to the different sources of nutrients on N uptake by plant is presented in the Table 6. From the data it is observed that N uptake by plant increased significantly over the control. The maximum N uptake in plant was found in treatment T_5 {100% RDF+PSB+FYM} (1.563), and the lowest was found in treatment T_1 control (0.673), which was at par with the treatment T_{12} (1.433).

It was evident from the result that, with application of 100% RDF+PSB+FYM significantly increased the nitrogen uptake over lower levels of nutrient application. From the above analysis we can conclude that application of 100% RDF+PSB+FYM significantly increase the nitrogen uptake in plant of green gram. The similar finding was reported by Pandey et al., [23].

3.4.5 Total phosphorus uptake g pot^{-1}

The data recorded to the different sources of nutrients on Phosphorus uptake by plant is presented in the Table 6. From the data it is observed that Phosphorus uptake by plant increased significantly over the control. The maximum P uptake in plant was found in treatment T_5 {100% RDF+PSB+FYM} (0.519), and the lowest was found in treatment T_1 control (0.248), which was at par with the treatment T_{12} (0.484).

In of the green gram at a particular level of nutrient application, 100% RDF+PSB+FYM recorded highest phosphorus uptake over all other treatments. It shows that PSB plays a significant role in increasing the phosphorus content in both seed and stover of green gram. From the above analysis we can conclude that application of 100% RDF+PSB+FYM significantly increase the phosphorus uptake in plant of green gram. The similar finding was reported by Singh et al., [7].

3.4.6 Total potassium uptake g pot^{-1}

The data identified to the different sources of nutrients on Potassium uptake by plant is presented in the Table 6. From the data it is observed that Potassium uptake by plant increased significantly over the control. The maximum K uptake in plant was found in treatment T_5 {100% RDF+PSB+FYM} (0.939), and the lowest was found in treatment T_1 control (0.544), which was at par with the treatment T_{12} (0.894).

Table 5. Effect of different sources of nutrients on Nutrient uptake in stover and seed of green gram

Treatments	Nutrient uptake of seed (g pot^{-1})			Nutrient uptake of stover (g pot^{-1})		
	N	**P**	**K**	**N**	**P**	**K**
T_1: control	0.123	0.071	0.066	0.550	0.178	0.478
T_2: 100%RDF	0.331	0.160	0.154	0.860	0.262	0.659
T_3: 100%RDF+PSB	0.360	0.175	0.162	0.905	0.277	0.671
T_4: 100%RDF+FYM	0.371	0.174	0.167	0.942	0.275	0.682
T_5: 100%RDF+PSB+FYM	0.464	0.217	0.201	1.100	0.302	0.738
T_6: 75%RDF+PSB	0.278	0.135	0.133	0.786	0.244	0.627
T_7: 75%RDF+FYM	0.289	0.135	0.138	0.807	0.237	0.634
T_8: 75%RDF+PSB+FYM	0.308	0.149	0.147	0.834	0.253	0.649
T_9: 50%RDF+PSB	0.195	0.093	0.096	0.677	0.207	0.574
T_{10}: 50%RDF+FYM	0.216	0.098	0.105	0.718	0.203	0.588
T_{11}: 50%RDF+PSB+FYM	0.251	0.118	0.122	0.754	0.225	0.612
T_{12}: 125%RDF	0.417	0.196	0.184	1.016	0.289	0.710
SEm±	0.016	0.008	0.008	0.044	0.012	0.019
CD (P = 0.05)	0.048	0.023	0.024	0.128	0.036	0.055

Total Nutrient uptake (N, P, and k) by plant

It was evident from the that application of 100% RDF+PSB+FYM significantly increased the potassium uptake over lower levels of nutrient application. From the above analysis we can conclude that application of 100% RDF+PSB+FYM significantly increase the potassium uptake in plant of green gram The similar finding was reported by Rekha et al., [24].

3.5 Quality Parameters

3.5.1 Protein content (%)

The data recorded in the Table 7 revealed the effect of different sources of nutrients for seed protein content has showed significant. The maximum protein content in seed was found in treatment T_5 {100% RDF+PSB+FYM} (24.79), and the lowest was found in treatment T_1 control (15.16), which was at par with the treatment T_{12} (23.91).

It was seen that with the definite levels of nutrient application, NPK, FYM and PSB levels was significantly increased. Treatment T_5 (100%RDF +PSB+FYM) recorded significantly maximum protein content over than other treatments. From the above, it can be concluded that highest protein content was associated with nitrogen content in seeds of green gram with the application of 100%RDF+PSB+FYM. These results were like the work done by Sengupta et al., [25] and Ghule et al., [26].

Table 6. Effect of different sources of nutrients on total nutrient uptake by plant

Treatments	Total nutrient uptake by plant (g pot^{-1})		
	N	P	K
T_1: control	0.673	0.248	0.544
T_2: 100%RDF	1.190	0.422	0.813
T_3: 100%RDF+PSB	1.265	0.453	0.834
T_4: 100%RDF+FYM	1.313	0.449	0.850
T_5: 100%RDF+PSB+FYM	1.563	0.519	0.939
T_6: 75%RDF+PSB	1.063	0.379	0.760
T_7: 75%RDF+FYM	1.096	0.372	0.772
T_8: 75%RDF+PSB+FYM	1.143	0.402	0.795
T_9: 50%RDF+PSB	0.873	0.299	0.671
T_{10}: 50%RDF+FYM	0.934	0.301	0.693
T_{11}: 50%RDF+PSB+FYM	1.005	0.344	0.734
T_{12}: 125%RDF	1.433	0.484	0.894
SEm±	0.055	0.014	0.022
CD (P = 0.05)	0.160	0.041	0.065

Table 7. Effect of different sources of nutrients on protein content

Treatments	Protein In Seed (%)
T_1: control	15.16
T_2: 100%RDF	21.87
T_3: 100%RDF+PSB	22.75
T_4: 100%RDF+FYM	23.04
T_5: 100%RDF+PSB+FYM	24.79
T_6: 75%RDF+PSB	20.70
T_7: 75%RDF+FYM	21.00
T_8: 75%RDF+PSB+FYM	21.29
T_9: 50%RDF+PSB	19.54
T_{10}: 50%RDF+FYM	20.12
T_{11}: 50%RDF+PSB+FYM	20.41
T_{12}: 125%RDF	23.91
SEm±	0.539
CD (P = 0.05)	1.583

4. CONCLUSION

The results of the current investigation suggest that among the twelve different treatments studied, the application of 100% recommended dose of fertilizer (RDF) along with phosphorus-solubilizing bacteria (PSB) and farm yard manure (FYM) led to superior performance in terms of various aspects related to green gram crop cultivation. This treatment demonstrated positive effects on growth attributes, yield attributes, overall yield, and quality of the green gram crop. Furthermore, it was observed that this treatment also contributed to improvements in nutrient content and uptake in both the stover (above-ground plant parts) and seeds of the green gram plant. Additionally, the availability of nutrients in the soil post-harvest was enhanced by the application of this treatment.

In conclusion, based on the findings of this investigation, it can be inferred that the application of 100%RDF along with PSB and FYM is highly effective in promoting the growth, yield, and quality of green gram crop. This treatment not only positively impacts the crop itself but also enriches the nutrient content of the plant parts and enhances nutrient availability in the soil after the harvest. These positive effects were particularly notable under the specific acidic soil conditions present in Nagaland state.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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