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Influence of Vermicompost, Neem Cake and Biofertilizers on Growth, Yield and Economics of Green Gram (*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

The findings of the present investigation titled, Influence of vermicompost, neem cake and biofertilizers on growth, yield and economics of Green gram (*Vigna radiata* L.), carried out during the *kharif* season of 2023 at the Baba Farid Institute of Technology's Crop Research Farm in Dehradun. It is situated between latitude 30.3436 and longitude 77.9367. The Shivalik hills and the

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lower Himalayas in the Indian states of Uttarakhand, Himachal Pradesh, and Haryana are home to the extraordinarily wide and lengthy valley known as the doon valley. The investigation was conducted in Randomized Block Design consisting of 10 treatment combinations with 3 replications and was laid out with the different treatments allocated randomly in each replication. Application of vermicompost (1.25t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed), recorded maximum plant height (45.44 cm), Number of branches per plant (6.08), number of nodules/plant (11.05), dry weight (g/plant) (6.57), no. of pods/plant (28.38), seeds per pod (10.13), test weight(g) (38.14), grain yield (1094.06 kg/ha), stover yield (1523.95 kg/ha) and biological yield (2618.01 kg/ha). Where the maximum gross return (101249.80 INR/ha), net return (76043.75 INR/ha) and B:C ratio (3.02) were also recorded with application of vermicompost (1.25 t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed).

Keywords: Green gram; biofertilizers; vermicompost; neem cake; growth; yield; economics.

1. INTRODUCTION

In the Indian economy, agriculture has always held a prominent position. The green gramme, also called mung or mung bean (*Vigna radiata* L.), is a common food. It is one of the Indian subcontinent's most significant and widely grown pulse crops. Pulses are significant food crops that hold a special place in all farming systems that are currently in use, serving as main, cover, intercrop, green manure, and mix crops. Rotational farming maintains the soil's vitality and productivity. The fact that agriculture is the people's primary source of income indicates the great importance of agriculture to the nation's economy. More than 58,000 people live in villages throughout India, where the majority work in agriculture, making the nation primarily an agricultural nation [1].

The primary source of protein, especially for vegetables, is pulses. The ICMR's minimum recommended daily intake of 70g of pulses was met by only 32g of pulses per capita in 2014, a sharp decline from 56g per day in 1968 [2]. According to CMIE [3], green gramme accounts for 11.48% (514 lakh tonnes) of India's total pulse production and 18% (34.4 lakh hectares) of the country's pulse area. About one-fifth of the land under food grains and one-twelfth of their output are made up of pulses. They also make up around one-twelfth of the total cropped area and the value of the principal crop's output. As members of the leguminous family, they are crucial to preserving the fertility of the soil.

“Green manure and organic materials are biofertilizers. Farmers use biofertilizers, which are carrier-based inoculants containing cells of effective strains of particular microorganisms (specifically, bacteria), to increase soil productivity through fixing atmospheric nitrogen, solubilizing soil phosphate, or promoting plant growth for the synthesis of substances that promote growth. The selective adsorption of immobile (P, Zn, Cu) and mobile (C, S, Ca, K, Mn, Cl, Br, and N) elements to plants is largely dependent on biofertilizers” (Tinker, 1984). According to Subba Rao [4,5], Dwivedi [6], “the rhizosphere bacteria secrete growth substances and secondary metabolic processes that aid in seed germination and plant growth. Bacteria that are free-living (Azotobacter), associated (Azospirillum), symbiotic (Rhizobium), and phosphate-solubilizing (Bacillus megaterium, B. polymyxa, and Pseudomyxa) have become increasingly popular in recent times. To protect the environment, the natural economy, and chemical fertilisers, such practises are being promoted”.

“When added to the soil, neem cake—the leftover residue from neem seeds after their oil is extracted—improves the soil's organic matter content while reducing nitrogen losses through nitrification inhibition and extending the nitrogen's availability to both long- and short-duration crops. Long-term crop yield is increased, it is a great soil conditioner, and it doesn't harm the environment” (Lokanadha et al. 2012). Additionally, according to Radwanksi and Wickens [7], “the seed cake contains nitrogen (2–5%), phosphorus (0.5–1.0%), potassium (1-2%), calcium (0.5–3%), and magnesium (0.3–1%)”.

“Vermicompost contains growth enhancing substances with many numbers of beneficial microorganisms like nitrogen fixing, P solubilising and cellulose decomposing organisms. Enriching vermicompost with rock phosphate may enhance multiplication of beneficial microbes and the P solubilising organisms present and are expected to react with rock phosphate and convert the insoluble phosphate to plant available forms. The phosphate solubilizing microorganisms (Pseudomonas) play an important role in conversion of unavailable inorganic P (Ca-P, Fe-P and Al-P) into available inorganic P forms through secretion of organic acids and enzymes" [8].

2. MATERIALS AND METHODS

This experiment was laid out during the *Kharif* season of 2023 at the Baba Farid Institute of Technology's Crop Research Farm in Dehradun. It is situated between latitude 30°34'36" N and longitude 77°93'67" E. The Shivalik hills and the lower Himalayas in the Indian states of Uttarakhand, Himachal Pradesh, and Haryana are home to the extraordinarily wide and lengthy valley known as the doon valley. The experiment was laid out in Randomized Block Design (RBD) which consisting of ten treatments; T_1 – vermicompost (2.5t/ha) + rhizobium (20 g/kg seed), T_2 – vermicompost (2.5 t/ha) + PSB (20 g/kg seed), T_3 – vermicompost (2.5 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed), T_4 - neem cake (1.25 t/ha) + rhizobium (20 g/kg seed), T_5 - neem cake (1.25 t/ha) + PSB (20 g/kg seed), T_6 - neem cake (1.25 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed), T_7 - vermicompost (1.25 t/ha) + neem cake (0.625 t/ha) + rhizobium (20 g/kg seed), T_8 - vermicompost (1.25 t/ha) + neem cake (0.625 t/ha) + PSB (20 g/kg seed), T_9 - vermicompost (1.25 t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed + PSB (10 g/kg seed), T_{10} – Control. The soil in the experimental area was sandy loam with pH (7.6), organic Carbon (0.36%), available N (0.028 %), available P (13.05 kg/ha), and available K (156.44 kg/ha). Seeds are sown at a spacing of 30 cm × 10 cm to a seed rate of 12-16 kg/ha. Data recorded on different aspects of crop, *viz.,* growth, yield attributes were subjected to statistical analysis by analysis of variance (ANOVA) method [9] and economic data analysis by mathematical method [10].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

The data revealed that significantly and maximum plant height (45.44 cm) was observed the applications of vermicompost (1.25 t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed), whereas the lowest value (35.19 cm) was observed in treatment control.

3.1.2 Number of branches plant^{-1}

The data revealed that significantly and maximum number of branches plant^{-1} (6.08) was observed the applications of vermicompost (1.25 t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed), whereas the lowest value (4.25) was observed in treatment control.

3.1.3 Number of nodules plant^{-1}

The data revealed that significantly and maximum number of nodules plant^{-1} (11.05) was observed the applications of vermicompost (1.25 t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed), whereas the lowest value (5.71) was observed in treatment control.

3.1.4 Dry weight (g) plant^{-1}

The data revealed that significantly and maximum dry weight (g) per plant (6.57) was observed the applications of vermicompost (1.25t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed), whereas the lowest value (4.14) was observed in treatment control.

3.2 Yield and Yield Attribute

3.2.1 Number of pods per plant

The results revealed that there was significant difference between the treatments and maximum no. of pods per plant (28.38) was observed by the application of vermicompost (1.25t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed), whereas the lowest value no. of pods per plant (22.07) was observed in control.

3.2.2 Number of seeds per pod

The results revealed that "there was significant difference between the treatments and maximum no. of seeds/pod (10.13) was observed by the application of vermicompost (1.25 t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed), whereas the lowest value no. of seeds/pod (6.78) was observed in control" [11].

Table 1. Effect of vermicompost, neem cake and biofertilizers on growth of green gram

S. No.	Treatment Combination	At 60 DAS			
		Plant height (cm)	Number of branches plant^{-1}	Number of nodules plant^{-1}	Dry weight (g) plant^{-1}
1	Vermicompost (2.5 t/ha) + Rhizobium (20 g/kg seed)	42.12	4.88	8.52	4.98
2	Vermicompost (2.5 t/ha) + PSB (20 g/kg seed)	41.39	4.71	7.50	5.15
3	Vermicompost (2.5 t/ha) + Rhizobium (10 g/kg seed) + PSB (10 g/kg seed)	43.48	4.40	9.29	5.34
4	Neem cake (1.25 t/ha) + Rhizobium (20 g/kg seed)	43.12	5.31	9.48	4.51
5	Neem cake (1.25 t/ha) + PSB (20 g/kg seed)	43.19	4.79	8.54	5.09
6	Neem cake (1.25 t/ha) + Rhizobium (10 g/kg seed) + PSB (10 g/kg seed)	42.50	4.29	9.76	4.72
7	Vermicompost (1.25 t/ha) + Neem cake (0.62 5 t/ha) + Rhizobium (20 g/kg seed)	43.87	5.01	10.08	5.40
8	Vermicompost (1.25 t/ha) + Neem cake (0.625 t/ha) + PSB (20 g/kg seed)	44.71	5.89	10.90	5.54
9	Vermicompost (1.25 t/ha) + Neem cake (0.625 t/ha) + Rhizobium (10 g/kg seed) + PSB (10 g/kg seed)	45.44	6.08	11.05	6.57
10	Control	35.19	4.25	5.71	4.14
	F-Test	S	S	S	S
	C.D. at 0.5	3.61	0.96	2.34	0.55
	S.Ed(+)	1.22	0.32	0.79	0.18
	CV (%)	5.00	11.30	15.10	6.20

Table 2. Effect of vermicompost, neem cake and biofertilizers on yield and yield attribute of green gram

S.No.	Treatment Combination	Yield and yield attribute				
		No. of pods plant^{-1}	Seeds pod^{-1}	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})
1	Vermicompost (2.5 t/ha) + Rhizobium (20 g/kg seed)	22.81	7.79	579.05	794.35	1373.40
2	Vermicompost (2.5 t/ha) + PSB (20 g/kg seed)	23.37	7.65	617.31	836.53	1453.83
3	Vermicompost (2.5 t/ha) + Rhizobium (10 g/kg seed) + PSB (10 g/kg seed)	25.57	6.81	633.05	855.00	1488.05
4	Neem cake (1.25 t/ha) + Rhizobium (20 g/kg seed)	24.24	7.38	633.63	849.10	1482.73
5	Neem cake (1.25 t/ha) + PSB (20 g/kg seed)	23.31	8.37	655.47	819.18	1474.65
6	Neem cake (1.25 t/ha) + Rhizobium (10 g/kg seed) + PSB (10 g/kg seed)	25.42	7.97	713.21	711.19	1424.41
7	Vermicompost (1.25 t/ha) + Neem cake (0.62 5 t/ha) + Rhizobium (20 g/kg seed)	26.74	8.98	883.23	1000.64	1883.87
8	Vermicompost (1.25 t/ha) + Neem cake (0.625 t/ha) + PSB (20 g/kg seed)	27.81	9.87	1041.38	1227.49	2268.87
9	Vermicompost (1.25 t/ha) + Neem cake (0.625 t/ha) + Rhizobium (10 g/kg seed) + PSB (10 g/kg seed)	28.38	10.13	1094.06	1523.95	2618.01
10	Control	22.07	6.78	482.23	549.13	1031.36
	F-Test	S	S	S	S	S
	C.D. at 0.5	2.23	1.44	170.74	193.85	246.02
	S.Ed(+)	0.75	0.48	57.47	65.25	82.81
	CV (%)	5.20	10.30	13.60	12.30	8.70

Table 3. Economics of Green gram on levels of vermicompost, neem cake and biofertilizers

S. No.	Treatment Combination	Economics			
		Total Cost of Cultivation	Gross return (INR/ha)	Net return (INR/ha)	B:C ratio
1	Vermicompost (2.5 t/ha) + Rhizobium (20 g/kg seed)	23698	53526.94	29828.94	1.26
2	Vermicompost (2.5 t/ha) + PSB (20 g/kg seed)	23714	57011.62	33297.62	1.40
3	Vermicompost (2.5 t/ha) + Rhizobium (10 g/kg seed) + PSB (10 g/kg seed)	23706	58451.56	34745.56	1.47
4	Neem cake (1.25 t/ha) + Rhizobium (20 g/kg seed)	26698	58471.62	31773.62	1.19
5	Neem cake (1.25 t/ha) + PSB (20 g/kg seed)	26714	60190.83	33476.83	1.25
6	Neem cake (1.25 t/ha) + Rhizobium (10 g/kg seed) + PSB (10 g/kg seed)	26706	64592.74	37886.74	1.42
7	Vermicompost (1.25 t/ha) + Neem cake (0.62 5 t/ha) + Rhizobium (20 g/kg seed)	25198	80590.4	55392.4	2.20
8	Vermicompost (1.25 t/ha) + Neem cake (0.625 t/ha) + PSB (20 g/kg seed)	25214	95259.11	70045.11	2.78
9	Vermicompost (1.25 t/ha) + Neem cake (0.625 t/ha) + Rhizobium (10 g/kg seed) + PSB (10 g/kg seed)	25206	101249.8	76043.75	3.02
10	Control	21650	44014.94	22364.94	1.03

3.2.3 Grain yield (kg/ha)

The results revealed that “there was significant difference between the treatments and maximum grain yield (kg/ha) (1094.06) was observed by the application of vermicompost (1.25 t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed), whereas the lowest value grain yield (kg/ha) (482.33) was observed in control” [11].

3.2.4 Stover yield (kg/ha)

The results revealed that there was significant difference between the treatments and maximum stover yield (kg/ha) (1523.95) was observed by the application of vermicompost (1.25t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed), whereas the lowest value stover yield (kg/ha) (549.13) was observed in control.

3.2.5 Biological yield (kg/ha)

The results revealed that there was significant difference between the treatments and maximum biological yield (kg/ha) (2618.01) was observed by the application of vermicompost (1.25 t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed), whereas the lowest value biological yield (kg/ha) (1031.36) was observed in control.

3.3 Economics

3.3.1 Cost of production (INR/ha)

Cost of production (26714.00 INR) was found to be highest in treatment 5 [neem cake (1.25 t/ha) + PSB (20 g/kg seed)] as compared to other treatment.

3.3.2 Gross return (INR/ha)

Gross return (101249.8) was found to be highest in treatment 9 [vermicompost (1.25 t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed] as compared to other treatment.

3.3.3 Net return (INR/ha)

Net return (76043.75) was found to be highest in treatment 9 [vermicompost (1.25 t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed] as compared to other treatment.

3.3.4 B: C ratio

Benefit Cost Ratio (3.02) was found to be highest in treatment 9 [vermicompost (1.25 t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed] as compared to other treatment.

4. CONCLUSIONS

It is concluded that for obtaining higher yield in green gram, the treatment combination of vermicompost (1.25 t/ha) + neem cake (0.625 t/ha) + rhizobium (10 g/kg seed) + PSB (10 g/kg seed) recorded significantly higher grain yield (1094.06 kg ha^{-1}), gross returns (101249.80 INR/ha), net returns (76043.75 INR/ha) and benefit cost ratio (3.02).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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