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Integrated Nutrient Management for Growth, Yield and Economic Assessment in Black Gram in Dehradun Valley

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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 field experiment was carried out at a designated location on the Agricultural Research Farm of Graphic Era Hill University in Dehradun during the kharif season of 2023 to study the influence of integrating organic and inorganic sources of nutrients on growth and productivity of black gram

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(*Vigna mungo*). The experiment was laid out in Randomized Complete Block Design (RCBD) consisting of nine treatments *viz* Control (T_1), 100% RDF (20:40:20 Kg/ha NPK)(T_2), Vermicompost @ 5 t ha^{-1} (T_3) Bio nitrogen @ 20gm kg^{-1} seed (T_4), 100% RDF+ Vermicompost @ 5 t ha^{-1} (T_5), 100% RDF + Bio nitrogen @ 20gm kg^{-1} seed (T_6), Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} seed (T_7), 70% RDF + Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} seed (T_8), 100% RDF+ Vermicompost @ 5 ha^{-1}+ Bio-Nitrogen (T_9) each replicated thrice. Integrated Nutrient Management had significantly affected growth, yield and economics of black gram. Maximum emergence count (13.3 m^2) was recorded with 70% RDF + Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} seed which at par with 100% RDF + Bio nitrogen@ 20gm kg^{-1} seed (T_6) and 100% RDF+ Vermicompost @ 5 ha^{-1}+ Bio-Nitrogen (T_9). Growth parameter *viz.* plant height, number of nodules/plant, dry matter accumulation/m^2, branches/plant were reported to be significantly influenced by INM with 70% RDF + Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} seed. Similarly, maximum seed yield (36.33 q ha^{-1}) was obtained under 70% RDF + Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} seed. Increase in seed yield with the application of by 358.1% and 233.3% was obtained over control (T_1) and 100% RDF (T_2). The study highlights that combining organic and inorganic sources of nutrients is a simple and effective strategy to improve initial plant stand of black gram crop, ultimately contributing to increased crop growth, yield and better economic returns.

Keywords: Bio-nitrogen; black gram; Dehradun valley; growth; integrated nutrient management; vermicompost.

1. INTRODUCTION

Pulses are cultivated globally, with India leading production, followed by the Russian Federation and Poland [1]. These edible seeds from the Fabaceae family are valued for their ability to enhance soil fertility through nitrogen fixation via a symbiotic relationship with Rhizobia bacteria. This process not only supports the pulse plants themselves but also enriches the soil for future crops, making each pulse plant a mini-fertilizer factory [2]. Pulses also offer significant nutritional benefits and are linked to reduced risks of non-communicable diseases such as colon cancer and cardiovascular conditions [3]. Often referred to as "poor man's meat" and "rich man's vegetables," pulses are grown across approximately 9.57 million hectares, yielding about 9.22 million tonnes with an average productivity of 964 kg per hectare. Major pulses in India include Pigeon Peas, Green Beans, Chickpeas, Black Gram, Red Kidney Beans, Black Eyed Peas, Lentils, and White Peas. Notably, India produces 70% of the world's Black Gram, with around 2.7 million tonnes harvested from 4.4 million hectares, averaging 598 kg per hectare. This crop constitutes roughly 10% of India's total pulse production, primarily sourced from ten states, including Maharashtra, Karnataka, and Madhya Pradesh.

Black Gram, or urd bean, is a key pulse in the Fabaceae family, renowned for its nutritional profile. It thrives in various cropping systems—mixed, catch, sequential, and standalone after rice harvests or other summer crops in semi-irrigated and dryland settings. Additionally, crop residues serve as valuable fodder for cattle. Black Gram contributes to soil fertility by improving physical characteristics and fixing atmospheric nitrogen [4]. However, productivity challenges exist, particularly concerning fertilizer management, which significantly affects yields in intensive cropping systems. To achieve sustainable agricultural practices, it is crucial to balance nutrient removal from the soil with the nutrients applied. This balance extends beyond external inputs to include the inherent soil nutrients. Since the introduction of synthetic fertilizers in the 1840s, crops have increasingly relied on these chemicals, necessitating strategies to preserve natural resources while maintaining productivity. Utilizing various nutrient sources in an integrated manner can lead to sustainable yields and high-quality crops. The combined application of organic manures with inorganic fertilizers, along with biofertilizers, can sustain soil fertility and enhance crop quality.

Implementing Integrated Nutrient Management (INM) practices is expected to significantly improve the growth, yield, and nutritional quality of Black Gram compared to traditional fertilizer methods. This hypothesis can be tested by evaluating different INM strategies, such as the combination of organic and inorganic fertilizers, against conventional approaches, measuring outcomes like plant height, pod yield, seed quality, and soil health indicators. The objective of the research on INM's effects on Black Gram is to assess its potential for enhancing soil fertility and crop productivity sustainably. By integrating organic and inorganic inputs, we aim to understand their influence on yields, nutritional quality, and overall soil health. This study seeks to provide farmers with effective strategies to boost crop resilience and economic viability while reducing reliance on chemical fertilizers, ultimately contributing to sustainable agricultural practices and food security.

2. MATERIALS AND METHODS

A field experiment was conducted during the Kharif season of 2023 using black gram variety SML-668 at the Agriculture Research Farm, Graphic Era Hill University, Dehradun, Uttarakhand. Dehradun is characterized by humid sub-tropical climate with warm summer and severe cold winter. Generally, south-west monsoon sets in the second or third week of June and continue up to the end of September. The highest temperature is found in the month of May-June and that of the lowest in December-January. The mean annual rainfall of this region is 2025 mm, of which 70% is received during rainy season (July- September). Frost generally occurs towards the end of December and may continue till the end of January. Minimum temperature in the coldest month during winter varies from 1-9°C and during summer, the maximum temperature varies from 30-43 °C.

The experiment consisted of nine treatments which were replicated three times and layout in randomized block design *viz.,* Control (T_1), 100% RDF (T_2), Vermicompost @ 5 t ha^{-1} (T_3) Bio nitrogen @ 20gm kg^{-1} seed (T_4), 100% RDF+ Vermicompost @ 5 t ha^{-1} (T_5), 100% RDF + Bio nitrogen @ 20gm kg^{-1} seed (T_6), Vermicompost + Bio nitrogen @ 20gm kg^{-1} seed (T_7), 70% RDF + Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} seed (T_8), 100% RDF+ Vermicompost @ 5 ha^{-1}+ Bio-Nitrogen @ 20gm kg^{-1} seed (T_9). The gross plot measured 3 m × 3 m and net plot was 2.25 m × 2 m. In each plot, five plants were randomly tagged from the third row to record growth parameters *viz.,* plant height, number of branches/plant whereas, ten plants were taken randomly from the produce harvested from net plot (2.25 m × 2 m) for recording yield attributes (pods/plant, pod length, number of seeds/pods, seed index), yield (seed yield, biological yield, stover yield and harvesting index) and economics (cost of cultivation, gross return, net return and benefit-cost ratio). The initial soil samples were collected from the experimental field at 0-15 cm depth. The soil of experimental field was low in organic carbon (0.39%) with **Walkley and black method**, medium in available nitrogen (157 kg ha^{-1}) with **Alkaline KMnO4 method**, available phosphorus (15.5 kg ha^{-1}) with **Olsen's phosphorus extraction method** and available potassium (112.6 kg ha^{-1}) with **Neutral normal ammonium acetate extraction method**. Natural soil reaction was sandy loam in texture, Soil pH 7.4 (**Glass electrode pH meter**).

3. RESULT AND DISCUSSION

3.1 Emergence Count and Plant Height

The result shows that emergence count and plant height of Black gram were significantly affected due to different treatments as presented in Table 1. Highest emergence (13.3/m^2) was recorded under 70% RDF + Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} seed (T_8) which was statically at par with 100% RDF + Bio nitrogen @ 20gm kg^{-1} seed (T_6) and 100% RDF+ Vermicompost @ 5 ha^{-1}+ Bio-Nitrogen @ 20gm kg-^{1} seed (T_9) and significantly higher than rest of the treatments. Minimum emergence count (6.6/m^2) was recorded under control (T_1). Application of 70% RDF + Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} seed (T_8) emergence/m^2 resulted in increased emergence count by 60.2% and 101.5% over 100% RDF (T_2) and control (T_1), respectively at 20 DAS. Treatments where bio-nitrogen is combined with RDF has shown maximum emergence count. Bio-nitrogen containing nitrogen-fixing bacteria like Rhizobium, significantly enhances the emergence number in legume plants.

The results are in conformity with Keerthanan et al. [5] as they reported that application of recommended dose of fertilizer 25:50:25 NPK kg ha^{-1} + Vermicompost @ 5 t ha^{-1} increases plant population (15.3/m^2) significantly.

The results obtained from the experiment showed that the higher plant height (42.1 cm, 62.6 cm and 66.9 cm, respectively at 30, 60 & 90 DAS) was obtained with the application of 70% RDF + Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} (T_8) seed at all the crop growth stages. It was found to be statistically at par with 100% RDF + Bio-Nitrogen @ 20gm kg^{-1} seed (T_6) and 100% RDF+ Vermicompost @ 5 ha^{-1}+

Bio-Nitrogen @ 20gm kg^{-1} seed (T_9) and significantly higher over the remaining treatments. It may be possibly due to the balanced application of NPK, vermicompost and bio-fertilizers, which crucially enhances plant height by providing a balanced and adequate supply of essential nutrients, such as nitrogen, phosphorus, and potassium, tailored to meet the specific needs of leguminous crops. The result showed similarity with Yuganthra et al. [6] that the highest plant height (36.73cm) noticed with 50% RDF + 25% FYM + 25% vermicompost.

3.2 Dry Natter Accumulation and Number of Nodules/Plant

The dry matter of black gram increased continuously with advancement of crop age and attained its maximum value at the maturity stage (Table 2). The results showed that the dry matter accumulation varied significantly under the influence of different treatments at all the crop growth stages. Dry matter accumulation (77.0, 611.3, 1251.7 respectively at 30, 60 & 90 DAS) was recorded maximum under 70% RDF + Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} seed (T_8). It was statistically at par with 100% RDF+ Vermicompost @ 5 ha^{-1}+ Bio-Nitrogen @ 20gm kg^{-1} seed (T_9) and 100% RDF + Bio nitrogen@ 20gm kg^{-1} seed (T_6) but significantly higher than rest of the treatments. Dry matter accumulation/m^2 was recorded minimum (46.1gm/m^2, 305 gm/m^2 & 641.7gm/m^2 at 30, 60 & 90 DAS) for control (T_1) at all the crop growth stages. This may be due to RDF ensures the precise application of essential nutrients like phosphorus and potassium, promoting balanced growth. Together, these components optimize nutrient uptake, enhance photosynthesis, and improve plant health, leading to increased biomass production and higher dry matter content in legumes. The result showed similarity with Kumar et al. [7] application of 100% RDF + PSB (25g kg^{-1} of seed) + Rhizobium (25 g kg^{-1} seed) + FYM (2.5 t ha^{-1}) showed maximum dry matter accumulation (461.54 gm/m^2).

The number of nodules per plant varied significantly under the influence of various treatments. Maximum number of nodules/plant (32.9, 16.0, 6.5, respectively at 30, 60, 90 DAS) at all the crop growth stages recorded with 70% RDF + Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} seed (T_8). It was found statistically at par with 100% RDF+ Vermicompost @ 5 ha^{-1}+ Bio-Nitrogen @ 20gm kg^{-1} seed (T_9) and 100% RDF + Bio nitrogen@ 20gm kg^{-1} seed (T_6) and significantly higher than rest of the treatments. Minimum number of nodules/plant (5.6, 5.9 & 4.0, respectively at 30, 60, 90 DAS) was recorded under control (T_1) at all the crop growth stages. It might be due to seed treatment with bio nitrogen which has a pivotal role in influencing the number of nodules in legume plants.

These bacteria establish symbiotic relationships with legume roots, forming nodules where they convert atmospheric nitrogen into a usable form for the plant. The presence of bio nitrogen encourages the proliferation of nodules on the roots, as the plant responds to the increased availability of nitrogen by forming more nodules to accommodate the nutrient supply. The results are in conformity with Sahua et al. [8] application of 100% RDF+ Rhizobium culture @ 25g kg^{-1} of seed +Vermicompost @ 2.5 t ha^{-1}+ FYM @ 5 t ha^{-1} showed highest number of nodules/plants (123.37).

Table 1. Effect of integrated nutrient management on emergence/m^2 and plant height at different crop growth stages

Treatment	Plant height (cm)		
	30 DAS	60 DAS	90 DAS
T_1	28.6	49.8	52.8
T_2	35.8	55.0	58.6
T_3	32.5	54.7	56.2
T_4	30.3	53.6	56.7
T_5	33.2	54.4	56.4
T_6	37.0	57.9	61.3
T_7	33.8	54.9	57.4
T_8	42.1	62.6	66.9
T_9	38.9	58.0	63.3
SEm±	**1.7**	**1.8**	**2.0**
CD 5 %	**5.2**	**5.6**	**6.1**

Table 2. Effect of integrated nutrient management on dry matter accumulation (g/m²) and number of nodule/plants at different crop growth stages

Treatment	Dry matter accumulation(g/m²)			Number of nodule/plants		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	46.7	305.0	641.7	5.6	5.9	4.0
T_2	51.7	348.3	816.3	17.1	9.9	5.1
T_3	55.3	425.0	842.3	13.0	9.4	5.2
T_4	53.0	407.7	861.0	17.4	9.4	5.3
T_5	52.0	323.7	865.7	17.8	9.7	5.2
T_6	67.3	536.0	1160.3	30.2	15.4	6.2
T_7	56.3	368.3	704.0	16.6	10.2	5.2
T_8	77.0	611.3	1251.7	32.9	16.0	6.5
T_9	68.0	570.0	1207.3	29.5	14.7	5.9
SEm±	**3.9**	**26.8**	**44.9**	**1.1**	**0.7**	**0.3**
CD 5 %	**11.6**	**80.3**	**134.8**	**3.5**	**2.1**	**1.0**

Table 3. Effect of integrated nutrient management on crop growth rate (g/m²/day) at different crop growth stages

Treatment	CGR (g/m²/day)		
	0-30 DAS	30-60 DAS	60-90 DAS
T_1	1.6	8.6	11.2
T_2	1.7	9.9	15.6
T_3	1.8	12.3	12.6
T_4	1.8	11.8	15.1
T_5	1.7	9.1	14.8
T_6	2.2	15.6	19.1
T_7	1.9	10.4	11.3
T_8	2.6	17.8	22.2
T_9	2.3	16.7	20.8
SEm±	**0.1**	**0.9**	**1.2**
CD 5 %	**0.3**	**2.7**	**3.5**

Table 4. Effect of integrated nutrient management on relative growth rate (mg/g//day) at different crop growth stages

Treatment	RGR (mg/g/day)		
	0-30 DAS	30-60 DAS	60-90 DAS
T_1	0.128	0.185	0.193
T_2	0.131	0.188	0.198
T_3	0.134	0.197	0.199
T_4	0.132	0.195	0.200
T_5	0.131	0.187	0.202
T_6	0.140	0.205	0.214
T_7	0.134	0.191	0.194
T_8	0.145	0.209	0.215
T_9	0.141	0.207	0.212
SEm±	**0.002**	**0.003**	**0.004**
CD 5 %	**0.007**	**0.009**	**0.012**

3.3 CGR and RGR

The results indicates that maximum crop growth rate (2.6, 17.8 & 22.2 gm/m^2/day, respectively at 30, 60 & 90 DAS) was recorded with the application of 70% RDF+ Vermicompost @ 5 t/ha + Bio-Nitrogen (T_8) at all the crop growth stages. However, it was statistically at par with 100% RDF + Vermicompost @ 5 t/ha + Bio-Nitrogen (T_9) and 100% RDF + Bio-Nitrogen (T_6) and significantly higher than rest of the treatments. At 90 DAS, application of 70% RDF+ Vermicompost @ 5 t/ha + Bio-Nitrogen (T_8) increased crop growth rate by 50% and 96.4 % over 100% RDF+ Vermicompost @ 5 t/ha (T_5) and Vermicompost @ 5 t/ha + Bio-nitrogen (T_7), respectively. It may be attributed to the combined action of bio-fertilizer and RDF. Combination of these two sources of nutrients may have improved accessibility of major and minor nutrient to plant and 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 and finally increase.

The data indicates that relative growth rate (RGR) varied significantly under the influence of various treatments at various crop growth stages. Highest RGR (0.145, 0.209 & 0.215 mg/g/day respectively at 30, 60, 90 DAS) was obtained with the application of 70% RDF+ Vermicompost @ 5 t/ha + Bio-Nitrogen (T_8) and 100% RDF + Bio-Nitrogen (T_6) and significantly higher than rest of the treatments. Percent increase of 6.4% and 10.8% was recorded for RGR with the application of 70% RDF+ Vermicompost @ 5 t/ha + Bio-Nitrogen (T_8) over 100% RDF + Vermicompost @ 5 t/ha (T_5) and Vermicompost @ 5 t/ha+ Bio-nitrogen(T_7), respectively at 90 DAS. This might be due to the additional application of bio-nitrogen along with RDF and vermicompost which may have increased N supply.

3.4 Seed and Stover Yield of Black Gram

The results indicated that among the different Integrated Nutrient Management treatments, the seed yield of black gram was highest (36.3 q ha^{-1}) with application of 70% RDF + Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} seed (T_8). It was significantly higher than rest of the treatments but statistically at par with 100% RDF+ Vermicompost @ 5 ha^{-1}+ Bio-Nitrogen @ 20gm kg^{-1} seed (T_9) and 100% RDF + Bio nitrogen @ 20gm kg^{-1} seed (T_6). Minimum seed yield (7.9 q ha^{-1}) was observed in the control (T_1), likely due to application of RDF along with vermicompost and bio nitrogen application. This integrated approach to nutrient management not only enriches the soil with vital nutrients but also fosters the growth of beneficial microorganisms, thereby enhancing soil fertility and plant vitality. Vermicompost contributes valuable organic matter to the soil, while bio nitrogen aids in nitrogen fixation, ensuring a consistent supply of this crucial element. The combined action of these components facilitates in heightened seed yield and enhanced overall productivity in black gram cultivation. Similar result were found by Singh et al. [9].

The stover yield of black gram varied significantly under the influence of different treatments. Maximum stover yield (19.43 q ha^{-1}) was obtained with the application of 70% RDF + Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} seed (T_8) which was statistically at par with 100% RDF+ Vermicompost @ 5 ha^{-1}+ Bio-Nitrogen @ 20gm kg^{-1} seed (T_9) and 100% RDF + Bio nitrogen @ 20gm kg^{-1} seed (T_6) but significantly higher than rest of the treatments. Application of 70% RDF + Vermicompost @ 5 t ha-^{1} + Bio nitrogen @ 20gm kg-^{1} seed (T_8) resulted in increased stover yield by 59.2% and 134% over 100% RDF (T_2) and control (T_1), respectively. This may be due to the application of Vermicompost @ 5 t ha^{-1} plays a significant role in enhancing the growth and yield of stover. The presence of beneficial microorganisms in vermicompost aids in breaking down organic matter, making nutrients more available to plants. As a result, crops grown with vermicompost exhibit increased stover yield. The results are in conformity with Divyavani, et al., [10] as they reported that application of 100% NPK+ 50% Vermicompost showed maximum stover yield (3056 kg/ha).

3.5 Biological Yield and Harvest Index of Black Gram

The biological yield of black gram varied significantly under the influence of different treatments. Maximum biological yield (55.7 q ha^{-1}) was recorded with the application of 70% RDF + Vermicompost @ 5 t ha-^{1} + Bio nitrogen @ 20gm kg-^{1} seed (T_8). It is statistically at par with 100% RDF+ Vermicompost @ 5 ha^{-1}+ Bio-Nitrogen @ 20gm kg^{-1} seed (T_9) and 100% RDF + Bio nitrogen @ 20gm kg^{-1} seed (T_6). The remaining treatments were significantly lower than 70% RDF + Vermicompost @ 5 t ha-^{1} + Bio nitrogen @ 20gm kg-^{1} seed (T_8). The precent increased 141.4% & 250.9% over 100% RDF

(T_2) and control (T_1), respectively. Minimum biological yield (15.8 q ha^{-1}) was recorded under control (T_1). It might be due to the combination of RDF with vermicompost and bio-nitrogen. The integrated use of organic, inorganic and bio fertilizer combination resulted in better growth of plants associated with increased availability of nutrients might have resulted in the translocations and accumulation of photosynthesis resulted in increased biological yield of black gram significantly increased. The result showed similarity with Prasad et al. [11] application of 100% RDF (20:30:15 Kg ha^{-1}) + $ZnSO_4$ 5kg ha^{-1} + $FeSO_4$ 5kg ha^{-1} showed highest biological yield (2713 kg ha^{-1}).

The harvest index of black gram varied significantly under the influence of different treatments. It has been observed that maximum harvest index (67.6%) was obtained with the application of 100% RDF + Bio nitrogen @ 20gm kg^{-1} seed (T_6). It was significantly higher than Control (T_1), 100% RDF (T_2) and Vermicompost @ 5 t ha^{-1} (T_3) but was statistically at par with rest of the treatments. Increase in harvest index with the application of 100% RDF + Bio nitrogen @ 20gm kg^{-1} seed (T_6) by 45.0 % and 37.6 % was recorded over 100 % RDF (T_2) and control (T_1), respectively. Minimum harvest index (49.1%) was recorded under control. It might be due to the application of balanced dose of nutrients. Proper fertilization ensures optimal plant growth, improves nitrogen fixation, and enhances the development of pods and seeds. This balanced nutrient supply leads to a more efficient conversion of the plant's energy and resources into the harvested parts, ultimately increasing the harvest index. The results are in conformity with Kumar et al. [12] as they reported that application of 50% RDF + 50% RDN through compost + Rhizobium showed highest Harvest index (30.06).

3.6 Economics of Black Gram

The maximum cost of cultivation (₹ 42558.00 ha^{-1}) was recorded under 100% RDF+ Vermicompost @ 5 ha^{-1}+ Bio-Nitrogen @ 20gm kg^{-1} seed (T_9). whereas minimum cost of cultivation (₹ 25606.00 ha^{-1}) was recorded under control (T1). The gross return of black gram varied significantly under the influence of

Table 5. Effect of Integrated Nutrient Management on seed yield (q/ha) and stover yield (q/ha)

Treatment	Seed yield (q/ha)	Stover yield (q/ha)
T_1	7.93	8.30
T_2	10.90	12.20
T_3	12.43	14.00
T_4	20.27	11.17
T_5	21.04	11.09
T_6	34.87	16.10
T_7	20.74	14.20
T_8	36.33	19.43
T_9	35.20	16.87
SEm±	**0.53**	**1.09**
CD 5 %	**1.59**	**3.35**

Table 6. Effect of Integrated Nutrient Management on Biological yield (q/ha) and Harvest index

Treatment	Biological yield (q/ha)	Harvest index
T_1	15.87	49.19
T_2	23.10	46.67
T_3	26.43	46.72
T_4	31.43	65.36
T_5	32.13	65.92
T_6	51.50	67.68
T_7	34.93	59.40
T_8	55.77	65.46
T_9	52.07	67.61
SEm±	**1.57**	**3.29**
CD 5 %	**4.72**	**9.86**

Table 7. Effect of INM on Cost of cultivation, gross return, net return and B:C ratio

Treatment	Cost of cultivation	Gross return	Net return	B:C ratio
T_1	25606.00	55136.67	29530.67	1.15
T_2	33758.00	75755.00	41997.00	1.24
T_3	36076.00	86411.67	50335.67	1.40
T_4	27876.00	140853.33	140853.33	4.05
T_5	42258.00	146258.89	104000.89	2.46
T_6	34058.00	242323.33	208265.33	6.12
T_7	36376.00	144148.15	107772.15	2.96
T_8	40703.00	252516.67	211813.67	5.20
T_9	42558.00	244640.00	202082.00	4.75
SEm±	**-**	**3675.72**	**3675.72**	**0.12**
CD 5 %	**-**	**11019.00**	**11019.00**	**0.37**

different treatments. Vermicompost rate about 8500 ₹/5 tones and it is arranged by the university. It has been observed that highest gross return (₹ 252516.67 ha^{-1}) was obtained 70% RDF + Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} seed (T_8). It was significantly higher than rest of the treatments except 100% RDF + Bio nitrogen@ 20gm kg^{-1} seed (T_6) and 100% RDF+ Vermicompost @ 5 ha^{-1}+ Bio-Nitrogen @ 20gm kg^{-1} seed (T_9). The results were in conformity with Banotra et al. [13] where highest gross returns (₹58203 ha^{-1}) noticed with 75% NPK+25% N through vermicompost and FYM (1:1).

The Net return of black gram varied significantly under the influence of different treatments. It has been observed that highest net return (₹ 211813.67 ha^{-1}) was obtained with 70% RDF + Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} seed (T_8). It was significantly higher than rest of the treatments except 100% RDF+ Vermicompost @ 5 ha^{-1}+ Bio-Nitrogen @ 20gm kg^{-1} seed (T_9) and 100% RDF + Bio nitrogen @ 20gm kg^{-1} seed (T_6). Minimum net return (₹ 29530.67 ha^{-1}) was recorded under control (T_1). Higher net return under these treatments shows that these treatments accrued high gross return with a lower or similar cost of production. The results are in conformity with Keerthanan et al. [5] as they reported that maximum Net income (₹ 52150.00/ha) was recorded with integration of nutrients (RDF 25:50:25 NPK kg ha^{-1} +Vermicompost @ 5 t ha^{-1}).

The Benefit cost ratio of black gram varied significantly under the influence of different treatments. It has been observed that highest B:C ratio (6.12) was obtained with 100% RDF+ Bio-Nitrogen @ 20gm kg^{-1} seed (T_6). The result showed that 100% RDF + Bio nitrogen @ 20gm kg^{-1} seed (T_6) higher than all the other treatments. Minimum B:C ratio (1.15) was recorded under control (T_1). The results are in conformity with Muwal & Dhaked [14] as they reported that maximum B:C ratio (2:45) was recorded with application of Vermicompost 1 t ha^{-1} + 50% RDN. Higher B:C ratio under different treatments reveal that net return per unit cost of production was higher under these treatments.

4. CONCLUSION

Based on the present study, it is concluded that the use of Integrated Nutrient Management with application of 70% RDF + Vermicompost @ 5 t ha^{-1} + Bio nitrogen @ 20gm kg^{-1} seed (T_8) as an agricultural practice holds significant promise for enhancing the growth and yield of black gram. This outcome may be attributed to the improved nutrient provisioning achieved through integrating different nutrient sources which facilitated optimal growth and yield and highest harvest index. By judiciously combining organic and inorganic nutrient sources, this practice potentially reduces 25% as observed, the reliance on chemical fertilizers while ensuring a robust crop yield.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc have been used during writing or editing of this manuscript. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

Details of the AI usage are given below:

1. ChatGPT

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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