**Integrated nutrient management for growth, yield and economic assessment in Black gram in Dehradun valley**

**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 (*Vigna mungo*). The experiment was laid out in Randomized Complete Block Design (RCBD) consisting of nine treatments *viz* Control (T1), 100% RDF (T2), Vermicompost @ 5 t ha-1 (T3) Bio nitrogen @ 20gm kg-1 seed (T4), 100% RDF+ Vermicompost @ 5 t ha-1 (T5), 100% RDF + Bio nitrogen @ 20gm kg-1 seed (T6), Vermicompost @ 5 t ha-1 + Bio nitrogen @ 20gm kg-1 seed (T7), 70% RDF + Vermicompost @ 5 t ha-1 + Bio nitrogen @ 20gm kg-1 seed (T8), 100% RDF+ Vermicompost @ 5 ha-1+ Bio-Nitrogen (T9) each replicated thrice. Integrated Nutrient Management had significantly affected growth, yield and economics of black gram. Maximum emergence count (13.3 m2) 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 (T6) and 100% RDF+ Vermicompost @ 5 ha-1+ Bio-Nitrogen (T9). Growth parameter *viz.* plant height, number of nodules/plant, dry matter accumulation/m2,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 (T1) and 100% RDF (T2). 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, Growth, Integrated Nutrient Management, Parameter, Productivity, Seed, Harvest.*

**INTRODUCTION**

Pulses are produced all over the world, in which India represents the largest producer followed by the Russian Federation and Poland **(Marcello and Elena, 2017)**. Pulses are the edible dry seeds from plants in the Fabaceae family. They are recognized for their role in enhancing soil fertility, as their root nodules can fix atmospheric nitrogen through a symbiotic relationship with the bacterium Rhizobia. This process not only benefits the plants but also enriches the soil for future crops. Thus, every pulse plant is a mini-fertilizer factory itself and enhance the soil fertility also **(Dotaniya *et.al.,* 2014)**. Pulses provide significant nutritional and health benefits and are known to reduce several non-communicable diseases such as colon cancer and cardiovascular diseases **(Jukanti *et.al.,* 2012)**. Pulses are often referred to as "poor man's meat" and "rich man's vegetables." They are cultivated globally across approximately 9.57 million hectares, resulting in a total production of about 9.22 million tonnes, with an average productivity of 964 kg per hectare. In India, major pulses include Pigeon Peas, Green Beans, Chickpeas, Black Gram, Red Kidney Beans, Black Eyed Peas, Lentils, and White Peas. India is the world's largest producer of Black Gram, accounting for 70% of global production, followed by Myanmar and Pakistan. The country produces around 2.7 million tonnes from approximately 4.4 million hectares, with an average yield of 598 kg per hectare. Black gram contributes approximately 10% of the total pulse production in India with more than 90% of its production coming from 10 states, *viz.*, Maharashtra, Karnataka, Madhya Pradesh, Gujarat, Uttar Pradesh, Jharkhand, Telangana, Odisha, Andhra Pradesh and Tamil Nadu **(Ministry of Agriculture and Farmers Welfare.** [**www.india.gov.in**](http://www.india.gov.in)**. 2021).**

Black gram, also known as urd bean, is one of the most important pulse crops in the Fabaceae family. It is highly regarded for its nutritional value. Black gram is cultivated in various cropping systems, including as a mixed crop, catch crop, sequential crop, and as a standalone crop under residual soil moisture after rice harvesting, as well as following other summer crops in semi-irrigated and dryland conditions. Additionally, the crop residues—such as haulms, leaves, and pods—are utilized as fodder for cattle. It plays a vital role in supporting soil fertility by enlightening soil physical characteristics and fixation of atmospheric nitrogen (**Reddy *et al*., 2017).** There are numerous reasons responsible for lower productivity of black gram. Among them, fertilizer management are major factor contributing to low yields of black gram. In the current intensive cropping system. it is not easy to maintain productivity and protection of the environment for long.

Unless we create a balance between the nutrient removal by crop from the soil and applied nutrients. Balance nutrition does not mean only added nutrient from outside but also include that nutrient which are present already in the soil. In agriculture a major transformation started with the application of synthetic fertilizers to soil from the year 1840 after that crops were dependent partially on chemical fertilizers. Therefore, to save the natural resources by reducing the use of amount of chemical fertilizers thereby maintaining the production capacity of our natural resources. Use of different sources of nutrients in an integrated manner helps to produce sustainable yields with good quality crop. Application of both organic manure in combination with inorganic source of nutrients can sustain high yield significantly along with the application of biofertilizers helps to maintain soil fertility status. Proper combination of inorganic and organic fertilizers plays a vital role in production of vigorous plants having maximum number of branches, leaves, flowers and pod formation, have a positive impact on quality crop production. Integrated Nutrient Management practices will significantly enhance the growth, yield, and nutritional quality of black gram compared to conventional fertilizer application methods. This hypothesis can be tested by comparing various INM strategies, such as the combination of organic and inorganic fertilizers, against traditional methods, measuring parameters like plant height, pod yield, seed quality, and soil health indicators. The experiment on the effect of Integrated Nutrient Management (INM) on black gram was conducted to evaluate its potential to enhance soil fertility and crop productivity sustainably. By combining organic and inorganic inputs, we aimed to determine their impact on black gram yields, nutritional quality, and overall soil health. This research seeks to provide farmers with effective strategies to improve crop resilience and economic viability while reducing reliance on chemical fertilizers, ultimately contributing to sustainable agricultural practices and food security.

**MATERIAL 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 (T1), 100% RDF (T2), Vermicompost @ 5 t ha-1 (T3) Bio nitrogen @ 20gm kg-1 seed (T4), 100% RDF+ Vermicompost @ 5 t ha-1 (T5), 100% RDF + Bio nitrogen @ 20gm kg-1 seed (T6), Vermicompost + Bio nitrogen @ 20gm kg-1 seed (T7), 70% RDF + Vermicompost @ 5 t ha-1 + Bio nitrogen @ 20gm kg-1 seed (T8), 100% RDF+ Vermicompost @ 5 ha-1+ Bio-Nitrogen @ 20gm kg-1 seed (T9). 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**).

**Result and Discussion**

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/m2) was recorded under 70% RDF + Vermicompost @ 5 t ha-1 + Bio nitrogen @ 20gm kg-1 seed (T8) which was statically at par with 100% RDF + Bio nitrogen @ 20gm kg-1 seed (T6) and 100% RDF+ Vermicompost @ 5 ha-1+ Bio-Nitrogen @ 20gm kg-1 seed (T9) and significantly higher than rest of the treatments. Minimum emergence count (6.6/m2) was recorded under control (T1). Application of 70% RDF + Vermicompost @ 5 t ha-1 + Bio nitrogen @ 20gm kg-1 seed (T8) emergence/m2 resulted in increased emergence count by 60.2% and 101.5% over 100% RDF (T2) and control (T1), 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.* (2019)** 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/m2) 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 (T8) seed at all the crop growth stages. It was found to be statistically at par with 100% RDF + Bio-Nitrogen @ 20gm kg-1 seed (T6) and 100% RDF+ Vermicompost @ 5 ha-1+ Bio-Nitrogen @ 20gm kg-1 seed (T9) 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.* (2023)** that the highest plant height (36.73cm) noticed with 50% RDF + 25% FYM + 25% vermicompost.

**Table 1. Effect of Integrated Nutrient Management on emergence/m2 and plant height at different crop growth stages**

|  |  |
| --- | --- |
| **Treatment** | **Plant height (cm)** |
| **30****DAS** | **60****DAS** | **90****DAS** |
| T1 | 28.6 | 49.8 | 52.8 |
| T2 | 35.8 | 55.0 | 58.6 |
| T3 | 32.5 | 54.7 | 56.2 |
| T4 | 30.3 | 53.6 | 56.7 |
| T5 | 33.2 | 54.4 | 56.4 |
| T6 | 37.0 | 57.9 | 61.3 |
| T7 | 33.8 | 54.9 | 57.4 |
| T8 | 42.1 | 62.6 | 66.9 |
| T9 | 38.9 | 58.0 | 63.3 |
| SEm± | 1.7 | 1.8 | 2.0 |
| CD 5 % | 5.2 | 5.6 | 6.1 |

1. **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 (T8). It was statistically at par with 100% RDF+ Vermicompost @ 5 ha-1+ Bio-Nitrogen @ 20gm kg-1 seed (T9) and 100% RDF + Bio nitrogen@ 20gm kg-1 seed (T6) but significantly higher than rest of the treatments. Dry matter accumulation/m2 was recorded minimum (46.1gm/m2, 305 gm/m2 & 641.7gm/m2 at 30, 60 & 90 DAS) for control (T1) 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.* (2024)** 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/m2).

 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 (T8). It was found statistically at par with 100% RDF+ Vermicompost @ 5 ha-1+ Bio-Nitrogen @ 20gm kg-1 seed (T9) and 100% RDF + Bio nitrogen@ 20gm kg-1 seed (T6) 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 (T1) 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.* (2023)** 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 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** |
| T1 | 46.7 | 305.0 | 641.7 | 5.6 | 5.9 | 4.0 |
| T2 | 51.7 | 348.3 | 816.3 | 17.1 | 9.9 | 5.1 |
| T3 | 55.3 | 425.0 | 842.3 | 13.0 | 9.4 | 5.2 |
| T4 | 53.0 | 407.7 | 861.0 | 17.4 | 9.4 | 5.3 |
| T5 | 52.0 | 323.7 | 865.7 | 17.8 | 9.7 | 5.2 |
| T6 | 67.3 | 536.0 | 1160.3 | 30.2 | 15.4 | 6.2 |
| T7 | 56.3 | 368.3 | 704.0 | 16.6 | 10.2 | 5.2 |
| T8 | 77.0 | 611.3 | 1251.7 | 32.9 | 16.0 | 6.5 |
| T9 | 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 |

1. **CGR and RGR**

The results indicates that maximum crop growth rate (2.6, 17.8 & 22.2 gm/m2/day, respectively at 30, 60 & 90 DAS) was recorded with the application of 70% RDF+ Vermicompost @ 5 t/ha + Bio-Nitrogen (T8) at all the crop growth stages. However, it was statistically at par with 100% RDF + Vermicompost @ 5 t/ha + Bio-Nitrogen (T9) and 100% RDF + Bio-Nitrogen (T6) and significantly higher than rest of the treatments. At 90 DAS, application of 70% RDF+ Vermicompost @ 5 t/ha + Bio-Nitrogen (T8) increased crop growth rate by 50% and 96.4 % over 100% RDF+ Vermicompost @ 5 t/ha (T5) and Vermicompost @ 5 t/ha + Bio-nitrogen (T7), 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 (T8) and 100% RDF + Bio-Nitrogen (T6) 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 (T8) over 100% RDF + Vermicompost @ 5 t/ha (T5) and Vermicompost @ 5 t/ha+ Bio-nitrogen(T7), 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.

**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** |
| T1 | 1.6 | 8.6 | 11.2 |
| T2 | 1.7 | 9.9 | 15.6 |
| T3 | 1.8 | 12.3 | 12.6 |
| T4 | 1.8 | 11.8 | 15.1 |
| T5 | 1.7 | 9.1 | 14.8 |
| T6 | 2.2 | 15.6 | 19.1 |
| T7 | 1.9 | 10.4 | 11.3 |
| T8 | 2.6 | 17.8 | 22.2 |
| T9 | 2.3 | 16.7 | 20.8 |
| SEm± | 0.1 | 0.9 | 1.2 |
| CD 5 % | 0.3 | 2.7 | 3.5 |

**Table 3. 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** |
| T1 | 0.128 | 0.185 | 0.193 |
| T2 | 0.131 | 0.188 | 0.198 |
| T3 | 0.134 | 0.197 | 0.199 |
| T4 | 0.132 | 0.195 | 0.200 |
| T5 | 0.131 | 0.187 | 0.202 |
| T6 | 0.140 | 0.205 | 0.214 |
| T7 | 0.134 | 0.191 | 0.194 |
| T8 | 0.145 | 0.209 | 0.215 |
| T9 | 0.141 | 0.207 | 0.212 |
| SEm± | 0.002 | 0.003 | 0.004 |
| CD 5 % | 0.007 | 0.009 | 0.012 |

1. **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 (T8). 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 (T9) and 100% RDF + Bio nitrogen @ 20gm kg-1 seed (T6). Minimum seed yield (7.9 q ha-1) was observed in the control (T1), 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.* (2022).**

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 (T8) which was statistically at par with 100% RDF+ Vermicompost @ 5 ha-1+ Bio-Nitrogen @ 20gm kg-1 seed (T9) and 100% RDF + Bio nitrogen @ 20gm kg-1 seed (T6) but significantly higher than rest of the treatments. Application of 70% RDF + Vermicompost @ 5 t ha-1 + Bio nitrogen @ 20gm kg-1 seed (T8) resulted in increased stover yield by 59.2% and 134% over 100% RDF (T2) and control (T1), 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*., (2020)** as they reported that application of 100% NPK+ 50% Vermicompost showed maximum stover yield (3056 kg/ha).

 **Table 3. Effect of Integrated Nutrient Management on seed yield (q/ha) and stover yield (q/ha)**

|  |  |  |
| --- | --- | --- |
| **Treatment** | **Seed yield****(q/ha)** | **Stover yield****(q/ha)** |
| T1 | 7.93 | 8.30 |
| T2 | 10.90 | 12.20 |
| T3 | 12.43 | 14.00 |
| T4 | 20.27 | 11.17 |
| T5 | 21.04 | 11.09 |
| T6 | 34.87 | 16.10 |
| T7 | 20.74 | 14.20 |
| T8 | 36.33 | 19.43 |
| T9 | 35.20 | 16.87 |
| SEm± | 0.53 | 1.09 |
| CD 5 % | 1.59 | 3.35 |

1. **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 (T8). It is statistically at par with 100% RDF+ Vermicompost @ 5 ha-1+ Bio-Nitrogen @ 20gm kg-1 seed (T9) and 100% RDF + Bio nitrogen @ 20gm kg-1 seed (T6). The remaining treatments were significantly lower than 70% RDF + Vermicompost @ 5 t ha-1 + Bio nitrogen @ 20gm kg-1 seed (T8). The precent increased 141.4% & 250.9% over 100% RDF (T2) and control (T1), respectively. Minimum biological yield (15.8 q ha-1) was recorded under control (T1). 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*. (2015)** application of 100% RDF (20:30:15 Kg ha-1) + ZnSO4 5kg ha-1 + FeSO4 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 (T6). It was significantly higher than Control (T1), 100% RDF (T2) and Vermicompost @ 5 t ha-1 (T3) 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 (T6) by 45.0 % and 37.6 % was recorded over 100 % RDF (T2) and control (T1), 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.* (2023)** as they reported that application of 50% RDF + 50% RDN through compost + Rhizobium showed highest Harvest index (30.06)**.**

**Table 4. Effect of Integrated Nutrient Management on Biological yield (q/ha) and Harvest index**

|  |  |  |
| --- | --- | --- |
| **Treatment** | **Biological yield (q/ha)** | **Harvest index** |
| T1 | 15.87 | 49.19 |
| T2 | 23.10 | 46.67 |
| T3 | 26.43 | 46.72 |
| T4 | 31.43 | 65.36 |
| T5 | 32.13 | 65.92 |
| T6 | 51.50 | 67.68 |
| T7 | 34.93 | 59.40 |
| T8 | 55.77 | 65.46 |
| T9 | 52.07 | 67.61 |
| SEm± | 1.57 | 3.29 |
| CD 5 % | 4.72 | 9.86 |

1. **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 (T9). 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 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 (T8). It was significantly higher than rest of the treatments except 100% RDF + Bio nitrogen@ 20gm kg-1 seed (T6) and 100% RDF+ Vermicompost @ 5 ha-1+ Bio-Nitrogen @ 20gm kg-1 seed (T9). The results were in conformity with **Banotra *et al.* (2019)** 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 (T8). It was significantly higher than rest of the treatments except 100% RDF+ Vermicompost @ 5 ha-1+ Bio-Nitrogen @ 20gm kg-1 seed (T9) and 100% RDF + Bio nitrogen @ 20gm kg-1 seed (T6). Minimum net return (₹ 29530.67 ha-1) was recorded under control (T1). 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.* (2019)** 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 (T6). The result showed that 100% RDF + Bio nitrogen @ 20gm kg-1 seed (T6) higher than all the other treatments. Minimum B:C ratio (1.15) was recorded under control (T1). The results are in conformity with **Muwal & Dhaked (2022)** 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.

**Table 5. 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** |
| T1 | 25606.00 | 55136.67 | 29530.67 | 1.15 |
| T2 | 33758.00 | 75755.00 | 41997.00 | 1.24 |
| T3 | 36076.00 | 86411.67 | 50335.67 | 1.40 |
| T4 | 27876.00 | 140853.33 | 140853.33 | 4.05 |
| T5 | 42258.00 | 146258.89 | 104000.89 | 2.46 |
| T6 | 34058.00 | 242323.33 | 208265.33 | 6.12 |
| T7 | 36376.00 | 144148.15 | 107772.15 | 2.96 |
| T8 | 40703.00 | 252516.67 | 211813.67 | 5.20 |
| T9 | 42558.00 | 244640.00 | 202082.00 | 4.75 |
| SEm± | - | 3675.72 | 3675.72 | 0.12 |
| CD 5 % | - | 11019.00 | 11019.00 | 0.37 |

**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 (T8) 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.

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