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## Studies of organic manure and biofertilizer under on yield and economic response on black gram (*Vigna mungo* L.) at Gwalior

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### Abstract

A kharif-season field trial was carried out in 2025 at the Agriculture Research and Development Centre, Sakatpura, Vikrant University, Gwalior, Madhya Pradesh, to examine the effect of organic nutrient sources and seed-applied bio-fertilizers on yield components, productivity and monetary returns of black gram. Ten treatments were tested in a randomized block design with three replications. The nutrient combinations included vermicompost, farmyard manure and poultry manure, each integrated with PSB, *Rhizobium* or KSB, along with an absolute control. The integrated treatments improved crop performance over the control, and the strongest response was obtained with poultry manure @ 1.5 t ha<sup>-1</sup> + *Rhizobium* @ 20 g kg<sup>-1</sup> seed. This treatment produced the highest pods plant<sup>-1</sup> (38.2), pod length (5.8 cm), seeds pod<sup>-1</sup> (7.6), test weight (43.8 g), grain yield (1385 kg ha<sup>-1</sup>), straw yield (2450 kg ha<sup>-1</sup>) and biological yield (3835 kg ha<sup>-1</sup>). It also gave the highest gross return (₹1,08,030 ha<sup>-1</sup>), net return (₹77,030 ha<sup>-1</sup>) and B:C ratio (2.48), with 68.90 per cent higher grain yield and 97.72 per cent higher net return than the control. The response appeared to be associated with improved nodulation, sustained nutrient release, better nutrient availability and greater biomass partitioning. Under comparable agro-climatic situations, poultry manure @ 1.5 t ha<sup>-1</sup> integrated with *Rhizobium* seed inoculation @ 20 g kg<sup>-1</sup> seed may serve as a profitable nutrient management option for black gram.

**Keywords:** Black gram, *Rhizobium*, poultry manure, yield, net return, benefit-cost ratio

### Introduction

Black gram (*Vigna mungo* L.) is an important short-duration pulse crop grown for its protein-rich seed and for its role in maintaining soil fertility through symbiotic nitrogen fixation. Although the crop is cultivated across diverse seasons and production environments in India, its realized productivity is frequently constrained by low organic matter, inadequate nutrient supply and imbalanced fertilizer use. Improving nutrient management is therefore essential not only for yield enhancement but also for the economic viability of the crop.

Organic amendments such as farmyard manure (FYM), vermicompost and poultry manure contribute nutrients slowly, enhance soil physical condition, support moisture retention and stimulate microbial activity. In addition, seed inoculation with bio-fertilizers such as *Rhizobium*, phosphate solubilizing bacteria (PSB) and potassium solubilizing bacteria (KSB) can increase biological nitrogen fixation and improve the availability of relatively unavailable nutrients. Comparable benefits of integrated nutrient management in black gram have been reported in earlier studies with respect to yield attributes, seed yield and returns (Mehta *et al.*, 2015; Meena *et al.*, 2021; Singh *et al.*, 2022; Kumar *et al.*, 2023) [9, 8, 13, 1, 6].

The present experiment was undertaken to quantify the response of black gram yield attributes, yield and economics to selected organic manure and bio-fertilizer combinations under the Gwalior region of Madhya Pradesh.

### Materials and Methods

The experiment was conducted during kharif 2025 at the Agriculture Research and Development Centre, Sakatpura, Vikrant University, Gwalior, Madhya Pradesh.

The location falls under a semi-arid subtropical environment. Black gram variety LBG-752 was selected as the test crop. The trial followed a factorial randomized block design consisting of ten treatments and three replications.

Sowing was completed on 10 July 2025. Each gross plot measured 4.0 m × 3.6 m, while the net plot area used for yield estimation was 3.4 m × 3.0 m. Seeds were sown at a spacing of 30 cm × 10 cm with a seed rate of 20 kg ha<sup>-1</sup>. The recommended fertilizer dose considered for the crop was 20:40:20 kg ha<sup>-1</sup> N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O.

The treatment structure is given in Table 1. Organic manures were incorporated before sowing according to the treatment schedule. Seed inoculation with PSB, *Rhizobium* or KSB was done @ 20 g

kg<sup>-1</sup> seed for the respective treatments. Observations on yield attributes were taken from five randomly tagged plants in each plot. Grain and straw yields were harvested from the net plot and expressed as kg ha<sup>-1</sup>. Biological yield was estimated by adding grain and straw yield, and harvest index was computed as the ratio of grain yield to biological yield × 100 following the principle described by Donald and Hamblin (1976) [3]. Gross return, net return and B:C ratio were calculated using prevailing prices and treatment-wise cultivation costs. The data were analysed statistically for randomized block design, and treatment means were compared at the 5 per cent level of significance as described by Gomez and Gomez (1984) [4].

**Table 1:** Treatment combinations used in the experiment

| Treatment       | Treatment combination                                                                   |
|-----------------|-----------------------------------------------------------------------------------------|
| T <sub>1</sub>  | Absolute control                                                                        |
| T <sub>2</sub>  | Vermicompost @ 2 t ha <sup>-1</sup> + PSB @ 20 g kg <sup>-1</sup> seed                  |
| T <sub>3</sub>  | Vermicompost @ 2 t ha <sup>-1</sup> + <i>Rhizobium</i> @ 20 g kg <sup>-1</sup> seed     |
| T <sub>4</sub>  | Vermicompost @ 2 t ha <sup>-1</sup> + KSB @ 20 g kg <sup>-1</sup> seed                  |
| T <sub>5</sub>  | FYM @ 5 t ha <sup>-1</sup> + PSB @ 20 g kg <sup>-1</sup> seed                           |
| T <sub>6</sub>  | FYM @ 5 t ha <sup>-1</sup> + <i>Rhizobium</i> @ 20 g kg <sup>-1</sup> seed              |
| T <sub>7</sub>  | FYM @ 5 t ha <sup>-1</sup> + KSB @ 20 g kg <sup>-1</sup> seed                           |
| T <sub>8</sub>  | Poultry manure @ 1.5 t ha <sup>-1</sup> + PSB @ 20 g kg <sup>-1</sup> seed              |
| T <sub>9</sub>  | Poultry manure @ 1.5 t ha <sup>-1</sup> + <i>Rhizobium</i> @ 20 g kg <sup>-1</sup> seed |
| T <sub>10</sub> | Poultry manure @ 1.5 t ha <sup>-1</sup> + KSB @ 20 g kg <sup>-1</sup> seed              |

## Results and Discussion

### Yield attributes

Different organic manure and bio-fertilizer combinations caused measurable variation in yield attributes of black gram (Table 2). The best performance was observed under T<sub>9</sub>, where poultry manure @ 1.5 t ha<sup>-1</sup> was combined with *Rhizobium* @ 20 g kg<sup>-1</sup> seed. This treatment recorded 38.2 pods plant<sup>-1</sup>, 5.8 cm pod length, 7.6 seeds pod<sup>-1</sup> and 43.8 g test weight. Treatments T<sub>8</sub> and T<sub>10</sub>, both based on poultry manure with different bio-fertilizers,

ranked next, whereas the absolute control showed the lowest values for all recorded characters.

The superiority of poultry manure with *Rhizobium* may be related to a more favourable supply of nitrogen, enhanced nodulation, active microbial processes and improved movement of assimilates to developing pods and seeds. Similar improvements in black gram yield attributes under integrated nutrient management have been noted by Mahamud *et al.* (2022) [7], Singh *et al.* (2022) [7] and Kumar *et al.* (2023) [1, 6].

**Table 2:** Effect of organic manure and bio-fertilizers on yield attributes of black gram

| Treatment                                                                                                | Pods plant <sup>-1</sup> | Pod length (cm) | Seeds pod <sup>-1</sup> | Test weight (g) |
|----------------------------------------------------------------------------------------------------------|--------------------------|-----------------|-------------------------|-----------------|
| T <sub>1</sub> - Absolute control                                                                        | 24.5                     | 4.2             | 5.2                     | 34.5            |
| T <sub>2</sub> - Vermicompost @ 2 t ha <sup>-1</sup> + PSB @ 20 g kg <sup>-1</sup> seed                  | 31.8                     | 5.1             | 6.5                     | 38.8            |
| T <sub>3</sub> - Vermicompost @ 2 t ha <sup>-1</sup> + <i>Rhizobium</i> @ 20 g kg <sup>-1</sup> seed     | 30.5                     | 5.0             | 6.3                     | 37.9            |
| T <sub>4</sub> - Vermicompost @ 2 t ha <sup>-1</sup> + KSB @ 20 g kg <sup>-1</sup> seed                  | 31.0                     | 5.0             | 6.4                     | 38.2            |
| T <sub>5</sub> - FYM @ 5 t ha <sup>-1</sup> + PSB @ 20 g kg <sup>-1</sup> seed                           | 32.5                     | 5.2             | 6.7                     | 39.5            |
| T <sub>6</sub> - FYM @ 5 t ha <sup>-1</sup> + <i>Rhizobium</i> @ 20 g kg <sup>-1</sup> seed              | 33.8                     | 5.3             | 6.9                     | 40.2            |
| T <sub>7</sub> - FYM @ 5 t ha <sup>-1</sup> + KSB @ 20 g kg <sup>-1</sup> seed                           | 32.0                     | 5.2             | 6.6                     | 39.0            |
| T <sub>8</sub> - Poultry manure @ 1.5 t ha <sup>-1</sup> + PSB @ 20 g kg <sup>-1</sup> seed              | 36.5                     | 5.6             | 7.3                     | 42.5            |
| T <sub>9</sub> - Poultry manure @ 1.5 t ha <sup>-1</sup> + <i>Rhizobium</i> @ 20 g kg <sup>-1</sup> seed | 38.2                     | 5.8             | 7.6                     | 43.8            |
| T <sub>10</sub> - Poultry manure @ 1.5 t ha <sup>-1</sup> + KSB @ 20 g kg <sup>-1</sup> seed             | 35.5                     | 5.5             | 7.1                     | 41.5            |
| SEm±                                                                                                     | 1.25                     | 0.18            | 0.22                    | 1.05            |
| CD (P = 0.05)                                                                                            | 3.70                     | 0.52            | 0.65                    | 3.10            |
| CV (%)                                                                                                   | 9.8                      | 8.60            | 9.2                     | 8.90            |

### Yield

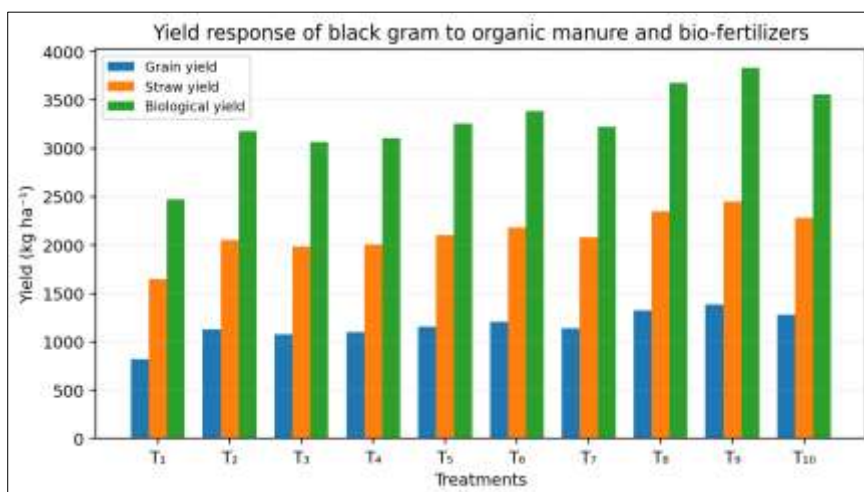
Grain, straw and biological yields responded distinctly to the nutrient treatments (Table 3 and Fig. 1). Grain yield varied from 820 kg ha<sup>-1</sup> in the control to 1385 kg ha<sup>-1</sup> under T<sub>9</sub>. Based on the critical difference, the yield recorded by T<sub>9</sub> was statistically at par with T<sub>8</sub> and T<sub>10</sub>. The same treatment also produced the highest straw yield (2450 kg ha<sup>-1</sup>) and biological yield (3835 kg ha<sup>-1</sup>), while the untreated control remained the poorest performer.

The yield advantage under T<sub>9</sub> can be explained by the combined contribution of readily mineralizable nutrients from poultry

manure and additional biological nitrogen fixation from *Rhizobium* inoculation. Higher pod number, seeds pod<sup>-1</sup> and test weight under this treatment contributed directly to improved grain yield, while the rise in straw and biological yield reflected better overall plant growth and dry matter accumulation. These findings are consistent with reports of Meena *et al.* (2021) [8], Rathod *et al.* (2020) [12], Mahamud *et al.* (2022) [7] and Parashar *et al.* (2023), who also observed higher black gram productivity under integrated nutrient management.

**Table 3:** Effect of organic manure and bio-fertilizers on yield of black gram

| Treatment                                                                                                | Grain yield (kg ha <sup>-1</sup> ) | Straw yield (kg ha <sup>-1</sup> ) | Biological yield (kg ha <sup>-1</sup> ) | Harvest index (%) |
|----------------------------------------------------------------------------------------------------------|------------------------------------|------------------------------------|-----------------------------------------|-------------------|
| T <sub>1</sub> - Absolute control                                                                        | 820                                | 1650                               | 2470                                    | 33.2              |
| T <sub>2</sub> - Vermicompost @ 2 t ha <sup>-1</sup> + PSB @ 20 g kg <sup>-1</sup> seed                  | 1125                               | 2050                               | 3175                                    | 35.4              |
| T <sub>3</sub> - Vermicompost @ 2 t ha <sup>-1</sup> + <i>Rhizobium</i> @ 20 g kg <sup>-1</sup> seed     | 1080                               | 1985                               | 3065                                    | 35.2              |
| T <sub>4</sub> - Vermicompost @ 2 t ha <sup>-1</sup> + KSB @ 20 g kg <sup>-1</sup> seed                  | 1100                               | 2005                               | 3105                                    | 35.4              |
| T <sub>5</sub> - FYM @ 5 t ha <sup>-1</sup> + PSB @ 20 g kg <sup>-1</sup> seed                           | 1155                               | 2100                               | 3255                                    | 35.5              |
| T <sub>6</sub> - FYM @ 5 t ha <sup>-1</sup> + <i>Rhizobium</i> @ 20 g kg <sup>-1</sup> seed              | 1205                               | 2180                               | 3385                                    | 35.6              |
| T <sub>7</sub> - FYM @ 5 t ha <sup>-1</sup> + KSB @ 20 g kg <sup>-1</sup> seed                           | 1140                               | 2080                               | 3220                                    | 35.4              |
| T <sub>8</sub> - Poultry manure @ 1.5 t ha <sup>-1</sup> + PSB @ 20 g kg <sup>-1</sup> seed              | 1325                               | 2350                               | 3675                                    | 36.0              |
| T <sub>9</sub> - Poultry manure @ 1.5 t ha <sup>-1</sup> + <i>Rhizobium</i> @ 20 g kg <sup>-1</sup> seed | 1385                               | 2450                               | 3835                                    | 36.1              |
| T <sub>10</sub> - Poultry manure @ 1.5 t ha <sup>-1</sup> + KSB @ 20 g kg <sup>-1</sup> seed             | 1280                               | 2280                               | 3560                                    | 36.0              |
| SEM±                                                                                                     | 45                                 | 80                                 | 110                                     | 0.85              |
| CD (P = 0.05)                                                                                            | 135                                | 240                                | 330                                     | NS                |
| CV (%)                                                                                                   | 9.2                                | 9.8                                | 10.1                                    | 4.5               |

**Fig 1:** Yield response of black gram to organic manure and bio-fertilizers

### Economics

Treatment-wise economics reflected both input costs and realized yield (Table 4 and Fig. 2). The cultivation cost ranged from ₹25,000 ha<sup>-1</sup> in the absolute control to ₹31,000 ha<sup>-1</sup> in T<sub>9</sub>. Despite its comparatively higher cost, T<sub>9</sub> generated the maximum gross return (₹1,08,030 ha<sup>-1</sup>), net return (₹77,030 ha<sup>-1</sup>) and B:C ratio (2.48). The next best treatment was T<sub>8</sub>, which recorded ₹1,03,350 ha<sup>-1</sup> gross return, ₹72,850 ha<sup>-1</sup> net return and a B:C ratio of 2.40. The control treatment produced the lowest returns and benefit-cost ratio.

The greater profitability of poultry manure + *Rhizobium* was mainly a consequence of higher grain and straw yields, which more than compensated for the additional input expenditure. Relative to the control, T<sub>9</sub> increased grain yield and gross return by 68.90 per cent and net return by 97.72 per cent. The treatment therefore produced the highest return per unit investment under the conditions of this experiment. Improvement in black gram returns through balanced or integrated nutrient supply has also been reported by Joshi *et al.* (2023) <sup>[5]</sup>, Kumar *et al.* (2023) <sup>[1, 6]</sup> and Arumugam *et al.* (2023) <sup>[1]</sup>.

**Table 4:** Effect of organic manure and bio-fertilizers on economics of black gram

| Treatment                                                                                                | Cost of cultivation (₹ ha <sup>-1</sup> ) | Gross return (₹ ha <sup>-1</sup> ) | Net return (₹ ha <sup>-1</sup> ) | B:C ratio |
|----------------------------------------------------------------------------------------------------------|-------------------------------------------|------------------------------------|----------------------------------|-----------|
| T <sub>1</sub> - Absolute control                                                                        | 25,000                                    | 63,960                             | 38,960                           | 1.56      |
| T <sub>2</sub> - Vermicompost @ 2 t ha <sup>-1</sup> + PSB @ 20 g kg <sup>-1</sup> seed                  | 28,500                                    | 87,750                             | 59,250                           | 2.08      |
| T <sub>3</sub> - Vermicompost @ 2 t ha <sup>-1</sup> + <i>Rhizobium</i> @ 20 g kg <sup>-1</sup> seed     | 28,200                                    | 84,240                             | 56,040                           | 1.99      |
| T <sub>4</sub> - Vermicompost @ 2 t ha <sup>-1</sup> + KSB @ 20 g kg <sup>-1</sup> seed                  | 28,350                                    | 85,800                             | 57,450                           | 2.03      |
| T <sub>5</sub> - FYM @ 5 t ha <sup>-1</sup> + PSB @ 20 g kg <sup>-1</sup> seed                           | 29,000                                    | 90,090                             | 61,090                           | 2.10      |
| T <sub>6</sub> - FYM @ 5 t ha <sup>-1</sup> + <i>Rhizobium</i> @ 20 g kg <sup>-1</sup> seed              | 29,500                                    | 93,990                             | 64,490                           | 2.18      |
| T <sub>7</sub> - FYM @ 5 t ha <sup>-1</sup> + KSB @ 20 g kg <sup>-1</sup> seed                           | 29,200                                    | 88,920                             | 59,720                           | 2.04      |
| T <sub>8</sub> - Poultry manure @ 1.5 t ha <sup>-1</sup> + PSB @ 20 g kg <sup>-1</sup> seed              | 30,500                                    | 1,03,350                           | 72,850                           | 2.40      |
| T <sub>9</sub> - Poultry manure @ 1.5 t ha <sup>-1</sup> + <i>Rhizobium</i> @ 20 g kg <sup>-1</sup> seed | 31,000                                    | 1,08,030                           | 77,030                           | 2.48      |
| T <sub>10</sub> - Poultry manure @ 1.5 t ha <sup>-1</sup> + KSB @ 20 g kg <sup>-1</sup> seed             | 30,000                                    | 99,840                             | 69,840                           | 2.33      |

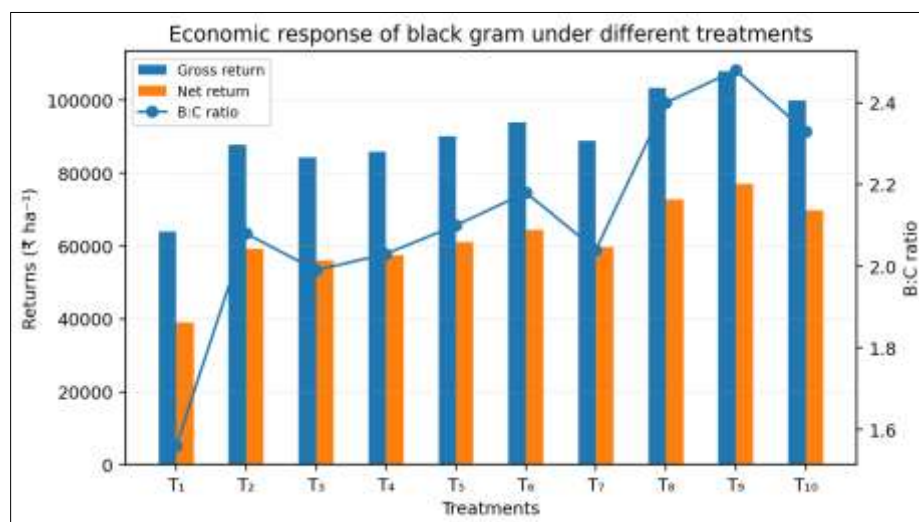


Fig 2: Economic response of black gram under different organic manure and bio-fertilizer treatments

## Conclusion

The study showed that integrating organic manures with bio-fertilizers improved the yield attributes, yield and economic returns of black gram under Gwalior conditions. Among the tested nutrient combinations, T<sub>9</sub> (poultry manure @ 1.5 t ha<sup>-1</sup> + *Rhizobium* @ 20 g kg<sup>-1</sup> seed) gave the most favourable performance, recording the highest pods plant<sup>-1</sup>, pod length, seeds pod<sup>-1</sup>, test weight, grain yield, straw yield, biological yield, gross return, net return and B:C ratio. On the basis of these results, poultry manure @ 1.5 t ha<sup>-1</sup> along with *Rhizobium* seed inoculation @ 20 g kg<sup>-1</sup> seed may be recommended for improving productivity and profitability of black gram in Gwalior and similar agro-climatic situations, subject to local field validation.

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