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Effect of Organic and Inorganic Nutrient Sources on Growth, Yield and Economics of Black gram

Chander Bhan[1*], D.P. Singh[2], K.K. Yadav[3], Pooja Sharma[4], Hari Singh[5], S.C. Meena[3], Maniram[6], Rajveer[1], Dinesh[1], Harpreet Singh[1], Archana Rani[1]

[1]Research Scholar, Department of Soil Science and Agricultural Chemistry, RCA, MPUAT, Rajasthan, India
[2]Assistant Professor, Department of Soil Science and Agricultural Chemistry, RCA, MPUAT, Udaipur, Rajasthan, India
[3]Professor, Department of Soil Science and Agricultural Chemistry, RCA, MPUAT, Udaipur, Rajasthan, India
[4]Assistant Professor, Department of Statistics, RCA, MPUAT, Rajasthan, India
[5]Professor, Department of Agricultural Economics, RCA, MPUAT, Udaipur, Rajasthan, India
[6]Subject Matter Specialist, KVK, Vallabhnagar, MPUAT, Udaipur, Rajasthan, India
*Corresponding author Email ID: Chanderbhan10082002@gmail.com

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Abstract*— The current study, "Effect of Organic and Inorganic nutrient sources on Black gram [Vigna mungo (L.) Hepper]" was carried out at the Instructional farm, Rajasthan College of Agriculture, Udaipur, Rajasthan during kharif, 2025. Fourteen treatments with three replications were included in the randomized block design of the field study. The application of 100% RDF + vermicompost + Rhizobium + PSB (T_{12}) resulted in significantly higher growth parameters, such as plant height, effective root nodulation and dry matter accumulations as well as yield attributes, number of pod plant^{-1}, number of seed pod^{-1} and test weight. These results were statistically comparable to those of T_{11} (100% RDF + FYM + Rhizobium + PSB) and T_{10} (100% RDF + vermicompost + Rhizobium), and outperformed the remaining treatments. The treatment T_{12}(100% RDF + vermicompost + Rhizobium + PSB) also produced significantly higher seed yield, haulm yield, biological yield, gross returns, and net returns was higher recorded in T_{11} (100% RDF + FYM + Rhizobium + PSB) statistically at par with T_{12} (100% RDF + vermicompost + Rhizobium + PSB. However, the administration of treatment T_{11} (100% RDF + FYM + Rhizobium + PSB) yielded the highest benefit-cost ratio that was statistically comparable to 100% RDF + vermicompost + Rhizobium + PSB (T_{12}).

***Keywords*— Vermicompost, Farm yard manure (FYM), Rhizobium, PSB.**

I. INTRODUCTION

Pulses are an important part of the diet of millions of people, particularly in developing countries, and are often popularly referred to as the "poor man's meat" because of their rich protein content and affordability. They play a vital role in ensuring food and nutritional security and are an important source of protein in cereal-based diets. In Indian agriculture, pulses have an additional advantage because they improve soil fertility through biological nitrogen fixation. Being leguminous crops, they develop a symbiotic association with Rhizobium bacteria in their root nodules, which helps in fixing atmospheric nitrogen. However, despite their nutritional and agricultural importance, pulse crops have received comparatively less attention since the Green Revolution, resulting in low productivity. Improving pulse productivity has consequently become an important challenge for achieving food and nutritional security (Pooniya *et al.,* 2015). Pulses contain approximately 20–25 per cent protein, which is nearly three times higher than rice and twice that of wheat, making them an indispensable component of the Indian diet (APEDA, 2023).

Among the important pulse crops, black gram [*Vigna mungo* (L.) Hepper], commonly known as urad or urdbean, occupies a prominent position. The crop is believed to have originated in India and is now widely cultivated in several Asian countries, including India, Pakistan and Myanmar. India is the largest producer and consumer of black gram in the world. During 2021–2022, approximately 28.4 lakh tonnes of black gram were produced from 47.6 lakh hectares, with an average productivity of 596 kg ha^{-1}. The crop contributes approximately 10.25 per cent to India's total pulse production and occupies nearly 29 per cent of the total area under pulses. During 2023–2024, Madhya Pradesh was the leading producer of black gram, followed by Uttar Pradesh, Andhra Pradesh, Rajasthan, Tamil Nadu and Maharashtra (Anonymous, 2024).

Black gram is primarily consumed as dhal and is widely used in the preparation of several traditional food products. Besides its importance as a source of protein, it also contains dietary fibre and several biologically active compounds. Different fractions of black gram contain phenolic compounds such as gallic, protocatechuic, gentisic, vanillic, syringic, caffeic and ferulic acids, which contribute to its antioxidant and other health-promoting properties (Girish *et al*., 2012).

The productivity of black gram is closely associated with the availability and efficient management of plant nutrients. Excessive and imbalanced use of chemical fertilizers can adversely affect soil health, reduce nutrient-use efficiency and increase environmental pollution (Aulakh and Adhya, 2005). Therefore, the use of biofertilizers and organic manures has gained importance in sustainable crop production. Biofertilizers improve nutrient availability and soil fertility, while organic manures provide a favourable environment for beneficial microorganisms (Yadav *et al*., 2022; Mannivanan *et al*., 2009). Phosphate-solubilizing bacteria help in making fixed phosphorus available to plants, whereas Rhizobium inoculation enhances biological nitrogen fixation and supports the growth and productivity of pulse crops (Sasidhar *et al*., 2022).

Vermicompost is another valuable organic source of plant nutrients, containing macro- and micronutrients, enzymes, growth-promoting substances and beneficial microorganisms. Its gradual release of nutrients provides a continuous supply to the crop and supports vegetative growth, pod formation and grain filling. It contains approximately 2.1–2.6 per cent nitrogen, 1.5–1.7 per cent phosphorus and 1.4–1.6 per cent potassium, along with several micronutrients (Giraddi, 2001; Giraddi *et al*., 2006). Thus, the integrated use of organic manures, inorganic fertilizers and biofertilizers offers a promising approach for improving soil fertility, nutrient-use efficiency and black gram productivity while maintaining the long-term sustainability of agricultural production (Sharma *et al*., 2008; Kumar *et al*., 2022).

II. MATERIAL AND METHODS

The research investigation was carried out in *kharif,* 2025 at Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan. It was located with latitude 24° 35′ 52.93″ N and longitude 73° 42′ 14.4″ E, at an elevation of 581.13 meters above mean sea level. This area falls under the Agro-climatic Zone IVa, which can be classified as the Sub-Humid Southern Plain and Aravalli hills region of the southern rajasthan. The region of Udaipur has a sub-tropical climate having slight winters and having moderate summer season including high humidity. It receives annually an average rainfall of 664.33 mm most of which can be comes from the Southwest Monsoon from July to September. The soil texture of the investigational field was clay-loam. The experiment comprises of total 14 treatments that should be laid out in a Randomized Block Design with three replications. The variety used during the study was MU-2 which is generally a high yielding variety. The treatments were applied according to the treatment details given in the Table 1. Recommended doses of P and K (40:20 kg ha^{-1}) was applied as basal application at the time of sowing and the half of the recommended dose of N (20 kg ha^{-1}) was applied as basal application and remaining half should be applied in two equal splits as top dressing. For performing the statistical analysis, standard procedures should be followed and ANOVA analysis should be done to evaluate the impact of various treatments on the studied parameters.

Table 1: Treatment details

Treatments	
T_1	Control
T_2	75% RDF
T_3	75% RDF + FYM @5 tons ha-1
T_4	75% RDF + vermicompost @ 3 tons ha-1
T_5	75% RDF + FYM @5 tons ha-1 + Rhizobium
T_6	75% RDF + vermicompost @ 3 tons ha-1 + Rhizobium
T_7	75% RDF + FYM @5 tons ha-1 + Rhizobium + PSB
T_8	75% RDF + vermicompost @ 3 tons ha-1 + Rhizobium + PSB
T_9	100% RDF + FYM @5 tons ha-1 + Rhizobium
T10	100% RDF + vermicompost @ 3 tons ha-1 + Rhizobium
T11	100% RDF + FYM @5 tons ha-1 + Rhizobium +

	PSB
T12	100% RDF + vermicompost @ 3 tons ha-1 + Rhizobium + PSB
T13	100% RDF + FYM @5 tons ha-1
T14	100% RDF + vermicompost @ 3 tons ha-1

III. RESULT AND DISCUSSION

Growth parameters:

As indicated by the data presented in Table 2, the application of organic and inorganic sources of nutrients significantly improved plant height, effective nodulation and dry matter accumulation in blackgram compared with the control treatment (T_1). The maximum plant height (60.2 cm), effective nodules (39.2 plant^{-1} at 40 DAS) and dry matter accumulation at 40 DAS (1143.0 kg ha^{-1}) and 55 DAS (1714.5 kg ha^{-1}) were recorded under T_{12} (100% RDF + vermicompost @ 3 t ha^{-1} + *Rhizobium* + PSB). The increase in plant height, effective nodules and dry matter accumulation under T_{12} over the control was 92.95, 92.16, 87.13 and 87.13 per cent, respectively. Treatment T_{11} (100% RDF + FYM + *Rhizobium* + PSB) and T_{10} (100% RDF + vermicompost + *Rhizobium*) remains statistically at par with Treatment T_{12}. The superior growth performance under integrated nutrient management may be attributed to the balanced and continuous supply of nutrients through inorganic fertilizers, vermicompost and biofertilizers. Vermicompost improved soil physical properties, nutrient availability and microbial activity, while *Rhizobium* enhanced biological nitrogen fixation and PSB improved phosphorus availability. The combined effect of improved nutrient availability, enhanced root development and efficient nutrient uptake promoted plant growth, nodulation and dry matter accumulation. Similar beneficial effects of integrated nutrient management and the combined application of organic manures, inorganic fertilizers and biofertilizers on growth, nodulation and dry matter production in blackgram have been reported by Sasidhar *et al*. (2022), Yadav *et al*. (2022), Kumar *et al*. (2024), Soni *et al*. (2024) and Kankarwal *et al*. (2025).

Table 2: Effect of organic and inorganic nutrient sources on plant height at harvest (cm), effective nodules (40 DAS) and dry matter accumulation

Treatment		Plant height (cm)	Effective nodules plant^{-1} (40 DAS)	Dry matter accumulation (kg ha^{-1})	
				40 DAS	55 DAS
T_1	Control	31.2	20.4	610.8	916.2
T_2	75% RDF	34.8	23.1	688.8	1033.2
T_3	75% RDF + FYM	37.5	25.8	765.0	1147.5
T_4	75% RDF + vermicompost	39.2	27.6	787.2	1180.8
T_5	75% RDF + FYM + Rhizobium	40.7	28.4	829.2	1243.8
T_6	75% RDF + vermicompost + Rhizobium	41.5	29.6	843.0	1264.5
T_7	75% RDF + FYM + Rhizobium + PSB	44.3	30.2	892.8	1339.2
T_8	75% RDF + vermicompost + Rhizobium + PSB	47.8	32.1	946.8	1420.2
T_9	100% RDF + FYM + Rhizobium	53.4	37	1081.2	1621.8
T10	100% RDF + vermicompost + Rhizobium	59.7	38.1	1120.8	1681.2
T11	100% RDF + FYM + Rhizobium + PSB	59.9	38.7	1132.8	1699.2
T12	100% RDF + vermicompost + Rhizobium + PSB	**60.2**	**39.2**	**1143.0**	**1714.5**
T13	100% RDF + FYM	52	34.5	1000.8	1501.2
T14	100% RDF + vermicompost	54.6	35.8	1041.0	1561.5
	SEm±	0.8	0.39	13.15	22.38
	C.D.(P=0.05)	2.35	1.14	38.25	65.08

Table 3: Effect of organic and inorganic nutrient sources on yield attributes

Treatments		No. of Pods plant^{-1}	No. of Seeds pod^{-1}	Test weight (g)
T_1	Control	21.20	5.01	27.45
T_2	75% RDF	22.45	5.36	33.18
T_3	75% RDF + FYM	23.90	5.72	34.06
T_4	75% RDF + vermicompost	24.15	5.84	34.42
T_5	75% RDF + FYM + Rhizobium	24.80	5.96	34.84
T_6	75% RDF + vermicompost + Rhizobium	25.10	6.12	35.16
T_7	75% RDF + FYM + Rhizobium + PSB	25.95	6.28	35.72
T_8	75% RDF + vermicompost + Rhizobium + PSB	26.85	6.55	36.48
T_9	100% RDF + FYM + Rhizobium	29.60	7.42	38.85
T10	100% RDF + vermicompost + Rhizobium	31.78	8.59	40.93
T11	100% RDF + FYM + Rhizobium + PSB	32.10	8.67	41.68
T12	100% RDF + vermicompost + Rhizobium + PSB	**32.40**	**8.71**	**42.12**
T13	100% RDF + FYM	27.90	6.88	37.24
T14	100% RDF + vermicompost	28.45	7.10	37.96
	SEm±	0.657	0.48	0.1
	CD (P=0.05)	1.39	0.29	1.79

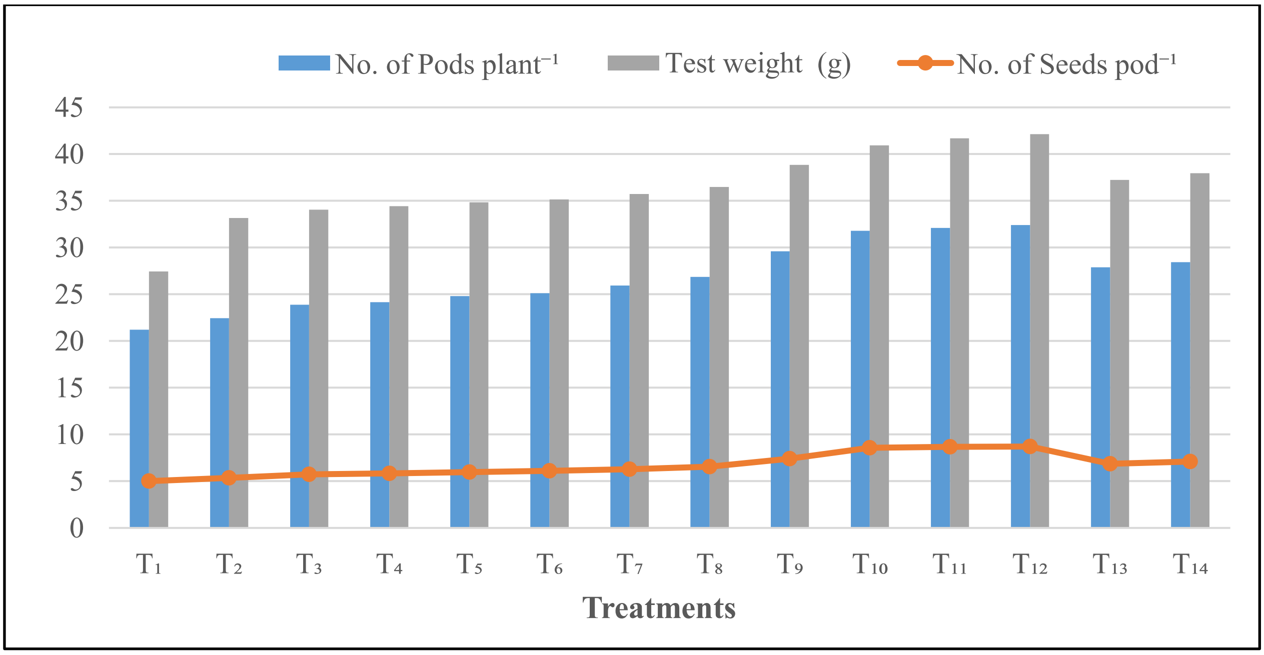

Fig. 1 Effect of organic and inorganic nutrient sources on yield attributes

Table 4: Effect of organic and inorganic nutrient sources on yield parameters

Treatments		Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index (%)
T_1	Control	549	1018	1567	35.03
T_2	75% RDF	638	1148	1786	35.07
T_3	75% RDF + FYM	690	1275	1965	35.1
T_4	75% RDF + vermicompost	714	1312	2026	35.11
T_5	75% RDF + FYM + Rhizobium	743	1382	2125	35.11
T_6	75% RDF + vermicompost + Rhizobium	766	1405	2171	35.18
T_7	75% RDF + FYM + Rhizobium + PSB	821	1488	2309	35.25
T_8	75% RDF + vermicompost + Rhizobium + PSB	856	1578	2434	35.27
T_9	100% RDF + FYM + Rhizobium	990	1802	2792	35.72
T10	100% RDF + vermicompost + Rhizobium	1038	1868	2906	35.87
T11	100% RDF + FYM + Rhizobium + PSB	1056	1888	2944	35.38
T12	100% RDF + vermicompost + Rhizobium + PSB	**1072**	**1905**	**2977**	36.01
T13	100% RDF + FYM	912	1668	2580	35.3
T14	100% RDF + vermicompost	950	1735	2685	35.46
SEm±		14.1	22.11	25.33	0.5
CD (P=0.05)		40.98	64.29	73.63	NS

Yield attributes:

As indicated by the data presented in Table 3, the application of organic and inorganic sources of nutrients significantly improved the yield attributes of blackgram. The maximum number of pods plant^{-1} (32.40), seeds pod^{-1} (8.71) and test weight (42.12 g) were recorded under T_{12} (100% RDF + vermicompost @ 3 t ha^{-1} + *Rhizobium* + PSB), which was significantly superior to T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, T_{13} and T_{14}, whereas the minimum values were recorded under T_1 (control), being 21.20 pods plant^{-1}, 5.01 seeds pod^{-1} and 27.45 g, respectively. Treatment T_{11} (100% RDF + FYM + *Rhizobium* + PSB) and T_{10} (100% RDF + vermicompost + *Rhizobium*) remains statistically at par with Treatment T_{12}. The increase in number of pods plant^{-1}, seeds pod^{-1} and test weight under T_{12} over the control was 52.83, 73.85 and 53.44 per cent, respectively. The superior performance of T_{12} may be attributed to the balanced and continuous supply of nutrients through inorganic fertilizers, vermicompost and biofertilizers, which improved root growth, nutrient availability and nutrient uptake. The combined application of vermicompost, *Rhizobium* and PSB with 100% RDF enhanced biological nitrogen fixation, phosphorus availability and microbial activity, thereby promoting greater photosynthetic activity and assimilate production. Efficient translocation of photosynthates towards reproductive parts consequently resulted in increased pod formation, seed development and test weight of black gram. Similar beneficial effects of integrated nutrient management involving organic manures, inorganic fertilizers and biofertilizers on growth and yield attributes of blackgram have been reported by Sasidhar *et al*. (2022), Yadav *et al*. (2022), Kumar *et al*. (2024), Soni *et al*. (2024) and Kankarwal *et al*. (2025).

Yield parameters:

Data presented in Table 4 revealed that the application of different combinations of organic and inorganic sources of nutrients significantly enhanced the yield parameters of black gram, viz., seed yield, haulm yield and biological yield. The maximum seed yield (1072 kg ha^{-1}), haulm yield (1905 kg ha^{-1}) and biological yield (2977 kg ha^{-1}) were recorded under T_{12} (100% RDF + vermicompost @ 3 t ha^{-1} + Rhizobium + PSB), whereas the minimum values were recorded under T_1 (control), being 549, 1018 and 1567 kg ha^{-1}, respectively. The data further indicated that the increase in seed yield, haulm yield and biological yield under T_{12} over T_1 was 95.26, 87.13 and 89.98 per cent, respectively. The higher yield under T_{12} may be attributed to the balanced and continuous supply of nutrients through inorganic fertilizers, vermicompost and biofertilizers, which enhanced root growth, nutrient availability, biological nitrogen fixation and phosphorus availability. The improved nutritional environment promoted greater photosynthetic activity, assimilate production and translocation towards the developing reproductive organs, resulting in higher seed and biomass production. The combined application of organic manure and biofertilizers also improved soil fertility and microbial activity, thereby supporting better crop growth and yield formation. Mohammad *et al*. (2017) reported that the integrated application of phosphorus and bio-organics improved the yield and soil fertility status. Similarly, Amruta *et al*. (2015), Meena *et al*. (2013), Yadav *et al*. (2021) and Singh *et al*. (2017) also reported significant improvement in yield and yield attributes of pulse crops through the integrated use of inorganic fertilizers, organic manures and biofertilizers.

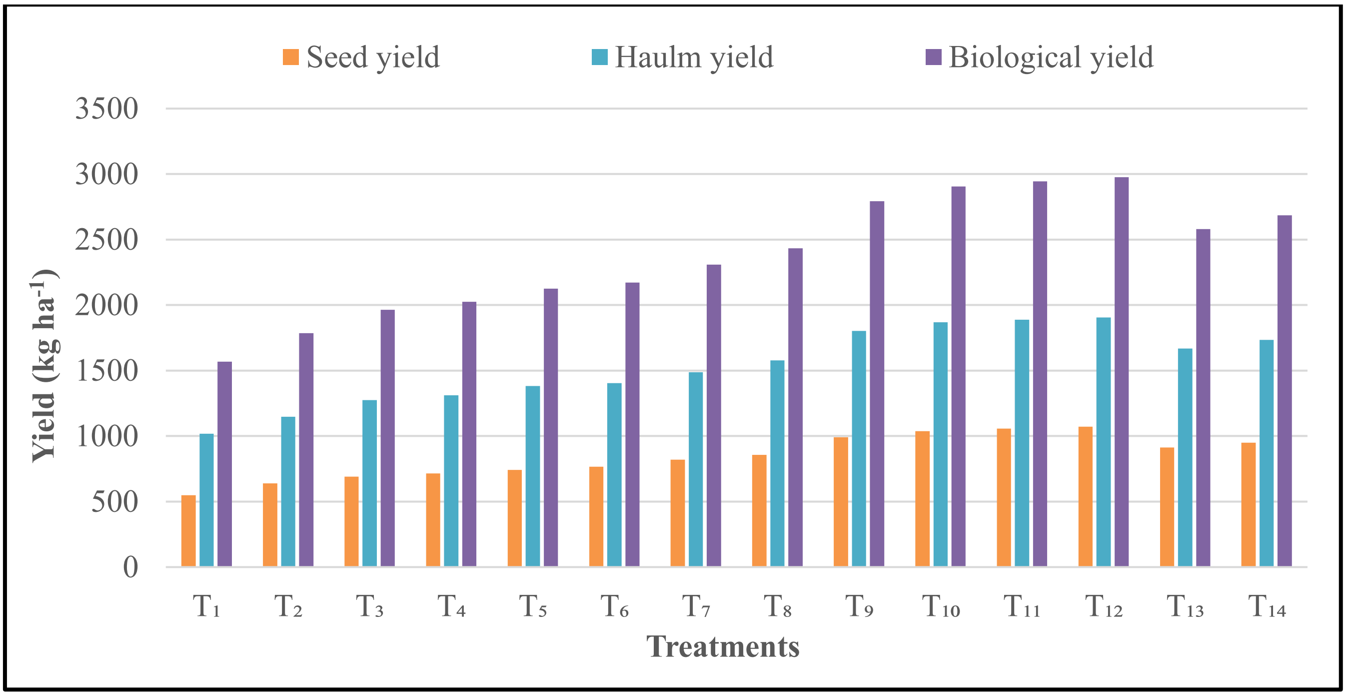

Fig. 2: Effect of organic and inorganic nutrient sources on yield Parameters

Table 5: Effect of organic and inorganic nutrient sources on economics of black gram

Treatments		Gross return (₹ ha^{-1})	Net returns (₹ ha^{-1})	Benefit-Cost Ratio
T_1	Control	46894	26210	1.27
T_2	75% RDF	54200	31524	1.39
T_3	75% RDF + FYM	58920	26244	0.80
T_4	75% RDF + vermicompost	60944	24768	0.68
T_5	75% RDF + FYM + *Rhizobium*	63650	30854	0.94
T_6	75% RDF + vermicompost + *Rhizobium*	65968	29672	0.82
T_7	75% RDF + FYM + *Rhizobium* + PSB	70014	37068	1.13
T_8	75% RDF + vermicompost + *Rhizobium* + PSB	73080	36634	1.01
T_9	100% RDF + FYM + Rhizobium	84828	51370	1.54
T10	100% RDF + vermicompost + *Rhizobium*	88416	51458	1.39
T11	100% RDF + FYM + Rhizobium + PSB	90080	**56472**	**1.68**

T12	100% RDF + vermicompost + *Rhizobium* + PSB	**91236**	54128	1.46
T13	100% RDF + FYM	77808	44470	1.33
T14	100% RDF + vermicompost	81220	44382	1.20
	SEm±	1038	1038	0.04
	CD (P=0.05)	3018	3018	0.15

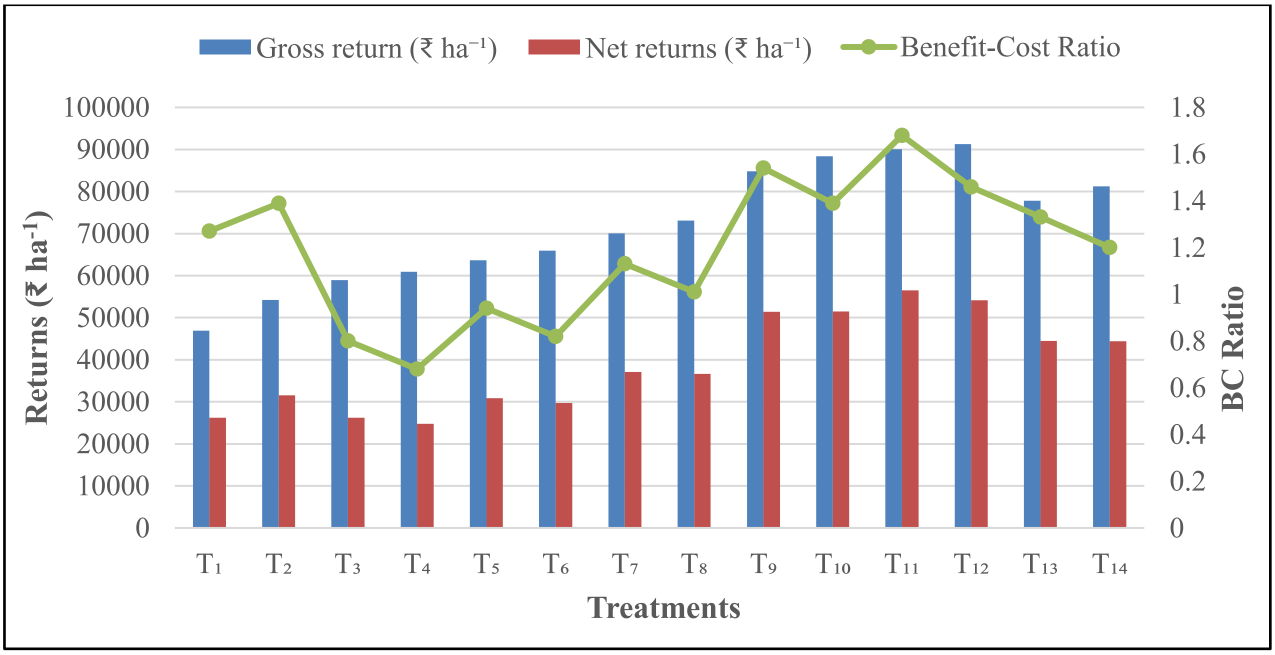

Fig. 3 Effect of organic and inorganic nutrient sources on economics of black gram

Economics:

As indicated by the data presented in Table 5, the application organic and inorganic sources of nutrients significantly influenced the economic returns of blackgram. The highest gross return (₹91,236 ha^{-1}) was recorded under T$_{12}$ (100% RDF + vermicompost @ 3 t ha^{-1} + *Rhizobium* + PSB), followed by T$_{11}$ and T$_{10}$, owing to the higher seed and haulm yields obtained under this treatment. The highest net return (₹56,121.80 ha^{-1}) and B:C ratio (1.66) were recorded under T$_{11}$ (100% RDF + FYM @ 5 t ha^{-1} + Rhizobium + PSB). The superior economic performance of T$_{11}$ may be attributed to its higher seed and haulm production combined with the comparatively lower cost of FYM than vermicompost, which resulted in better economic returns. In contrast, although T$_{12}$ recorded the highest seed, haulm and gross returns, the higher cost of vermicompost reduced its net return and B:C ratio. The improved economic returns under integrated nutrient management may therefore be attributed to the combined effect of enhanced crop productivity and efficient utilization of applied nutrients. Similar beneficial effects of integrated nutrient management on the economics and profitability of pulse crops have been reported by Mohammad *et al.* (2017), Meena *et al.* (2013), Yadav *et al.* (2021), Singh *et al.* (2017) and Soni *et al.* (2024).

IV. CONCLUSION

Based on the findings of the present investigation, it can be concluded that the application of organic and inorganic sources of nutrients significantly improved the growth, yield attributes, yield and economic returns of blackgram over the control treatment. Among the different treatments, T$_{12}$ (100% RDF + vermicompost @ 3 t ha^{-1} + *Rhizobium* + PSB) recorded the maximum plant height, effective nodules, dry matter accumulation at 40 DAS and 55 DAS, as well as the highest number of pods plant^{-1}, seeds pod^{-1}, test weight, seed yield, haulm yield and biological yield. The highest gross return (₹91,236 ha^{-1}) was also recorded under T$_{12}$. However, the highest net return (₹56,121.80 ha^{-1}) and B:C ratio (1.66) were recorded under T$_{11}$ (100% RDF + FYM @ 5 t ha^{-1} + *Rhizobium* + PSB), owing to its high productivity and comparatively lower cost of FYM than vermicompost. Therefore, the application of 100% RDF + FYM @ 5 t ha^{-1} + *Rhizobium* + PSB (T$_{11}$) be recommended for obtaining higher productivity and profitability of blackgram under the conditions of the present investigation.

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