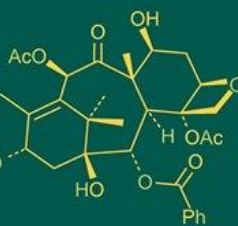
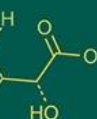
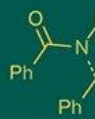


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Economic analysis of black gram (*Vigna mungo*) cultivation with organic and inorganic fertilizers under Moringa (*Moringa oleifera*) based agroforestry systems

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Abstract

A field experiment was carried out during 2024-2025 at Forest Nursery and Research center, College of Forestry, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj to study the effect of integrated nutrient management on economics of black gram (*Vigna mungo* L.) under Moringa (*Moringa oleifera*) based agroforestry system. The experiment was conducted in randomized block design with three replications comprising of 22 nutrient management treatments on black gram variety 'Shekhar-2'. The treatments were different levels of recommended dose of fertilizer (RDF) in combination with farmyard manure (FYM), poultry manure, vermicompost and Rhizobium culture. The economic parameters like cost of cultivation, gross return, net return and benefit: cost (B:C) ratio were worked out. The cost of cultivation ranged from Rs. 35,033 ha⁻¹ in the control (T₁) to Rs. 64,989 ha⁻¹ in T₂₂. The highest gross return (₹1,23,363 ha⁻¹), net return (₹58,374 ha⁻¹) and B:C ratio (1.90) were obtained with T₂₂ (75% RDF + 5 t ha⁻¹ Vermicompost + Rhizobium culture) followed by T₂₀ (75% RDF + 5 t ha⁻¹ Poultry manure + Rhizobium culture) with a gross return of ₹1,15,416 ha⁻¹, net return of ₹53,094 ha⁻¹ and B:C ratio of 1.85. Control recorded gross return of ₹49,440 ha⁻¹, net return of ₹14,407 ha⁻¹ and B:C ratio of 1.41. The results revealed that the combined application of organic fertilizer, vermicompost and Rhizobium improved the economic efficiency of black gram production even when the cost of the organic inputs was higher. Among the treatments evaluated, the treatment (T₂₂) 75% RDF + 5 t ha⁻¹ Vermicompost + Rhizobium culture was found to be the most economically promising nutrient management practice under the experimental conditions.

Keywords: Agroforestry systems, black gram, FYM, economics, poultry manure, rhizobium, Vermicompost

Introduction

Agroforestry is a sustainable land management approach that combines trees and agricultural crops to improve productivity, soil health, biodiversity, and ecological sustainability. Trees recycle nutrients from deep soil horizons and litterfall organic matter. They may also provide farmers with other goods and income. It mitigates climate change by sequestering carbon in tree biomass and in soil organic matter (Garrity, 2004) [7].

Moringa oleifera is a useful multi-functional tree for tropical and subtropical agroforestry systems because of its fast growing, drought tolerant and requires few resources, and has wide nutritional, medicinal and economic uses (Fuglie, 2001) [6]. It can also provide additional environmental benefits by producing biomass and sequestering carbon (Adekiya *et al.* 2020) [11]. Black gram (*Vigna mungo* L.) is an important short duration legume which is highly valued for its nutritional richness, flexibility and its ability to fix atmospheric nitrogen. It contains 22-24% protein and 56.6-59.6% carbohydrates. It is best suited for tropical and sub-tropical agro-climatic regions and its short growth duration makes it suitable for multi cropping and intercropping systems with agroforestry (Tomar *et al.*, 2011, Selvakumar *et al.*, 2012) [16, 14].

However, the availability of nutrients is a major factor that influences agricultural productivity, more so in situations where crops are grown together with trees. Integrated nutrient management (INM) is the integrated use of inorganic fertilizers, organic manures and biofertilizers in synergy to improve nutrient-use efficiency, maintain soil health and ensure sustained production (Meena *et al.*, 2015; Dhakal *et al.*, 2016) [12, 5].

Organic supplements such as vermicompost, farmyard manure and poultry manure may improve soil physical characteristics, microbial activity and nutrient availability, whereas Rhizobium inoculation could improve biological nitrogen fixation in legumes (Vessey 2003; Bhatt *et al.* 2013) ^[17, 3]. Vermicompost is an organic nutrition source that supplies nutrients and physiologically active substances in a gradually available form, which enhances root development, nutrient absorption, and agricultural yield (Arancon *et al.*, 2004) ^[2]. FYM enhances soil structure, increases moisture retention capacity and microbial activity along with supply of organic matter and nutrients (Gaur 1999; Ghosh *et al.*, 2004) ^[8, 9]. The well decomposed poultry manure is able to greatly enhance the soil fertility and provide readily available nutrients due to its relatively high nutrient density and rapid mineralization (Gupta & Sharma, 2010) ^[10]. Rhizobium forms symbiotic association with leguminous plants leading to fixation of atmospheric nitrogen, thereby improving nitrogen nutrition and agricultural yield (Meena *et al.*, 2016; Bhavya *et al.*, 2018) ^[13, 4].

An agroforestry system based on *Moringa oleifera* with

integrated nutrient management (INM) can be an effective approach to increase black gram yield, improve soil health, optimize the use of resources and ensure sustainability. The present research was carried out to evaluate the effect of integrated nutrient management techniques i.e. chemical fertilizers, organic manures and biofertilizers on the growth of black gram grown under moringa based agroforestry system. The objectives of the experiment were to evaluate the economics of different treatments.

Materials and Methods

The experiment was conducted at Forest Nursery and Research Center, College of Forestry, Sam Higginbottom University, Prayagraj during 2024-2025 on a Moringa plantation with a spacing of 9 × 9 m². The research site is located at latitude 25° 24' 42" N and longitude 81° 50' 56" and elevation at 98m above mean Sea level. The location is situated to the southeast of Uttar Pradesh and has a tropical to sub-tropical climate with temperature ranging from 5 °C in winter to more than 45 °C in summer and an average annual rainfall of 1100 mm mainly during the monsoon months from July to September.

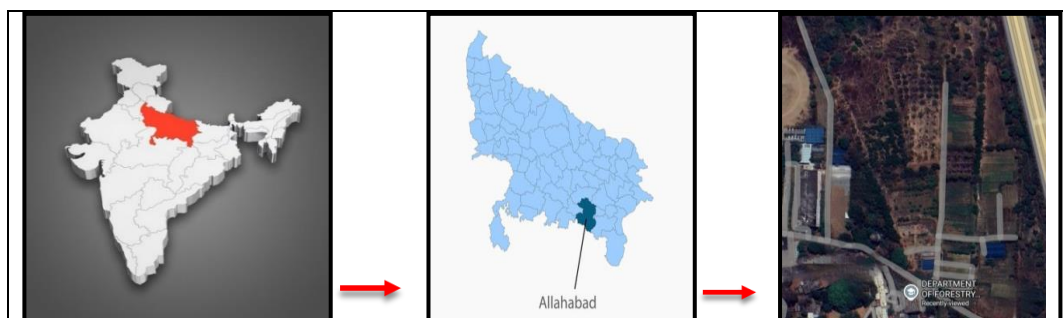


Fig 1: Study Area (Forest Nursery and Research Center) at College of Forestry, SHUATS, Prayagraj, Uttar Pradesh

The experiment was conducted in a randomized block design (RBD) with 22 treatment combinations and 66 plots (2 × 2 m²) of Black gram variety “Shekhar-2”. These treatments varied in use of recommended doses of fertilizers

(RDF) and mixture of rhizobium culture and different organic amendments like farmyard manure (FYM), poultry manure and vermicompost.

Table 1: Treatment Combinations of Research Experiment

Symbol	Treatment Combinations
T ₁	Control
T ₂	RDF 0% + Rhizobium culture
T ₃	RDF 0% + 2.5 t/ha FYM + Rhizobium culture
T ₄	RDF 0% + 5 t/ha FYM + Rhizobium culture
T ₅	RDF 0% + 2.5 t/ha POULTRY MANURE + Rhizobium culture
T ₆	RDF 0% + 5 t/ha POULTRY MANURE + Rhizobium culture
T ₇	RDF 0% + 2.5 t/ha VERMICOMPOST + Rhizobium culture
T ₈	RDF 0% + 5 t/ha VERMICOMPOST + Rhizobium culture
T ₉	RDF 50% + Rhizobium culture
T ₁₀	RDF 50% + 2.5 t/ha FYM + Rhizobium culture
T ₁₁	RDF 50% + 5 t/ha FYM + Rhizobium culture
T ₁₂	RDF 50% + 2.5 t/ha POULTRY MANURE + Rhizobium culture
T ₁₃	RDF 50% + 5 t/ha POULTRY MANURE + Rhizobium culture
T ₁₄	RDF 50% + 2.5 t/ha VERMICOMPOST + Rhizobium culture
T ₁₅	RDF 50% + 5 t/ha VERMICOMPOST + Rhizobium culture
T ₁₆	RDF 75% + Rhizobium culture
T ₁₇	RDF 75% + 2.5 t/ha FYM + Rhizobium culture
T ₁₈	RDF 75% + 5 t/ha FYM + Rhizobium culture
T ₁₉	RDF 75% + 2.5 t/ha POULTRY MANURE + Rhizobium culture
T ₂₀	RDF 75% + 5 t/ha POULTRY MANURE + Rhizobium culture
T ₂₁	RDF 75% + 2.5 t/ha VERMICOMPOST + Rhizobium culture
T ₂₂	RDF 75% + 5 t/ha VERMICOMPOST + Rhizobium culture

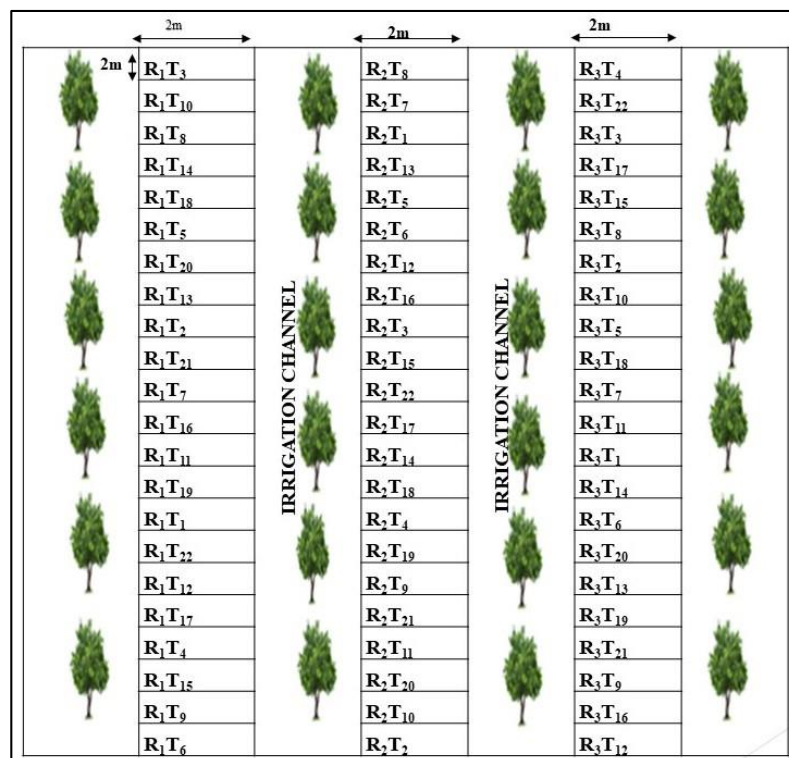


Fig 2: Experimental Layout

Results and Discussion

Table 2 shows the effect of different level of recommended doses of fertilizers (RDF) and mixture of rhizobium culture and different organic amendments like farmyard manure (FYM), poultry manure and vermicompost on the economics of Black gram. It was noted that the economics of Black gram was greatly influenced by different level of recommended doses of fertilizers (RDF) and mixture of rhizobium culture and 2.5 t ha⁻¹ and 5 t ha⁻¹ of organic amendments like farmyard manure (FYM), poultry manure and vermicompost. Variations in cultivation costs resulted in

different production costs. The cost of cultivation increases with increasing level of RDF. However, there was a maximum B:C ratio at T₂₂ (75% RDF + 5 t ha⁻¹ Vermicompost with Rhizobium culture) i.e., 1.90. Increases in level of RDF and Organic manure from the lowest to the highest significantly improved gross returns, net returns and benefit cost ratio. This can be attributed to the fact that the application of Integrated Nutrient Management from lowest to highest increased the yield of Black gram. These results are consistent with the experimental findings of (Kumar *et al.*, 2020; Singh *et al.*, 2019) [11, 15].

Table 2: Economic Analysis of Black Gram (*Vigna mungo* L.) Cultivation with Integrated Nutrient Management under Moringa (*Moringa oleifera*) based Agroforestry System

Treatment	Treatment Combination	Cost of Cultivation ha ⁻¹ (Rs.)	Gross Return ha ⁻¹ (Rs.)	Net Return ha ⁻¹ (Rs.)	B:C Ratio
T ₁	Control	35033	49440	14407	1.41
T ₂	RDF 0% + Rhizobium culture	35247	52698	17451	1.50
T ₃	RDF 0% + 2.5 t/ha FYM + Rhizobium culture	44580	59588	15008	1.34
T ₄	RDF 0% + 5 t/ha FYM + Rhizobium culture	53913	66718	12805	1.24
T ₅	RDF 0% + 2.5 t/ha POULTRY MANURE + Rhizobium culture	45913	62002	16089	1.35
T ₆	RDF 0% + 5 t/ha POULTRY MANURE + Rhizobium culture	56580	68422	11842	1.21
T ₇	RDF 0% + 2.5 t/ha VERMICOMPOST + Rhizobium culture	47247	63458	16211	1.34
T ₈	RDF 0% + 5 t/ha VERMICOMPOST + Rhizobium culture	59247	71082	11835	1.20
T ₉	RDF 50% + Rhizobium culture	39075	56860	17785	1.46
T ₁₀	RDF 50% + 2.5 t/ha FYM + Rhizobium culture	48408	74734	26326	1.54
T ₁₁	RDF 50% + 5 t/ha FYM + Rhizobium culture	57741	81350	23609	1.41
T ₁₂	RDF 50% + 2.5 t/ha POULTRY MANURE + Rhizobium culture	49741	77744	28003	1.56
T ₁₃	RDF 50% + 5 t/ha POULTRY MANURE + Rhizobium culture	60408	84658	24250	1.40
T ₁₄	RDF 50% + 2.5 t/ha VERMICOMPOST + Rhizobium culture	51075	80816	29741	1.58
T ₁₅	RDF 50% + 5 t/ha VERMICOMPOST + Rhizobium culture	63075	89706	26631	1.42
T ₁₆	RDF 75% + Rhizobium culture	40989	58570	17581	1.43
T ₁₇	RDF 75% + 2.5 t/ha FYM + Rhizobium culture	50322	93632	43310	1.86
T ₁₈	RDF 75% + 5 t/ha FYM + Rhizobium culture	59655	101110	41455	1.69
T ₁₉	RDF 75% + 2.5 t/ha POULTRY MANURE + Rhizobium culture	51655	96374	44719	1.87
T ₂₀	RDF 75% + 5 t/ha POULTRY MANURE + Rhizobium culture	62322	115416	53094	1.85
T ₂₁	RDF 75% + 2.5 t/ha VERMICOMPOST + Rhizobium culture	52989	98376	45387	1.86
T ₂₂	RDF 75% + 5 t/ha VERMICOMPOST + Rhizobium culture	64989	123363	58374	1.90

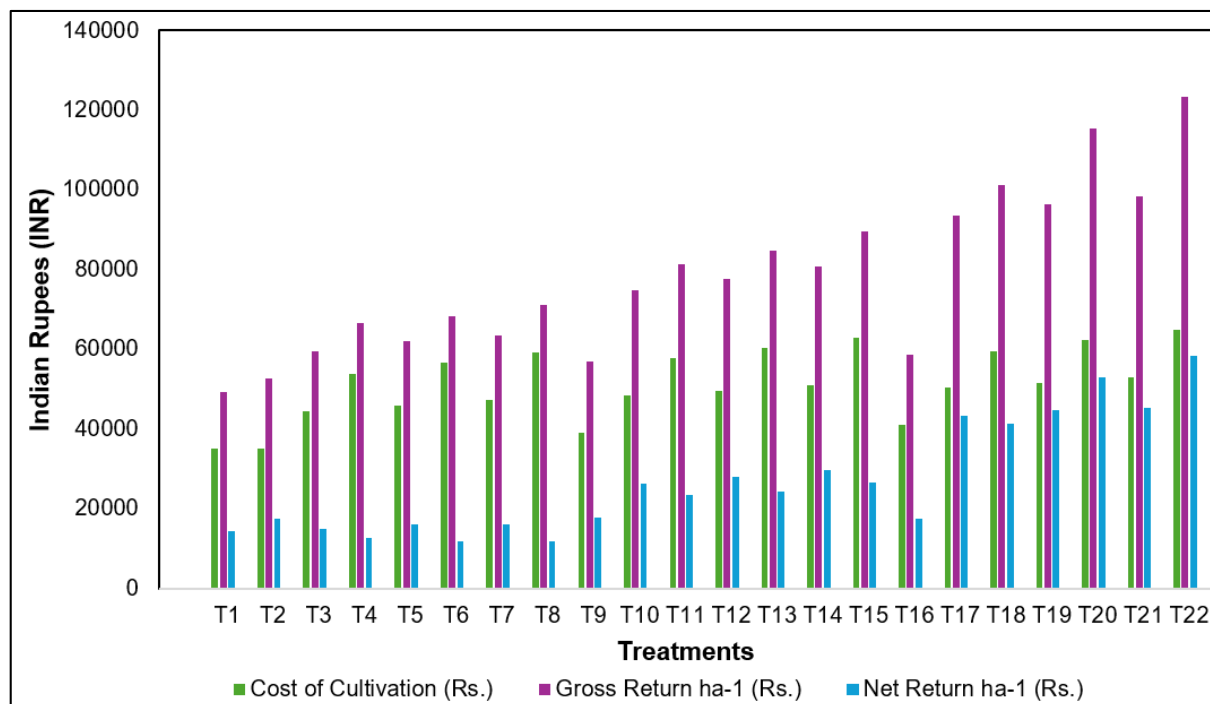


Fig 3: Economic Analysis of Black Gram (*Vigna mungo* L.) Cultivation under Moringa (*Moringa oleifera*) based Agroforestry System

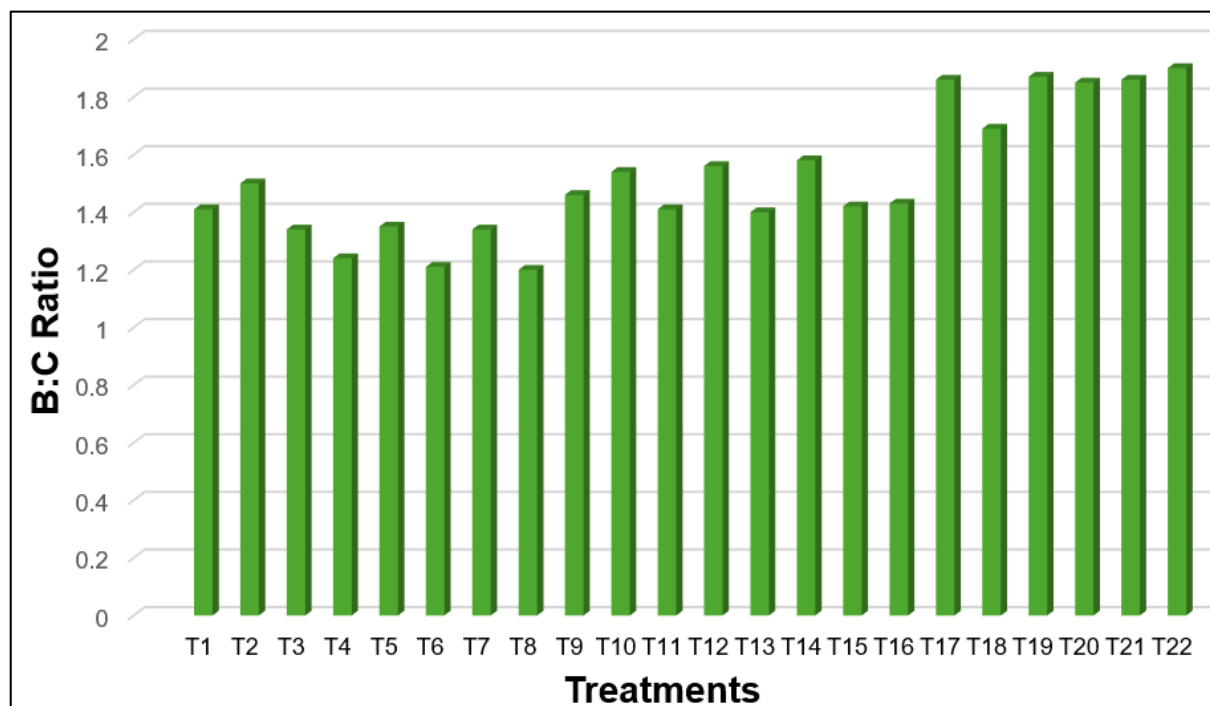


Fig 4: B:C Ratio of Black Gram (*Vigna mungo* L.) Cultivation under Moringa (*Moringa oleifera*) based Agroforestry System

Conclusion

Economic analysis showed that the integrated nutrient management significantly increased the profitability of black gram as against control and treatments with organic manures without adequate inorganic fertilizer. The treatment T₂₂ recorded the highest cost of cultivation (₹64,989 ha⁻¹) but maximum gross return (₹1,23,363 ha⁻¹), net return (₹58,374 ha⁻¹) and B:C ratio (1.90). Thus, T₂₂ (75% RDF + 5 t ha⁻¹ Vermicompost + Rhizobium culture) was observed to be the most economic treatment among the various nutrient management combinations. The results indicated that the combined application of organic fertilizer, vermicompost and Rhizobium enhanced the productivity and profitability of black gram under the experimental

conditions and can be recommended as a promising nutrient management strategy for sustainable black gram production.

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