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Economic Benefits of NPK and Organic Amendments on Green Gram Yield

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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 research study titled Economic benefits of application of NPK, fermented organic manures and mycorrhiza on yield and production of green gram (*Vigna radiata* L.) *Var.* PDM-139." was conducted during the Zaid season of 2023 at the Central Research Farm, Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj, Uttar Pradesh, India. The experimental layout followed a 3x3 Randomized Block Design (RBD), incorporating three levels of fermented organic manure (0%, 50%, and 100%), Mycorrhiza (0%, 50%, and 100%), and N, P, K at the Recommended Dose of Fertilizers (RDF). The variety chosen was PDM-139, which was released

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by the State Variety Release Committee (SVRC) of Uttar Pradesh in 1974. The recorded average yield ranged from 6 to 9 quintals per hectare. The response of total seed yield of green gram recorded as influenced by different levels NPK, fermented organic manure and mycorrhizal inoculation. The seed yield of green gram was found to be increased significantly with the increase in levels of NPK, fermented organic manure and mycorrhizal inoculation. The maximum seed yield was recorded as 16.42 (q ha^{-1}) T_9 (NPK@RDF + M_2@ 10Kg ha^{-1} 50% + F_2@ 50 l ha^{-1} 50%) which was higher than any other treatment combination and the minimum seed yield was recorded as 8.76 (q ha^{-1}) in T_1 (control). However, as for the economy of different treatments is concerned, the treatment T_9 (NPK@RDF + M_2@ 10Kg ha^{-1} 50% + F_2@ 50 l ha^{-1} 100%) provide highest net profit of ₹ 68139.13 ha^{-1} with highest cost benefit ratio is 1:1.605.

Keywords: NPK; fermented organic manure; mycorrhizal inoculation; seed yield; cost-benefit ratio; etc.

1. INTRODUCTION

The majority of the Indian population follows a vegetarian diet, and pulses are a cost-effective and excellent source of protein, providing 20-25% protein—more than twice the amount found in cereals. India imports around 3 million tonnes of pulses, with a projected demand of 28 million tonnes by 2017 (Anonymous, 2011). Currently, the availability of pulses in India is 36g per person per day, which is significantly lower than the minimum and optimal requirements of 80g and 104g per person per day, respectively. Due to limited opportunities for expanding the cultivation area for pulses, the potential for increasing production seems minimal. In such challenging circumstances, intensifying cropping practices, particularly through intercropping, offers a promising alternative (Jat et al., 2014).

Green gram (*Vigna radiata* L.), commonly known as moong, belongs to the Leguminosae family and is cultivated in countries such as India, Burma, Sri Lanka, Pakistan, China, Fiji, Queensland, and parts of Africa. (Smartt, 2013). India is the largest producer of green gram, grown in almost all states, covering an area of about 3.6 million hectares with a total production of approximately 1.7 million tonnes and an average yield of 500 kg per hectare. Key green gram-producing states include Odisha, Maharashtra, Andhra Pradesh, Madhya Pradesh, Gujarat, Rajasthan, and Bihar.

Green gram is the third most important legume crop in India and holds particular significance as a Zaid season crop in Uttar Pradesh, typically sown with the onset of summer. However, many farmers do not apply the recommended dose of fertilizers or seed treatments due to the short growing season. (Nair et al., 2020).

Green gram can thrive in a variety of soil types, from black cotton soils in North India to red laterite soils in the South and sandy soils in Uttar Pradesh. For optimal production, well-drained loamy to sandy loam soils are preferred. The seeds of moong beans contain 22-28% carbohydrates, 60-65% protein, 1-1.5% fats, 3-4.5% fibre, and 4.5-5.5% ash (USDA National database, 2023). This versatile crop is used for both seeds and forage, as it produces significant biomass and can regenerate after grazing to yield more seeds. As a protein-rich food, green gram is consumed as both whole and split pulses in India. Some prominent hybrids include RUM-I, PDM-139, PDM-4, K-851, and PDM-11.

2. MATERIALS AND METHODS

The field trial was conducted during the Zaid season of 2023 at the Central Research Farm of the Department of Soil Science and Agricultural Chemistry at Sam Higginbottom University of Agriculture, Technology and Sciences (U.P.), located at 25°24’30’’ N latitude, 81°51’10’’ E longitude, and 98m above mean sea level. This location is part of the Agro-Ecological Sub Region [North Alluvium Plain Zone (0-1% slope)] and the Agro-Climatic Zone (Upper Gangetic Plain Region). Agro-climatically, Prayagraj District falls within the subtropical belt of Southeast Uttar Pradesh, experiencing extremely hot summers and fairly cold winters. The maximum temperature ranges up to 46°C, rarely dropping below 4-5°C, with relative humidity between 20-94%. The area receives an average annual rainfall of about 1100mm, primarily from July to the end of September, though occasional winter precipitation is not uncommon. During the crop season, temperatures ranged from a minimum of 21.38℃ to a maximum of 37.82℃, while humidity varied from 46.42% to 96.85%

2.1 Experimental Design

The experimental design was a 3x3 Randomized Block Design with three levels of fermented organic manure (0, 50, 100%), mycorrhiza (0, 50, 100%), and NPK at recommended doses (RDF). Each plot measured 2m x 2m, and the green gram variety used was PDM-139, aimed at evaluating soil properties and health.

3. METHODOLOGY

The grain yield obtained from each plot in each harvest was sum up which gave the total grain yield per plot and thereafter with the use of multiplication factor this yield was converted into per hectare for each treatment.

3.1 Economics of Treatments

As per as existing market process, the input and output costs were computed treatment wise and different economics parameters *viz.* Net profit and Cost benefit ratio were calculated.

3.1.1 Cost of cultivation (₹ ha^{-1})

The cost of cultivation of each treatment was calculated separately taken into consideration all the cultural practices followed in the cultivation of green gram.

3.1.2 Gross return (₹ ha^{-1})

The gross return from each treatment was calculated taking into consideration the cost ofcultivation and the market price of the produce.

3.1.3 Net profit (₹ ha^{-1})

The net profit from each treatment was calculated separately by using the formula given below.

Net profit (₹ ha^{-1}) = Gross return - Cost of cultivation.

3.1.4 Cost Benefit Ratio (C: B)

The benefit ratio for each treatment was calculated by using following formula.

Cost Benefit Ratio = Gross Return / Cost of cultivation

3.2 Statistical Analysis

A randomized block design (RBD) is an experimental design where the experimental units are in groups called blocks. The treatments are randomly allocated to the experimental units inside each block. When all treatments appear at least once in each block, we have a completely randomized block design. Otherwise, we have an incomplete randomized block design. This kind of design is used to minimize the effects of systematic error. If the experimenter focuses exclusively on the differences between treatments, the effects due to variations between the different blocks should be eliminated.

The data recorded during the course of investigation subjected to statistical analysis by analysis of variance (ANOVA) technique. The significant and nonsignificant of treatment effect was judged with the help of 'F' (variance ratio) table (Fisher 1960). The significant different between the mean were tested against the critical difference at 5% level for testing the hypothesis the following table issued.

Table 1. Treatment combination of green gram

Treatments	Treatment Combination	Symbol
T_1	Absolute control	$L_0M_0F_0$
T_2	NPK@RDF + M_0 + F_1 @ 50%	LM_0F_1
T_3	NPK@RDF + M_0 + F_2 @ 100%	LM_0F_2
T_4	NPK@RDF + M_1@ 50% + F_0	LM_1F_0
T_5	NPK@RDF + M_1@ 50% + F_1@ 50%	LM_1F_1
T_6	NPK@RDF + M_1@ 50% + F_2@ 100%	LM_1F_2
T_7	NPK@RDF + M_2@ 100% + F_0	LM_2F_0
T_8	NPK@RDF + M_2@ 100% + F_1@ 50%	LM_2F_1
T_9	NPK@RDF + M_2@ 100% + F_2@ 100%	LM_2F_2

Note: RDF = Recommended Dose of Fertilizer, M= Mycorrhiza and F= Fermented Organic Manure

Table 2. Anova table

Source of variation	d.f.	S.S.	M.S.S	F (cal.) Value	F (tab) Value on 5% LOS
Due to replication	r-1	R.S.S.	M.R.S.S.	M.R.S.S. E.M.S.S.	F(t-1) (r-1) (t-1) 5%
Due to treatment	t-1	Tr.S.S.	M.T.S.S.	M.T.S.S. E.M.S.S.	
Due to error	(r-1) (t-1)	E.S.S.	E.M.S.S.		
Total	**Rt-1**	**T.S.S.**			

C.D. = S.Em. ± x t-test (error d. f.) at 5%

$$S.\ Em.\ \pm = \left[\sqrt{\frac{2\ E.\ M.ss}{r}}\right]$$

Where,

r = Replication

t = Treatment

T = Total

d.f. = Degree of freedom

MSS = Mean sum of squares

TrSS = Treatment sum of squares

TSS = Total sum of squares

RSS = Replication sum of squares

ESS = Error sum of squares

MRSS = Mean replication sum of squares

MTSS = Mean treatment sum of squares

F cal. = Calculated value of F

F tab. = Tabulated value of F

C.D. = S.E (D) x 't' error d. f. at 5 % level of significance

$$S.\ Ed.\ \pm = \sqrt{\frac{2\ E.\ M.ss}{r}}$$

The significance and non-significance of the treatment effect was judged with the help of 'F' variance ratio test. Calculated 'F' value was compared with the table value 'F' at 5 % level of significance. If calculated value exceeds the table value the effect was considered to be significant. The significant difference between the means was tested critical differences at 5 % level of significance. For testing the hypothesis, the ANOVA table was used.

4. RESULTS AND DISCUSSION

The data presented in Table 3. and depicted in clearly shows clearly shows the response of total seed yield of green gram recorded as influenced by different levels NPK, fermented organic manure and mycorrhizal inoculation. The seed yield of green gram was found to be increased significantly with the increase in levels of N P K and Rhizobium seed inoculation. The maximum seed yield was recorded as 14.43 (q ha-1) T9 (NPK@RDF + M2@ 10Kg ha-1 50% + F2@ 50 l ha-1 50%) which was higher than any other treatment combination and the minimum seed yield was recorded as 7.88 (q ha-1) in T1 (control).

Table 3. Effect of different levels of N P K, fermented organic manure and mycorrhizal inoculation on number of grain pod^{-1}, number of pod plant^{-1} and seed yield (q ha^{-1}) of Green gram var. PDM-139

S. No.	Treatment combination	Seed yield (q ha^{-1})
T_1	Absolute control	8.76
T_2	NPK@RDF + M_0 + F_1@ 25 l ha^{-1} 50%	9.82
T_3	NPK@RDF + M_0 + F_2@ 50 l ha^{-1} 100%	10.50
T_4	NPK@RDF + M_1@ 5Kg ha^{-1} 50% + F_0	11.70
T_5	NPK@RDF + M_1@ 5Kg ha^{-1} 50% + F_1@ 25 l ha^{-1} 50%	12.88

S. No.	Treatment combination	Seed yield (q ha^{-1})
T_6	NPK@RDF + M_1@ 5Kg ha^{-1} 50% + F_2@ 50 l ha^{-1} 100%	13.55
T_7	NPK@RDF + M_2@ 10Kg ha^{-1} 50% + F_0	14.52
T_8	NPK@RDF + M_2@ 10Kg ha^{-1} 50% + F_1@ 25 l ha^{-1} 50%	15.51
T_9	NPK@RDF + M_2@ 10Kg ha^{-1} 50% + F_2@ 50 l ha^{-1} 100%	16.42
F-test		**S**
S.Em. (±)		**0.15**
C.D.@5%		**0.32**

The combined application of NPK, fermented organic manure and mycorrhizal inoculation played a very important role. Application of organic manure increased supply of major assimilated as well as micro nutrient to plants, Mycorrhiza also perform better when soil is well applied with nutrients. Similar results were also reported by Jat et al., (2012), Koushal and Singh (2011).

Table 4. Cost of cultivation of green gram (₹ ha^{-1})

S. No.	Particular	Units	Rates (₹ ha^{-1})	Total cost
(A)	**Land Preparation**			
1.	Ploughing with (Mould Board plough)	4 hr	@500 hr^{-1}	2000
2.	Ploughing with (Harrow)	4 hr	@500 hr^{-1}	2000
3.	Levelling of field (Leveller)	3 hr	@500 hr^{-1}	1500
4.	Preparation of layout	4 hr	@250 hr^{-1}	1000
(B)	**Sowing and Irrigation Charge**			
1.	Green gram seed	20Kg/ha	@110 Kg^{-1}	2200
2.	Sowing charge	10 labours	@300 labour^{-1}	3000
3.	Irrigation charge (3 irrigation)	8hr/irrigation×3	@200 hr^{-1}	4800
4.	Irrigation labour charge	7 labours	@200/day/labour	4200
5.	Cost of urea for 25 Kg nitrogen	25Kg ha^{-1}	Rs. 9 kg $^{-1}$	225
6.	Cost of SSP for 50 Kg phosphorus	50Kg ha^{-1}	Rs. 12 kg $^{-1}$	600
7.	Cost of DOP for 25 Kg potassium	25Kg ha^{-1}	Rs. 16 kg $^{-1}$	400
8.	Cost of Fermented organic manure for 50 lit. ha^{-1}	50 lit ha^{-1}	Rs. 400 lit^{-1}	20000
9.	Cost of Mycorrhiza 10 kg ha^{-1}	10Kg ha^{-1}	Rs. 100 kg^{-1}	1000
10.	Fertilizer Application	8 labour	@300 Labour^{-1}	2400
(C)	**Weeding and harvesting**			
1.	2 Weeding were done	25 labour	@250/day/labour	12500
2.	Harvesting	25 labour	@ 250/labour	6250
3.	Threshing by beating	10 labour	@200/labour	2000
4.	Field rent	3 months	@4500/month	13500
5.	Supervision	3 month	@3000/month	9000
	Total			**₹ 86,575**

Table 5. Cost of cultivation of green gram as per the treatment

Treatment	Particular	Units	Rates (₹ ha^{-1})	Cost/Unit (₹ ha^{-1})	Cost of Cultivation	Total cost of Cultivation
T_1	**Absolute control**	**Absolute Control**	-	-	**86,575**	**86,575.00**
T_2	RDF + FOM @ 50% + Mycorrhiza @0%	@ 54.35 kg UREA @ 312.50 kg SSP @ 41.67 kg MOP @ 25 lit ha^{-1} FOM	9:12:16 kg^{-1} Fermented organic manure @ 400 lit^{-1}	489.15 3750.00 666.72 10000.00	86575.00+ 4905.87+ 10000.00	101480.87
T_3	RDF + FOM @ 100% + Mycorrhiza @0%	@ 54.35 kg UREA @ 312.50 kg SSP @ 41.67 kg MOP @ 50 lit ha^{-1} FOM	9:12:16 kg^{-1} Fermented organic manure @ 400 lit^{-1}	489.15 3750.00 666.72 20000.00	86575.00+ 4905.87+ 20000.00	111480.87
T_4	RDF + FOM @ 0% + Mycorrhiza @50%	@ 54.35 kg UREA @ 312.50 kg SSP @ 41.67 kg MOP @ 0 lit ha^{-1} FOM @ 5 kg ha^{-1} Mycorrhiza	9:12:16 kg^{-1} Fermented organic manure @ 400 lit^{-1} Mycorrhiza @ 100 kg^{-1}	489.15 3750.00 666.72 0.00 500.00	86575.00+ 4905.87+ 500.00	91980.87
T_5	RDF + FOM @ 50% + Mycorrhiza @50%	@ 54.35 kg UREA @ 312.50 kg SSP @ 41.67 kg MOP @ 25 lit ha^{-1} FOM @ 5 kg ha^{-1} Mycorrhiza	9:12:16 kg^{-1} Fermented organic manure @ 400 lit^{-1} Mycorrhiza @ 100 kg	489.15 3750.00 666.72 10000.00 500.00	86575.00+ 4905.87+ 500.00+ 10000.00	101980.87
T_6	RDF + FOM @ 100% + Mycorrhiza @50%	@ 54.35 kg UREA @ 312.50 kg SSP @ 41.67 kg MOP @ 50 lit ha^{-1} FOM @ 5 kg ha^{-1} Mycorrhiza	9:12:16 kg^{-1} Fermented organic manure @ 400 lit^{-1} Mycorrhiza @ 100 kg	489.15 3750.00 666.72 20000.00 500.00	86575.00+ 4905.87+ 500.00+ 20000.00	111980.87
T_7	RDF + FOM @ 0% + Mycorrhiza @100%	@ 54.35 kg UREA @ 312.50 kg SSP @ 41.67 kg MOP @ 0 lit ha^{-1} FOM @ 10 kg ha^{-1} Mycorrhiza .	9:12:16 kg^{-1} Fermented organic manure @ 400 lit^{-1} Mycorrhiza @ 100 kg ^{1}	489.15 3750.00 666.72 00.00 1000.00	86575.00+ 4905.87+ 1000.00	92480.87

Treatment	Particular	Units	Rates (₹ ha^{-1})	Cost/Unit (₹ ha^{-1})	Cost of Cultivation	Total cost of Cultivation
T8	RDF + FOM @ 50% + Mycorrhiza @100%	@ 54.35 kg UREA @ 312.50 kg SSP @ 41.67 kg MOP @ 25 lit ha^{-1} FOM @ 10 kg ha^{-1} Mycorrhiza .	9:12:16 kg^{-1} Fermented organic manure @ 400 lit^{-1} Mycorrhiza @ 100 kg^{1}	489.15 3750.00 666.72 10000.00 1000.00	86575.00+ 4905.87+ 1000.00+ 10000.00	102480.87
T9	RDF + FOM @ 100% + Mycorrhiza @100%	@ 54.35 kg UREA @ 312.50 kg SSP @ 41.67 kg MOP @ 50 lit ha^{-1} FOM @ 10 kg ha^{-1} Mycorrhiza .	9:12:16 kg^{-1} Fermented organic manure @ 400 lit^{-1} Mycorrhiza @ 100 kg^{1}	489.15 3750.00 666.72 20000.00 1000.00	86575.00+ 4905.87+ 1000.00+ 20000.00	112480.87

Table 6. Effect of Different Cost benefit ratio (C:B) of different treatment combination with Green gram

Treatment	Yield (q ha^{-1})	Selling price (₹ q^{-1})	Gross return (₹ ha^{-1})	Total cost of cultivation (₹ ha^{-1})	Net Profit (₹ ha^{-1})	Cost Benefit ratio (C:B)
T_1	8.76	11000	96360	86,575.00	9785.00	1.1130
T2	9.82	11000	108020	101480.87	6539.13	1.0644
T3	10.50	11000	115500	111480.87	4019.13	1.0360
T4	11.70	11000	128700	91980.87	36719.13	1.3992
T5	12.88	11000	141680	101980.87	39699.13	1.3892
T6	13.55	11000	149050	111980.87	37069.13	1.3310
T7	14.52	11000	159720	92480.87	67239.13	1.7270
T8	15.51	11000	170610	102480.87	68129.13	1.6647
T9	16.42	11000	180620	112480.87	68139.13	1.6057

5. CONCLUSION

It is revealed from trial that the various level of NPK fermented organic manure and mycorrhizal inoculation used from in the experiment, the treatment combination T_9 - (NPK@RDF + M_2@ 10Kg ha^{-1} 50% + F_2@ 50 l ha^{-1} 100%) was found to be the best treatment gave highest gross return ₹ 180620.00 benefit of ₹ 67139.13 with highest cost benefit ratio 1:1.605 for green gram it could be recommended for profitable production of Green gram (*Vigna radiata* L.) var. PDM-139 and treatment T_9 is best in terms of soil physical and chemical properties. Further it increased soil fertility and nutrient uptake by the plant. Increasing in the level of NPK and Fermented organic manure there was a significant increase in yield attributes. The maximum yield was found in T_9 (NPK@RDF + M_2@ 10Kg ha^{-1} 50% + F_2@ 50 l ha^{-1} 100%) and the minimum yield was recoded in T_1 (control). However, as for the economy of different treatments is concerned, the treatment T_9 (NPK@RDF + M_2@ 10Kg ha^{-1} 50% + F_2@ 50 l ha^{-1} 100%) provide highest net profit of ₹ 68139.13 ha^{-1} with highest cost benefit ratio is 1:1.605.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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