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Effect of organic nutrient sources on growth, yield, quality and economics of green gram (*Vigna radiata* L.) under organic farming

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Abstract
A study was conducted at ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari during the rabi season of 2020 to examine the impact of various organic nutrient sources on the growth, yield, quality and economic aspects of green gram cultivation in a certified organic farm. Among the individual treatments 100% RDN through vermicompost + EBPS 1% (T_6) recorded higher plant height at the time of harvest (63.7 cm), number of pods per plant (26.3), grain yield (11.2 q/ha), stover yield (22.7 q/ha) and highest crude protein yield (203.9 kg/ha) among all the treatments. Whereas, length of the pod, Number of seeds per pod, 1000 grain weight and Harvest index were not significantly influenced by different treatments. While looking to economics, 100% RDN through vermicompost + EBPS 1% (T_6) realized higher gross (105704 ₹/ha) and net returns (64001 ₹/ha) and 100% RDN through NADEP compost + EBPS 1% (T_2) recorded higher benefit-cost ratio (1.62) among all the treatments.

Keywords: Organic farming, organic nutrients, growth, yield and economics of the crop

Introduction
Commonly referred to as mung bean or golden gram, the green gram (*Vigna radiata*) is a highly significant short-duration pulse crop cultivated in India. As a legume crop, green gram has a reasonably low nitrogen requirement. Under usual conditions, it obtains a significant portion of its nitrogen needs via symbiotic nitrogen fixation facilitated by nodule bacteria, which utilizes atmospheric nitrogen (Kannaiyan, 1999) [5]. The green gram seed is a great source of protein (23-24%), carbohydrates, minerals and vitamins. To fully utilize the potential of green gram, it is crucial to employ various organic farming techniques. India produces more green grams than any other country. Both the production and consumption of green gram are dominated by India. With over one billion people dependent on its food supply, the Indian subcontinent produces an enormous amount of compostable agricultural waste. If these organic wastes are not recycled appropriately, it may pose serious environmental problems. Organic materials can be efficiently transformed into high-quality manure, such as compost and vermicompost, by combining them with other farm-based organic materials like sorghum stubbles, wheat straw, soybean straw, weed biomass and cattle dung using effective strains of earthworms and other techniques. Continuously adding organic materials to soil over a prolonged period leads to higher levels of organic matter, organic carbon, crop yield, soil biological activity and produce quality (Collins *et al.*, 1992) [4]. Farmers are starting to utilize solid organic manures and liquid organics, such as Jeevamrut, Beejamrut and Vermiwash, among others, to attain sustainable soil fertility and crop productivity. Fermented liquid organic manures are rich in macro and micronutrients, vitamins, essential amino acids, various microorganisms and growth-promoting substances. These components aid in enhancing plant growth, metabolic processes, and resilience against pests and diseases. The Enriched Banana Pseudostem Sap (EBPS) is the value-added product prepared from the Pseudostem. Approximately 15,000 to 20,000 liters of sap can be obtained from one hectare of Pseudostem. EBPS is a blend of essential nutrients, plant growth regulators and various beneficial microbes such as Rhizobium and Azotobacter, which contribute significantly to increasing crop productivity. (Akhila *et al.*, 2017) [1].

Materials and Methods

The study took place at Organic Farm, Navsari Agricultural University, Navsari, in the Rabi season of 2020-21. The farm switched to organic practices in 2005 and has since employed organic management techniques to cultivate crops. The soils in South Gujarat are referred to as 'Deep Black Soils'. The soil at the Navsari campus, where the experiment was conducted, belongs to the *Ustochrepts* great group and is classified under the Jalalpur series. The soils have a clayey texture and are mainly composed of the clay mineral montmorillonite, which exhibits significant cracking when dried. The experimental field's soil had high organic carbon content (0.86%), low available nitrogen (264.3 kg/ha), medium available P_2O_5 (38.9 kg/ha) and high available K_2O (502.0 kg/ha). The soil was slightly alkaline with a pH of 7.8 and had a normal electrical conductivity of 0.274 dS/m.

Table 1: treatment details.

T_1	100% RDN through NADEP compost
T_2	100% RDN through NADEP compost + EBPS 1%
T_3	100% RDN through NADEP compost + Cow urine 2%
T_4	100% RDN through NADEP compost + Vermiwash 1%
T_5	100% RDN through vermicompost
T_6	100% RDN through vermicompost + EBPS 1%
T_7	100% RDN through vermicompost + Cow urine 2%
T_8	100% RDN through vermicompost + Vermiwash 1%
T_9	Ghan-jivamrut @500 kg/ha + jivamrut @500l/ha
T_{10}	Ghan-jivamrut @500 kg/ha + jivamrut @500l/ha + EBPS 1%
T_{11}	Ghan-jivamrut @500 kg/ha + jivamrut @500l/ha + Cow urine 2%
T_{12}	Ghan-jivamrut @500 kg/ha + jivamrut@500l/ha + Vermiwash 1%

Organic sources such as NADEP compost, vermicompost, Ghan-jivamrut and jivamrut were applied to the soil at the time of sowing according to the treatments. Organic sources (EBPS, Cow urine and Vermiwash) are to be applied through foliar spray three times at 15, 30 and 45 days after sowing (DAS). Seeds were treated with Rhizobium and PSB at a rate of 10ml per kilogram for all treatments.

Results and Discussion

Growth and yield parameters

Periodical Plant Height (cm)

The data on growth, yield attributing parameters and yield of green gram are found in Tables 1 and 2. The growth parameters, such as plant height at 40 and 60 days after sowing and at harvest, the number of branches per plant, and the number of pods per plant at harvest, were significantly affected using different organic nutrient sources. At 20 days after sowing, there was no significant difference in plant height among the treatments. Treatment T_6, which consisted of (100% RDN through vermicompost + EBPS 1%), showed significantly greater plant height at 40 days after sowing compared to most treatments. Plant height was greater at 60 days after sowing and at harvest when T_6 (100% RDN through vermicompost + EBPS 1%), compared to other treatments. However, it was found to be on par with treatments T_2, T_3, T_4 and T_8. The improved accessibility of nitrogen and other essential nutrients from vermicompost, along with the application of a 1% Banana Pseudostem Sap foliar spray, promoted plant nitrogen uptake. This led to enhanced cell division and enlargement, resulting in greater vegetative growth and ultimately increased plant height. The results of this study closely aligned with the findings of Meena *et al.*, (2016) [7] and Patel *et al.*, (2020) [9]. Lower plant height was observed when Ghan-jivamrut was applied at a rate of 500 kg/ha along with jivamrut at 500l/ha at 40, 60 DAS and at harvest.

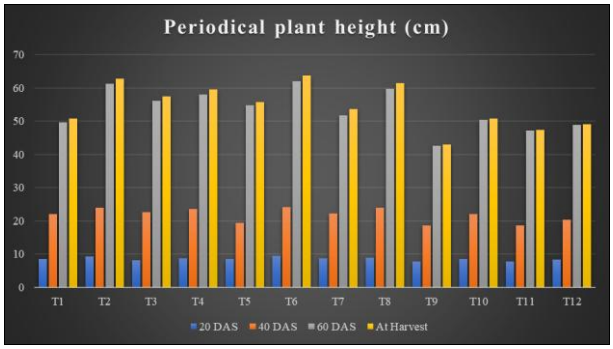

Fig 1: Effects of different treatments on periodical plant height of green gram

Number of branches per Plant

Table 2 results indicated that, at harvest, the number of branches per plant was significantly higher for treatment T_6 (100% RDN through vermicompost + EBPS 1%), but it was at par with treatments T_2, T_4 and T_8. However, a notably reduced number of branches per plant was observed at harvest under treatment T_9 (Ghan-jivamrut @500 kg/ha + jivamrut @500l/ha). The increased number of branches per plant in treatment T_6 may be attributed to the combined application of organic nutrient sources and biofertilizer, which likely enhanced growth and development, leading to a higher branch count per plant. The results of this study closely aligned with the findings of Vitnor *et al.*, (2015) [13] and Bhadu *et al.*, (2018) [2] in the green gram crop.

Number of Pods per Plant

Table 2 results indicated that treatment T_6 (100% RDN through vermicompost + EBPS 1%) had a significantly higher number of pods per plant at harvest compared to other treatments T_2, T_3, T_4, T_5 and T_8. However, a significantly lower number of pods per plant was observed at harvest under treatment T_9 (Ghan-jivamrut @500 kg/ha + jivamrut @500l/ha). The increased number of pods per plant in treatment T_6 may be attributed to vermicompost enhancing the soil's ability to adsorb cations and anions, which are then slowly released throughout the crop growth period, leading to improved nutrient availability during active crop growth. The results obtained in the current study closely aligned with the previous findings of Kumar *et al.*, (2014) [6] and Patel *et al.*, (2020) [9].

Table 2: Effects of different treatments on yield attributes and yield of green gram.

Treatments	At the time of harvest		Grain yield	Stover yield	Harvest index
	Branches/plant	Pods/plant			
T_1	5.6	22.0	7.3	19.9	26.9
T_2	7.4	25.7	10.1	22.7	30.8
T_3	6.5	23.7	7.7	22.3	25.7
T_4	6.9	24.0	9.1	22.3	29.0
T_5	6.4	23.3	8.4	22.1	27.4
T_6	7.5	26.3	11.2	22.7	33.0
T_7	5.7	22.3	8.6	20.1	30.0
T_8	7.3	24.3	9.7	22.6	30.0
T_9	4.2	21.0	6.8	18.5	26.9
T_{10}	5.5	22.0	7.7	18.8	29.1
T_{11}	4.3	21.3	7.2	18.5	28.0
T_{12}	4.4	21.7	7.3	18.7	28.0
SEm ±	0.3	1.1	0.5	0.9	1.7
CD (0.05)	0.9	3.1	1.6	2.7	NS
CV%	9.3	8.0	11.0	7.8	10.3

Grain Yield

Table 2 contains the data regarding the impact of various treatments on the grain yield of green gram crop after harvest. Treatment T_6, which involved 100% RDN through vermicompost + EBPS 1%, produced the highest grain yield of green gram at 11.2 q/ha compared to all other treatments. However, it showed no statistical difference compared to treatments T_2 and T_8. The lowest grain yield of green gram (6.8 q/ha) was observed in treatment T_9 (Ghan-jivamrut @500 kg/ha + jivamrut @500l/ha). Treatment T_6 likely resulted in a higher grain yield due to the sufficient supply of essential elements from vermicompost and EBPS. This led to improved growth and development of green gram, including increased plant height, functional leaves and dry matter accumulation. Additionally, it may have increased nutrient uptake, efficient distribution of photosynthates to reproductive parts and enhanced growth and yield attributes, ultimately resulting in a higher grain yield of green gram. The results of this study closely align with the findings of Choudhary *et al*., (2013) [3] in the green gram crop.

Stover Yield

Table 2 contains the data regarding the impact of various treatments on the Stover yield of green gram crop after harvest. Treatment T_6, which involved 100% RDN through vermicompost + EBPS 1%, led to a significantly higher stover yield of green gram at 22.7 q/ha. However, it did not show a statistically significant difference compared to all other treatments except T_1, T_{10}, T_{11} and T_{12}. However, a significantly lowest stover yield of green gram (18.5 q/ha) was observed in treatment T_9 (Ghan-jivamrut @500 kg/ha + jivamrut @500l/ha). The increased stover yield in treatment T_6 may be attributed to the organic nutrient sources containing a high level of organic matter. This organic matter enhances soil moisture retention and nutrient dissolution, especially phosphorus, leading to improved growth and development and ultimately resulting in a higher stover yield. The results of this study closely aligned with the findings of Choudhary *et al.,* (2013) [3] and Bhadu *et al.,* (2018) [2] in the green gram crop.

Harvest Index

The data from Table 2 indicated that there was no significant relationship between the treatments and the harvest index.

Quality Parameters

Table 3: Effect of different treatments on crude protein content and crude protein yield of green gram

Treatments	Crude protein	
	Content (%)	Yield (kg/ha)
T_1	19.1	138.4
T_2	18.3	184.2
T_3	18.6	142.6
T_4	18.6	168.9
T_5	19.4	162.5
T_6	18.2	203.9
T_7	19.4	165.1
T_8	18.4	177.8
T_9	19.1	130.6
T_{10}	19.2	148.4
T_{11}	19.4	140.7
T_{12}	19.6	143.2
SEm ±	0.6	9.7
CD (0.05)	NS	28.5
CV%	5.2	10.6

Crude Protein Content

Table 3 showed that the treatments had no significant effect on crude protein content (%).

Crude Protein Yield

Table 3's results showed that the treatments had a significant effect on crude protein yield. Treatment T_6, which involved 100% RDN through vermicompost and EBPS 1%, produced a significantly higher crude protein yield of 203.9 kg/ha. However, it showed no statistical difference compared to treatments T_2 and T_8. Significantly lowest crude protein yield of 130.6 kg/ha was observed in treatment T_9, which involved the application of Ghan-jivamrut at 500 kg/ha and jivamrut at 500l/ha. The increased crude protein yield in treatment T_6 may be attributed to vermicompost enhancing the soil's physical, chemical, and biological properties, as well as providing nearly all necessary plant nutrients for plant growth and development. Vermicompost containing humic acid improves the accessibility of both existing and supplemented micro-nutrients in the soil, leading to enhanced plant growth, yield characteristics and increased yield. The results obtained in this investigation closely aligned with the findings of Tak *et al.,* (2014) [12] and Shariff *et al.,* (2017) [10] in green gram crop.

Economics

The cost of production, gross return, net return, and BCR were calculated for various treatments based on the current market prices of green gram grain and stover, as well as different input costs. The results are shown in Table 4.

Table 4: Effect of different treatments on economics of green gram crop

Treatments	Yield (kg/ha)		Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	BCR
	Grain	Stover				
T_1	731	1995	29365	69780	40415	1.38
T_2	1008	2267	36385	95254	58869	1.62
T_3	769	2230	29725	73670	43945	1.48
T_4	909	2233	34765	86276	51511	1.48
T_5	837	2210	34683	79750	45067	1.30
T_6	1124	2272	41703	105704	64001	1.53
T_7	856	2006	35043	81052	46009	1.31
T_8	968	2258	40083	91636	51553	1.29
T_9	683	1853	30294	65176	34882	1.15
T_{10}	772	1877	37314	73234	35920	0.96
T_{11}	724	1853	30654	68866	38212	1.25
T_{12}	729	1995	35694	69600	33906	0.95

Gross Returns

Different treatments significantly impacted gross returns, as shown in Table 4. Treatment T_6 (100% RDN through vermicompost + EBPS 1%) yielded the highest gross returns of ₹ 1,05,704/ha, followed by treatment T_2 (100% RDN through NADEP compost + EBPS 1%) and T_8 (100% RDN through vermicompost + Vermiwash 1%) among all the treatments tested. Higher gross returns were clearly a direct outcome of increased yield. Treatment T_9 (Ghan-jivamrut @500 kg/ha + jivamrut @500l/ha) had reduced gross returns of ₹ 65,176/ha because of lower yields.

Net Returns

Table 4 presents the impact of different treatments on the net returns from green gram cultivation. The treatment with T_6 (100% RDN through vermicompost + EBPS 1%) yielded the highest net returns of ₹ 64,001/ha, followed by treatment T_2

(100% RDN through NADEP compost + EBPS 1%) and T_8 (100% RDN through vermicompost + Vermiwash 1%). The rise in net profits in this treatment could be attributed to increased grain yield. This aligns with the findings of Kumawat *et al.*, (2009) and Patel *et al.*, (2020) [9]. The lowest net returns of ₹ 33,906/ha were attributed to the application of Ghan-jivamrut @500 kg/ha + jivamrut@500l/ha + Vermiwash 1% (T_9), resulting from a decrease in yield.

Benefit-Cost Ratio

Table 4 displays how different treatments affected the Benefit-Cost ratio (BCR). T_2 Applying 100% Recommended Dietary Nutrient (RDN) through NADEP compost + EBPS 1% led to the highest benefit-cost ratio of 1.62, followed by treatments T_6 (100% RDN through vermicompost + EBPS 1%) and T_1 (100% RDN through NADEP compost). Treatment T_{12}, consisting of Ghan-jivamrut at 500 kg/ha, jivamrut at 500l/ha, and vermiwash at 1%, showed a reduced benefit-cost ratio of 0.95.

Conclusion

The study concluded that the treatment involving 100% RDN through vermicompost + EBPS 1% (T_6) resulted in the highest plant height at harvest, number of pods per plant, grain yield, stover yield and crude protein yield compared to all other treatments. Despite treatment T_6 showing superior growth, yield and quality parameters, it incurred higher costs to achieve these results. To achieve maximum yield, net profit and Benefit-Cost ratio for green gram in organic farming, apply treatment (T_2) consisting of 100% recommended nitrogen dose through NADEP compost + Enriched Banana Pseudostem Sap @ 1% sprays at 15, 30 and 45 days after sowing.

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Conflict of Interest

I declared that no conflict of interest related to my research. No any external funding involve during the course of experiment and analysis and publication decision.

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