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CHEMICAL CHARACTERIZATION OF ORGANIC MANURES AND THEIR INFLUENCE ON SOIL FERTILITY AND BLACK GRAM YIELD

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ABSTRACT

With increasing concern over the continuous application of chemical fertilisers, attention has shifted towards sustainable agricultural practices. Organic amendments like goat manure (GM), swine manure (SM) and vermicompost (VC) were applied alone and in double and triple manure concentrations, viz., 8, 12.5 and 17 t ha^{-1}. The initial soil was slightly alkaline with a pH of 7.6, low in organic carbon (0.0411%), and deficient in available nitrogen (128.50 kg ha^{-1}), with relatively high bulk density (1.1036 g/cm^3) and poor water holding capacity. After harvest, organic-amended soil exhibited a favourable reduction in pH (7.0 – 7.4) and a significant increase in organic carbon up to 0.0865%. Available nitrogen improved by 45 % compared to the control, while bulk density declined (1.0599 - 0.8039 gm cm^{-3}), and porosity and water holding capacity were enhanced, indicating active nutrient mineralisation. Statistical analysis confirmed that goat manure, along with vermicompost, was significantly superior ($p < 0.05$) to other treatments in enhancing soil fertility. These statistical improvements in soil chemical properties were observed in the soil of black gram. They were reflected in increased plant height, a greater number of pods per plant and a higher number of leaves per plant of black gram. This highlights the contribution of organic inputs toward improved plant vigour and productivity. The best agronomic result (990 kg ha^{-1}) was noted with GM+VC @ 17 t ha^{-1}. The findings exemplify that organic manure application not only improves soil health but also substantially enhances black gram productivity in an ecologically sound manner.

Keywords: Soil Chemical Properties, Chemical Analysis, Organic Manure, Plant Biometric Traits, Black Gram.

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INTRODUCTION

Sustainable agriculture is becoming increasingly reliant on the incorporation of organic amendments. These amendments help improve soil health and crop productivity. Black gram (*Vigna mungo L.*) is a crucial catch crop extensively grown in India and other Asian countries for its high protein content and soil-enriching properties. Over the past few years, declining soil health due to excessive application of synthetic fertilisers has adversely affected the productivity of this crop. Rejuvenation of soil fertility using organic inputs is considered a sustainable and eco-friendly alternative. Organic manure revamps soil structure, enhances microbial activity and increases the availability of water and nutrients to plants. Goat manure is rich in nitrogen and phosphorus.[1,2] Swine manure contains a balanced nutrient profile[3], and vermicompost is valued for its microbial activity and humic substances.[4] Despite the known agronomic benefits of these organic inputs, there is limited quantitative data on their relative impacts on the chemical

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attributes of soil. The statistical relationships among these parameters are rarely investigated using modern statistical tools. Therefore, this work was undertaken to predict the impact of different organic manures and their combinations at varying application rates on soil chemical properties and to statistically analyse how these aspects contribute to the yield of black gram. Biometric observations are frequently used as important measures to understand how well a plant is growing under different conditions. Parameters such as plant height, number of pods per plant and number of leaves per plant serve as indicators of plant growth and health. The goat manure contributes to the overall growth performance and yield of tomato (*Lycopersicum esculentum*). Agronomic parameters like leaf area of the tomato plant, plant height, number of branches, number of fruits and fruit diameter also got enhanced with the level of manure. In a previous investigation[5], 40 t ha^{-1} is recommended as the best concentration for the yield of tomatoes by 24.3 t ha^{-1}.

EXPERIMENTAL

Material and Methods

The field experiment was conducted at Servaikaranmadam in the Thoothukudi district. The study area lies at 8° 705' latitude and 78° 378' longitude. The experiment consisted of thirteen different treatments with organic manure applied at three levels, viz., 8, 12.5 and 17 t ha^{-1}. The experiment was laid out in a randomised block design (RBD) with three replications as shown in Table 1. Black gram varieties of Vamban BG (4) seeds were sown under uniform agronomic practices. Regular irrigation and weed control practices were followed throughout the crop duration. Soil samples were collected before sowing and after harvest to determine variations in soil physico-chemical and chemical properties[6,7,8] like pH, EC, available N, P, K and OC, OM, respectively. The yield of black gram was recorded on a per-plot basis and expressed in terms of kg ha^{-1}. The collected data were subjected to statistical analysis, which was performed using SPSS (Statistical Package for the Social Sciences) software. In the initial stage itself, ten plants were selected randomly and tagged as shown in Fig.-1 to monitor and record various biometric observations of black gram. The observations on plant growth factors were made at 15, 30, 45, 60 and 90 DAS. The plant height was measured from the ground level to the top of the leaves using a steel tape as shown in Figure-2. The mean height for ten plants was recorded as plant height in cm for each plot. The number of mature pods per plant was recorded at the time of harvest for the randomly selected ten plants. This was done for each treatment, and thus the average was found. The number of leaves grown in randomly selected ten plants was counted, and the mean value was determined and presented on a per-plant basis. The weight of the pod was measured in wet condition, and then it was made to dry under sunlight to reduce the moisture level to below 10 %. Then the yield of the pod was noted and expressed in kg ha^{-1}.

Table-1: Dosage of Organic Manure and Yield Produced by Black Gram Plant

S. No.	Treatment	Plot	Yield kg ha^{-1}
1	GM	T1-A	370
2	GM	T1-B	220
3	GM	T1-C	380
4	GM+SM	T2-A	240
5	GM+SM	T2-B	430
6	GM+SM	T2-C	440
7	GM+VC	T3-A	455
8	GM+VC	T3-B	360
9	GM+VC	T3-C	990
10	GM+SM+VC	T4-A	605
11	GM+SM+VC	T4-B	725
12	GM+SM+VC	T4-C	720
13	CONTROL (No organic inputs)	T5	94

A – 8 t ha^{-1}, B – 12.5 t ha^{-1}, C – 17 t ha^{-1}

Fig.-1: Field View of Tagged Black Gram (*Vigna mungo L.*) Plants Marked for Biometric Observations

Fig.-2: Measuring Plant Height using a Measuring Steel Tape

RESULTS AND DISCUSSION

Physico-Chemical Characteristics and Macronutrient Analysis of Organic Inputs

The pH values indicated that Goat Manure (GM) and Swine Manure (SM) was slightly alkaline with 7.93 and 7.96. But vermicompost was found to be somewhat acidic with 6.51. Goat Manure and Swine Manure's alkalinity arises from carbonate and bicarbonate salts. The pH of manure strongly influences nutrient stability and microbial dynamics, being favourable for most crops. The EC values ranged from 2.04 dS m^{-1} in Goat manure to 2.62 dS m^{-1} in swine manure, with vermicompost showing 2.46 dS m^{-1}.

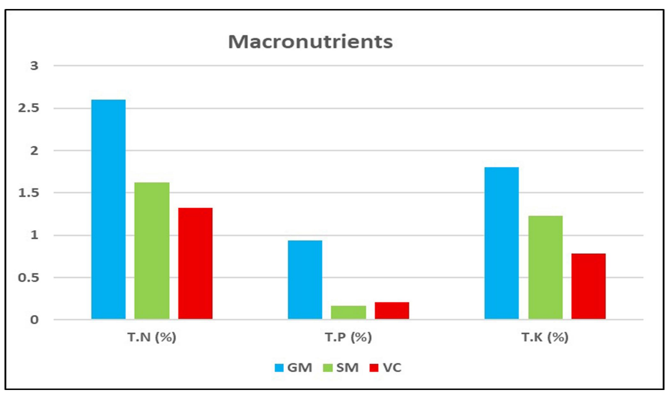

Fig.-3: Macronutrient Analysis of Organic Manures

Nitrogen content varied among the manures, with goat manure observed to have the highest (TN%) of 2.6%, followed by swine manure (1.62 %) and vermicompost (1.32 %) as represented in Fig.-3. Goat manure and Swine manure's richness in nitrogen shows their semisolid composition and rapid mineralisation potential. Vermicompost nitrogen mainly originates from microbial processes and the activity of earthworms. Although it contains lower N, it releases gradually and helps sustain long-term soil fertility. Phosphorus level was extremely high in goat manure (0.94%), followed by vermicompost with 0.21% and the least nitrogen was found in swine manure with 0.17%. The ultimate value of phosphorus in goat manure is due to the slow decomposition. Potassium levels are extremely high in goat manure (1.8%), followed by swine manure of medium contribution of 1.23% and vermicompost of 0.78%. The maximum value of goat manure might be due to the concentration of fibrous plant residues in their feed. Potassium plays a vital role in enzyme activation, photosynthesis, and making manure an effective potassium source.

Moisture and Organic Carbon Content

Moisture content varied notably among the manures, as shown in figure 4. Goat manure recorded the highest moisture, followed by swine manure (65%), whereas the lowest value was observed with vermicompost of 45%, as displayed in Fig.-4. Goat manure's higher water-holding capacity is attributed to its humified organic fractions, while lower moisture in vermicompost results in slower mineralisation, which supports long-term nutrient release. Organic carbon is responsible for soil fertility by promoting aggregation and water retention. OC content was highest in vermicompost (11.35%), followed by swine manure with 2.10% and goat manure contributed 1.34%. The highest OC value with vermicompost is due to the accumulation of humic and fulvic acids that are stable forms of organic carbon.

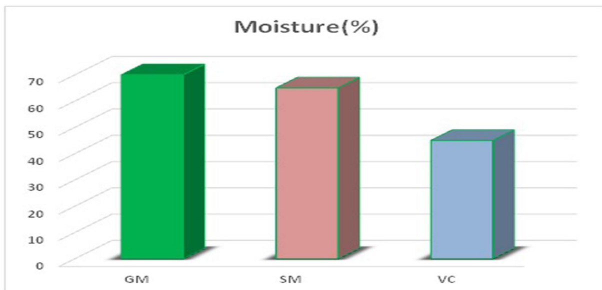

Fig.-4: Moisture Analysis of Organic Manures

Physico-Chemical Properties of Amended Soil Before and After Harvest

Potential of Hydrogen (pH)

Significant variation in soil pH was observed before and after harvest under different organic manure treatments. Before harvest, the control plot recorded the highest pH (7.6), while the lowest value (7.2) occurred in GM @ 12.5 t ha^{-1} and GM+SM @ 8 t ha^{-1}, as shown in Fig.-5. After harvest, a further decline was noted, with pH reaching 7.0 in GM+SM @ 8 t ha^{-1} and GM+VC @ 12.5 and 17 t ha^{-1}, representing a 7.89% reduction compared with the control. The gradual decrease in pH with increasing manure application is due to the release of organic acids during decomposition. These organic acids enhance nutrient solubility and help buffer soil reactions. Previous findings reported.[9,10,11]

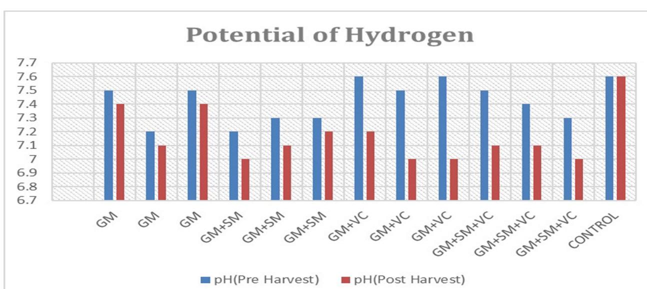

Fig.-5: pH of the Soil before and after Harvest

Electrical Conductivity (EC)

Electrical conductivity (EC) also showed a declining trend with manure application. Before harvest (BH), the control exhibited the highest EC (1.54 dS m^{-1}), while the lowest was recorded in GM+VC @ 17 t ha^{-1}. After harvest (AH), EC further decreased to 0.12 dS m^{-1} in GM+SM+VC @ 17 t ha^{-1} as given in Fig.-6. This consistent reduction suggests that organic manures mitigate soil salinity, likely by improving soil structure and facilitating leaching of soluble salts.

Soil Chemical Properties Before and after Harvest Under Organic Manure Treatments

Available Nitrogen (AN)

Organic amendments markedly improved soil nutrient status both before and after harvest. Before harvest, nitrogen was lowest in the control (80.23 kg ha^{-1}) and highest in GM+VC @ 8 t ha^{-1}(172.97 kg ha^{-1}) as represented in Fig.-7. After harvest, nitrogen declined due to plant uptake during growth[12], but the

GM+VC @ 8 t ha^{-1} plot still retained the highest value, showing a 44.44% increase over the control. A positive correlation between nitrogen and soil organic carbon further indicated the role of organic inputs in enhancing both N availability and C dynamics.

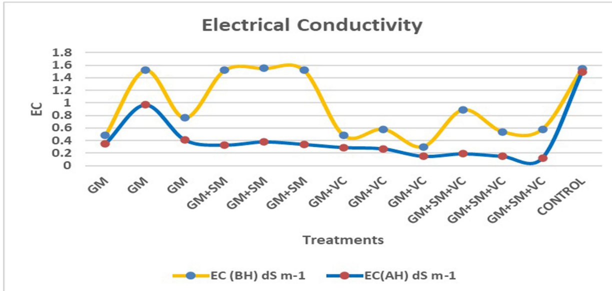

Fig.-6: Electrical Conductivity (EC) of the Soil Before and After Harvest

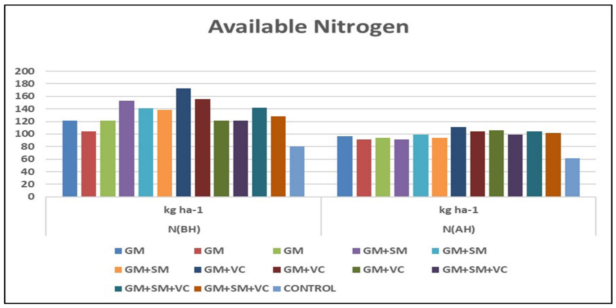

Fig. -7: Available Nitrogen of the Organically Treated Soil

Available Phosphorus (AP)

Phosphorus also increased significantly with organic manure. Before harvest, the maximum value (42.0 kg ha^{-1}) was obtained in GM+SM+VC @ 12.5 t ha^{-1}, an 82.36% increase compared with the control. Progressive increases were noted in sole GM treatments with higher dosages (8, 12.5, and 17 t ha^{-1}: 7.41, 12.36, and 29.65 kg ha^{-1}, respectively as displayed in Fig.-8. After harvest, phosphorus remained highest in GM+SM+VC @ 12.5 t ha^{-1} (79.59% increase), while GM+SM treatments also showed notable improvements (4.94, 7.41, and 17.30 kg ha^{-1}). The enhanced P availability may be due to mineralization[13] and solubilization of organic matter.

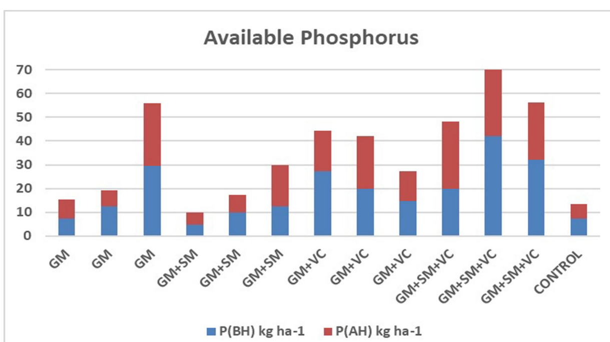

Fig.-8: Available Phosphorus of the Organically Treated Soil

Available Potassium (AK)

Potassium followed a similar trend. Before harvest, the lowest K content (368.18 kg ha^{-1}) was recorded in the control. The maximum K content (958.77 kg ha^{-1}) occurred in GM+SM+VC @ 12.5 t ha^{-1}. This represented a 61.60% increase. After harvest, enrichment persisted, with GM+SM+VC @ 12.5 t ha^{-1} maintaining the highest value (738.21 kg ha^{-1}). This was 49.46% higher than the control, as represented in Fig.-9. The improvement in available K can be attributed to the release of exchangeable potassium during manure decomposition.[14]

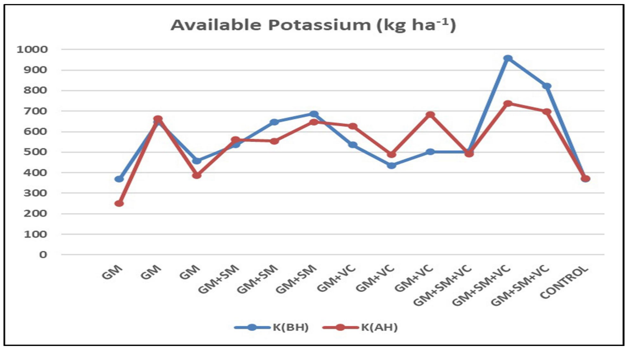

Fig.-9: Available Potassium of the Organically Amended Soil before and after Harvest

Soil Organic Carbon (OC) and Organic Matter (OM)

Soil organic carbon and organic matter were significantly enhanced under organic manure treatments. Before harvest, the highest organic carbon (0.2115%) was recorded in GM+SM+VC @ 17 t ha^{-1}, with sole GM treatment also showing a substantial increase (79.41% over control). Organic matter peaked in GM+SM+VC @ 12.5 t ha^{-1} (0.4667%), representing a 75.66% increase over the control as represented in Table-2. After harvest, organic carbon was lowest in the control (0.0381%). It increased steadily with higher GM+SM+VC applications (0.0501%, 0.0543%, and 0.0652%). The maximum (0.0865%) was achieved in sole GM @ 17 t ha^{-1}, a 55.95% improvement over the control 15. A similar trend was observed for organic matter, with maximum accumulation recorded in GM @ 17 t ha^{-1} and a notable increase even at GM @ 8 t ha^{-1} (0.1469%). These improvements may be attributed to the high carbon inputs and slower decomposition rate of goat manure, which contribute to long-term carbon buildup in soil. The correlation for the post-harvest chemical properties of the soil was given in Table-3.

Table-2: Soil Carbon Characteristics of the Treated Soil

Manure	Plot	BH		AH	
		OC %	OM %	OC %	OM %
GM	T1-A	0.1270	0.2456	0.0854	0.1469
GM	T1-B	0.1713	0.1978	0.0753	0.1295
GM	T1-C	0.2006	0.3654	0.0865	0.1488
GM+SM	T4-A	0.0838	0.2289	0.0543	0.0934
GM+SM	T4-B	0.0550	0.2596	0.0600	0.1032
GM+SM	T4-C	0.1270	0.1569	0.0519	0.0893
GM+VC	T5-A	0.0812	0.1062	0.0472	0.0812
GM+VC	T5-B	0.1492	0.0874	0.0456	0.0784
GM+VC	T5-C	0.0964	0.2304	0.0512	0.0881
GM+SM+VC	T7-A	0.1362	0.2813	0.0501	0.0862
GM+SM+VC	T7-B	0.1423	0.4667	0.0543	0.0934
GM+SM+VC	T7-C	0.2115	0.3995	0.0652	0.1121
CONTROL	T8	0.0413	0.1136	0.0381	0.0655
Grand Mean		0.1248	0.2415	0.0589	0.1012
Standard Deviation		0.0522	0.1157	0.0151	0.0260
Standard Error		0.0145	0.0321	0.0042	0.0072
Coefficient of Variance (%)		41.8171	47.9240	25.7139	25.7158
Significance		Not Significant	Not Significant	Most significant	Most significant

Table-3: Correlation for Chemical Properties of the Soil After Harvest

Properties	Yield	pH	EC	N	P	K	OC	OM
Yield	1							
pH	-0.52	1						
EC	-0.71 (**)	0.65 (**)	1					
N	0.66 (**)	-0.68 (**)	-0.88 (**)	1				
P	0.5	-0.2	-0.54	0.45	1			

K	0.54	-0.7 (**)	-0.34	0.46	0.23	1		
OC	-0.076	0.17	-0.11	0.11	0.021	-0.31	1	
OM	-0.076	0.17	-0.11	0.11	0.021	-0.31	1 (**)	1

** Correlation is significant at the 0.05 level (2 – tailed)

Biometric Observations

Plant Height

A consistent variation was observed with the growth of the crop up to 60 Days After Sowing (DAS). The highest height was observed with the triple manure treatment. During the second fortnight, integrated treatment was more effective. At 45 and 60 Days, GM+SM+VC observed the highest growth with 36.3 and 46.8 cm, respectively, as given in Fig.-10. Especially, the combination treatments outperformed individual applications, suggesting a synergistic effect of all organic inputs in maintaining nutrient supply and promoting soil fertility.[16]

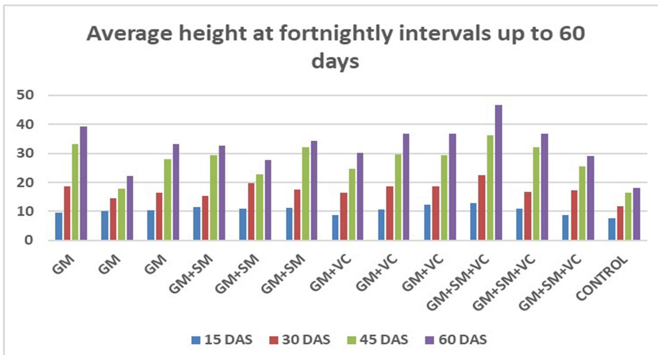

Fig.-10: Average Plant Height (cm) at different Days after Sowing

Pod Count Per Plant

Table 4 below represents the pod count per plant for different treatments at 15, 30, 45 and 60 DAS. For the 15 days, the growth of the pod was observed to be high for the integrated combination of manures. From the successive days of sowing, the double manure treatment, especially 8 t ha^{-1} and 12.5 t ha^{-1}, obtained a larger number of pods with 20 and 21.8. The vermicompost-treated soil particularly showed adequate growth. This happened due to the increased microbial activity and steady nutrient flow.

Number of Leaves Per Plant

The number of leaves per plant has improved gradually from 15 Days to 60 Days after sowing across all treatments. In the first fortnight, the number of leaves was significantly low. By the second fortnight, there was a mild rise with triple manure treatments compared to the sole application of manure. At 45 Days, a significant variation was observed for the GM+VC-treated plot. The GM+SM+VC plot had a greater number of leaves than the other plots. By 60 Days, the maximum leaf number was observed in the triple manure treatment, as shown in Fig.-11. This indicates a synergistic effect of the combined manures. The control had the lowest leaf count.

Table-4: Average Pod Number per Plant At 15, 30, 45, and 60 Days after Sowing Under Organic Manure

Manure	15 Days	30 Days	45 Days	60 Days
GM	1.2	5.4	12.3	18.3
GM	1.3	5.9	6.1	10.9
GM	1.5	5.7	8.1	13.5
GM+SM	3.2	5.7	7.9	13.9
GM+SM	2.9	5.7	9.2	13.2
GM+SM	1.6	5.9	10.7	15.5
GM+VC	1.7	6.3	16	20
GM+VC	3.3	7	11	21.8
GM+VC	1.9	5.3	11.5	19
GM+SM+VC	3.8	6.8	12.7	13.9

GM+SM+VC	3.2	5.2	10	12.4
GM+SM+VC	1.8	5.6	7.3	9.5
CONTROL	1.2	4.9	8.4	19.2

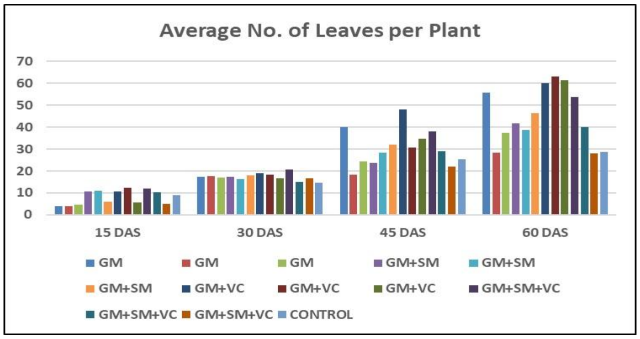

Fig.-11: Average Leaves per Plant at 15, 30, 45 and 60 Days Under Organic Manure Application

CONCLUSION

The present study shows that the application of organic manures, both individually and in combinations, significantly improves the physico-chemical properties of the soil. It also enhances the chemical properties of the soil. In addition, the yield of black gram (*Vigna Mungo L.*) is increased. Among all treatments, the concurrent application of goat manure and vermicompost (GM+VC) at 17 t ha^{-1} yielded the maximum output of 990 kg ha^{-1}. The treatment at GM+SM+VC at 8 t ha^{-1} also showed remarkable improvement with a yield increase of 84.46% over the control. These treatments notably reduced pH, Electrical Conductivity and improved macronutrients. These factors showed a positive correlation with yield. This suggests that lower doses of well-balanced organic manures can deliver superior yield and soil health benefits. It provides farmers with an economical and environmentally sustainable solution. Biometric observations suggest that the correct combination and proportion of organic manure is very important. This helps to attain better plant growth and overall development. The findings support the integration of organic manures into sustainable agricultural practices. They also highlight the importance of soil physical properties in crop productivity.

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CONFLICT OF INTERESTS

The authors affirm that there are no conflicts of interest.

AUTHOR CONTRIBUTIONS

The present work is related to *SDG-2: Zero Hunger*. All the authors contributed significantly to this manuscript, participated in reviewing/editing and approved the final draft for publication. The research profile of the authors can be verified from their ORCID ids, given below:

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