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Effect of organic amendments on growth and yield of brinjal (*Solanum melongena* L.) and physico–chemical properties of Alfisols of Tamirabarani tract

Kuzhalarasi JP[1], Paramasivan M[1*], Leninraja D[1], Jeberlin Prabina B[1] & Manivannan MI[2]

[1]Department of Soil Science and Agricultural Chemistry, V.O.C Agricultural College and Research Institute (TNAU), Killikulam, Thoothukudi 628 252
[2]Department of Horticulture, V.O.C Agricultural College and Research Institute (TNAU), Killikulam, Thoothukudi 628 252

*Email: paramusoil@gmail.com

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Abstract

A field experiment was conducted during February–May of 2023–2024 at V.O. Chidambaranar Agricultural College and Research Institute, Killikulam, to evaluate and study the effect of organic amendments with the combination of soil test crop response (STCR) based inorganic fertilizers on crop productivity, nutrient uptake, economic and soil fertility of brinjal (KKM 1). The experiment was carried out in a split–plot design replicated thrice with 3 main plots (M1, M2, M3) and 4 subplot (S1, S2, S3, S4) treatments. In comparison to the control, the application of 100% STCR NPK + 12.5 t ha-1 vermicompost resulted in significantly higher plant height (cm), days to first flowering, number of branches per plant, number of fruits per plant, fruit weight per plant (g), fruit yield (t ha-1), benefit-cost ratio (B:C ratio) and N, P and K uptake (kg ha-1). However, higher plant heights, number of branches per plant, days to first flowering, fruit yield, B:C ratio and N, P and K uptake were observed in 100% STCR NPK combined with 12.5 t ha-1 of organic manures. When 100% STCR NPK + 12.5 t ha-1 vermicompost was used, there was a notable build-up of organic carbon (0.49%), available N (248 kg ha-1), available P (13.33 kg ha-1), and available K (184 kg ha-1). It is believed that 12.5 t ha-1 municipal solid waste compost (MSWC) is a better alternative to other organic manures for the environmentally friendly, and also, the B:C ratio of this treatment was 4.48 compared to others.

Keywords

Alfisols; available nutrient; brinjal fruit yield; organic amendments; STCR; B:C ratio; MSW; MSWC

Introduction

In India, one of the most widely grown vegetables is the brinjal (Solanum melongena L.). 12.2 million tonnes are produced from 0.59 million hectares of cultivable land (1). This crop produces 17.5 t ha-1 on average nationally. In the report of the Government of Tamil Nadu's area and production of major crops from 2010 to 2021, brinjal is grown on 60119 hectares with a growth percentage of about 3.2. One of the main factors determining the yield targets of many crops is soil fertility. The application of organic amendments (vermicompost, municipal solid waste compost (MSWC), and poultry manure) will lead to significant improvements in the growth and yield of brinjal as well as enhanced physico-chemical properties of Alfisols in the Tamirabarani tract. It is

anticipated that these organic amendments will provide a sustainable and eco-friendly alternative to chemical fertilizers, contributing to improved agricultural practices and soil health. In general, heavy manuring is needed for the potential production of brinjal. It is also known as a “Poor man’s crop” as it is mainly grown by small and marginal farmers. Brinjal is a good source of vitamins like A, B and C. The fruit comprises 92.7 g of moisture, 1.4 g of protein, minerals 0.3 g, fiber content 1.3 g, 4.0 g of carbohydrate, oxalic acid 18 mg, phosphorus 47 mg, iron 0.9 mg, ascorbic acid 10 mg, etc.

However, farmers cannot afford to use costly commercial fertilizers in accordance with crop requirements. Consequently, the most recent and economical approach to managing nutrients for productivity and sustainability is the application of fertilizers in conjunction with organic manures (2). In addition to raising concerns about falling productivity, increased use of chemical fertilizers also degrades the health of the soil. The present study was conducted to investigate the physico-chemical characteristics of the soil and the growth and yield of brinjal in relation to the effects of organic amendments.

Materials and methods

A field experiment was conducted at V.O.C Agricultural College and Research Institute, Killikulam, from 2023 to 2024. Here the initial values (control) of the soil of the experimental field were sandy loam in texture, nearly neutral in reaction (pH 6.6), electrical conductivity 0.06 dS m-1, organic carbon 0.42% determined by chromic wet digestion method (Walkley and Black), available nitrogen 246 kg ha-1 by alkaline permanganate method, available phosphorous 10 kg ha-1 by Olsen’s method and available potassium 180 kg ha-1 by flame photometer method. The cation exchange capacity of the soil was 20.6 cmol (p+) kg-1, determined by the ammonium acetate method. The bulk density was 1.33 mg m-3 (cylinder method). The exchangeable calcium and magnesium were 4.92 cmol (p+) kg-1 (Ca), and 1.42 cmol (p+) kg-1 (Mg), determined by the versanate titration method (Table 1). The soil was taxonomically grouped as Alfisols (3). The experiment was conducted under a split-plot design, with the treatment comprised of a main plot and subplots, with three replications as mentioned in Table 2.

Table 1. Characteristics of initial soil

	Initial Soil Characteristics	
S. No	**Soil physical properties**	**Values**
1	Bulk density (mg m^{-3})	1.33
2	Soil Texture	Sandy loam
	Physico–chemical properties	
3	pH	6.6
4	EC (dSm^{-1})	0.06
5	Cation exchange capacity (cmol (p+) kg^{-1})	20.6
	Chemical properties	
6	Organic carbon (g kg^{-1})	0.4
7	Available Nitrogen (Alkaline $KMnO_4$ –N) kg ha^{-1}	246
8	Available Phosphorous (Olsen-P) kg ha^{-1}	10
9	Available Potassium (Neutral *N* NHO_4 Ac) kg ha^{-1}	180
10	Exchangeable Calcium (cmol (p+) kg^{-1})	4.92
11	Exchangeable Magnesium (cmol (p+) kg^{-1})	1.42

Table 2. Treatment details

Main plot
M_1 – Absolute control (No Inorganic)
M_2 - 100% STCR NPK
M_3 - 75% STCR NPK
Sub plot
S_1 - Absolute Control (No organic)
S_2 - Vermicompost @ 12.5 t ha^{-1}
S_3 - Poultry manure @ 12.5 t ha^{-1}
S_4 - Municipal Solid Waste Compost @ 12.5 t ha^{-1}

The brinjal variety KKM 1 was harvested as a test crop in February through May of 2024. Brinjal was planted in the morning of February with 60 × 60 cm spacing between each plant and transplanted by making ridges and furrows. The cultivation methods and intercultural operations were carried out in accordance with the Tamil Nadu Agricultural University's crop production guide (4). The fertilizer sources utilized were muriate of potash for K (60 % of K2O), single super phosphate for P (16 % water soluble P2O5), and urea for N (46% N). Here, we combined organic manures with soil test crop response (STCR)-based fertilizers. Growth and yield characteristics were recorded in accordance with standard protocols.Biometric and yield attributes, including plant height, number of branches, number of fruits per plant, fruit weight, and fruit yield, were observed in five representative samples of each plot and statistically analyzed. Using specified laboratory techniques, the nutrient content and plant uptake were examined. To analyze the physical, chemical and available nutrient status, post-harvest soil samples were taken at a depth of 0 to 30 cm. Soil samples were analysed for alkaline permanganate, oxidizable N, 0.5 M NaHCO3-extractable P and 1 N NH4OAc-exchangeable K (5). Using Gomez and Gomez's procedure**,** one-way and two-way analysis of variance were applied to the data gathered from the characterization of the compost and the field experiment. The analysis was done at the 5% probability level.

Results and Discussion

Growth and yield attributes

The plant height was measured and recorded at harvest, as mentioned in Table 3. The height of the plant significantly differed for various treatments. It ranged from 58.2 to 86.53 cm at final harvest. At harvest, the tallest plant with 106.06 cm average height was recorded in the treatment (M2S2) with 100% STCR NPK + vermicompost @ 12.5 t ha-1, followed by treatment (M3S2) with 75% STCR NPK + vermicompost @ 12.5 t ha-1 (97.82 cm), which was on par with (M2S3) 100% STCR NPK + poultry manure @ 12.5 t ha-1 (97.41 cm) and (M2S4) 100% STCR NPK + MSWC @ 12.5 t ha-1 (91.23 cm). The shortest plant (58.20 cm) was recorded in absolute control (M1). The maximum (12.00) and minimum (5.06) number of branches per plant were recorded with M2S2 and M1 respectively. Similar results have been reported in recent studies (6).

The number of days required for the first flowering of the crop was assessed in all the treatments and presented in Table 3.

Table 3. Influence of organic amendments on brinjal crop growth attributes

Treatment details		Plant height (cm)				Number of branches				Days to first flowering			
		M_1 Control	M_2 100% STCR NPK	M_3 75% STCR NPK	Mean	M_1 Control	M_2 100% STCR NPK	M_3 75% STCR NPK	Mean	M_1 Control	M_2 100% STCR NPK	M_3 75% STCR NPK	Mean
S_1	Control	58.2	64.57	62.23	61.67	5.06	6.86	6.93	6.28	59.33	50.66	54.66	54.88
S_2	Vermicompost @ 12.5 t ha^{-1}	77.73	106.06	97.82	93.87	9.37	12.00	10.76	10.71	50.33	43.33	49.00	47.55
S_3	Poultry manure @ 12.5 t ha^{-1}	71.10	97.41	92.47	86.98	7.60	11.90	9.73	9.74	52.00	47.01	50.33	49.77
S_4	MSWC @ 12.5 t ha^{-1}	69.33	91.23	86.53	82.36	7.73	9.23	8.63	8.53	54.00	48.10	54.20	52.00
	Mean	69.09	89.81	84.75		7.45	10.00	9.01		53.91	47.25	52.02	
		M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M
	SEd	0.943	0.813	1.542	1.408	0.186	0.292	0.476	0.507	0.333	0.507	0.830	0.878
	CD (p=0.05)	2.620	1.708	3.240	2.959	0.516	0.615	1.001	1.065	0.925	1.065	1.744	1.845

Among the treatments, M2S2 had shown first flowering at the earliest (43.33 days), followed by M2S3, which reached first flowering in 47.01 days. However, both the treatments were found to be on par with each other, followed by M2S4 (48.10 days). The first flowering period was late (59.33 days) in M1. Certain similar observations have been shown in research studies (7). Other yield attributes like the number of branches per plant, number of fruits, and weight of fruit per plant were significantly influenced by various treatments.

Among all the treatments, the maximum number of fruits per plant (15.63) was recorded by the application of M2S2 (Table 4). The application of M2S3 and M2S4 recorded an average of 15.00 fruits per plant and 14.50 fruits, respectively. However, these treatments were found to be on par with each other. The minimum number of fruits per plant (6.00) was registered from absolute control (M1). Similar results were reported in nutrient-related studies (8). The maximum weight of fruit per plant (43.03 g) was recorded in the treatment M2S2, followed by M3S2, which recorded 42.16 g fruit on an average. However, both treatments were found to be statistically on par. However, the treatment M2S3 and M2S4 recorded 41.23 g and 39.76 g of fruit, respectively. The minimum fruit weight per plant (23.01 g) was registered with M1. The same results have been given in the study which evaluated with the tomato fruit (9).

Yield

The application of organic amendments in brinjal with inorganic fertilizers significantly enhanced the fruit yield as compared to the control (10). The application of M2S2 produced the maximum and significantly higher fruit yield up to the tune of 33.73 t ha-1 over control. The second-best treatments were M2S3 and M2S4 , which recorded 32.33 and 31.86 t ha-1 of fruit yield, respectively; whereas, the lowest yield of fruit (15.83 t ha-1) was noticed with control (Table 4). The increase in fruit yield might have been due to increased growth and yield attributes. These results corroborate the findings of other studies that reported a significant increase in the yield of brinjal (11, 12).

Nutrient content and uptake

To know the influence of organic amendments application on NPK content (%) and uptake (kg ha-1) in brinjal whole plant,

Table 4. Effect of organic amendments on brinjal yield attributes

Treatment details		Number of fruits per plant				Fruit weight per plant (g)				Fruit yield (t ha^{-1})			
		M_1 Control	M_2 100% STCR NPK	M_3 75% STCR NPK	Mean	M_1 Control	M_2 100% STCR NPK	M_3 75% STCR NPK	Mean	M_1 Control	M_2 100% STCR NPK	M_3 75% STCR NPK	Mean
S_1	Control	6.00	10.13	9.13	8.42	23.01	25.13	24.43	24.18	15.83	22.07	20.42	19.44
S_2	Vermicompost @	13.06	15.63	14.76	14.48	31.10	43.03	42.16	38.76	26.81	33.73	30.93	30.49
S_3	Poultry manure @ 12.5 t ha^{-1}	12.16	15.00	14.17	13.78	29.76	41.23	40.51	37.16	25.95	32.33	29.47	29.25
S_4	MSWC @ 12.5 t ha^{-1}	11.69	14.50	13.77	13.32	27.23	39.76	39.33	35.44	25.05	31.86	28.60	28.50
	Mean	10.73	13.81	12.96		27.77	37.10	36.91		23.41	30.12	27.35	
		M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M
	SEd	0.096	0.138	0.228	0.239	0.156	0.211	0.353	0.366	0.114	0.138	0.237	0.240
	CD (p=0.05)	0.266	0.290	0.479	0.502	0.434	0.444	0.742	0.769	0.317	0.291	0.498	0.504

the data were analyzed and presented in Table 5. The combined application of inorganic fertilizers and compost influenced the nutrient content and uptake significantly. Uptake of nutrients also showed similar trends. The highest uptake of NPK in plants (143.59, 33.53, and 147.74 kg ha-1, respectively was recorded in the treatment with M2S2. The lowest uptake of NPK in plants (67.86, 11.16, and 70.63 kg ha-1 respectively) was noticed in control. Similar results have been reported in nutrient uptake in other studies (13,14).

Soil fertility

Scrutinizing the data in Table 6 showed that different treatments had a significant impact on the soil's available nutritional levels at the post-harvest stage. The highest values of soil organic carbon and available nitrogen (0.49 % and 278 kg ha-1) were recorded with M2S2, which was on par with M2S3 (0.47% and 269 kg ha-1) and followed by M2S4 (0.46% and 265 kg ha-1). These results suggest that integrated nutrient management strategies can significantly improve nitrogen availability and soil fertility (15, 16). The available phosphorus also was the highest (28.46 kg ha-1) for the same treatment followed by M2S3 (25.53 kg ha-1). The M2S4 recorded the phosphorous content of 23.86 kg ha-1, which was on par with M3S2 (23.36 kg ha-1). Poultry manure (S3) and MSWC (S4) also enhanced soil phosphorus, showing the potential of these amendments to release phosphorus gradually over time (17).

Table 5. Effect of organic amendments on nutrient uptake of brinjal plant

Treatment details		Nitrogen uptake of brinjal crop (kg ha^{-1})				Phosphorous uptake of brinjal crop (kg ha^{-1})				Potassium uptake of brinjal (kg ha^{-1})			
		M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3	
		Control	100% STCR NPK	75% STCR NPK	Mean	Control	100% STCR NPK	75% STCR NPK	Mean	Control	100% STCR NPK	75% STCR NPK	Mean
S_1	Control	41.34	49.60	45.16	45.36	6.56	8.03	7.73	7.44	41.87	59.10	54.37	51.78
S_2	Vermicompost @ 12.5 t ha^{-1}	58.56	74.56	69.23	67.45	8.77	13.53	10.87	11.06	64.20	78.17	71.77	71.38
S_3	Poultry manure @ 12.5 t ha^{-1}	56.23	70.87	65.83	64.31	8.63	12.17	10.23	10.34	63.63	75.80	71.33	70.26
S_4	MSWC @ 12.5 t ha^{-1}	55.77	69.37	64.13	63.09	8.17	11.43	9.57	9.72	63.17	74.27	70.17	69.20
	Mean	52.98	66.10	61.09		8.03	11.29	9.60		58.21	71.83	66.90	
		M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M
	SEd	0.001	0.031	0.063	0.054	0.023	0.025	0.044	0.043	0.060	0.068	0.118	0.117
	CD (p=0.05)	0.117	0.065	0.132	0.114	0.065	0.053	0.093	0.091	0.167	0.142	0.249	0.247

Table 6. Effect of organic amendments on organic carbon, nitrogen, phosphorous and potassium of post-harvest soil of brinjal

Treatment details		Soil Organic Carbon (%)				Available Nitrogen (kg ha^{-1})				Available Phosphorous (kg ha^{-1})				Available Potassium (kg ha^{-1})			
		M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3	
		Control	100% STCR NPK	75% STCR NPK	Mean	Control	100% STCR NPK	75% STCR NPK	Mean	Control	100% STCR NPK	75% STCR NPK	Mean	Control	100% STCR NPK	75% STCR NPK	Mean
S_1	Control	0.40	0.42	0.42	0.41	220	228	224	224	9.28	10.52	10.30	10.03	169	172	170	170
S_2	Vermicom-post @ 12.5 t ha^{-1}	0.45	0.49	0.46	0.46	229	248	235	237	11.20	13.33	13.19	12.57	175	184	180	179
S_3	Poultry manure @ 12.5 t ha^{-1}	0.44	0.47	0.45	0.45	227	246	232	235	11.16	12.24	12.03	11.81	173	182	180	178
S_4	MSWC @ 12.5 t ha^{-1}	0.43	0.44	0.42	0.43	224	239	230	231	11	11.66	11.63	11.43	171	180	179	176
	Mean	0.42	0.46	0.44		225	240	230		10.66	11.93	11.78		172	179	177	
		M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M
	SEd	0.012	0.004	0.013	0.007	0.872	1.047	1.810	1.818	0.320	0.262	0.510	0.479	0.691	1.007	1.661	1.744
	CD (p=0.05)	0.033	0.009	0.029	0.016	2.421	2.210	3.782	3.817	0.816	0.572	1.112	0.971	1.921	2.116	3.491	3.665

The highest available potassium (196 kg ha-1) was also recorded with the treatment M2S2 and was on par with M3S2 (195 kg ha-1).It was followed by M2S3 (188 kg ha-1), which was on par with the application of 75% STCR NPK long with 12.5 t ha-1 poultry manure (M3S3) (186 kg ha-1). This was followed by the plot supplied with M2S4 (182 kg ha-1). The same result was reported by other research studies (18).

It can be attributed to vermicompost's rich potassium content and ability to enhance nutrient mineralization through increased microbial activity (19). These results suggest that integrating organic and inorganic nutrient sources optimizes potassium availability by reducing leaching losses and improving soil K retention (20). The lowest values of available nutrients of OC, N, P, and K (0.40 %, 241, 15.33, and 171 kg ha-1, respectively) were recorded in the control.

Economics

The application of M2S4 fetched significantly higher net returns (413000 ha-1) and benefit-cost ratio (B:C ratio) (7.39) over other treatments (Table 7). The second best treatment was net return was up to the tune of 382000 ha-1 due to the application of M2S3 (ratio of 4.75) and followed by the application of 75% STCR NPK + MSWC @ 12.5 t ha-1 (M3S4) (net return upto 364000 ha-1 and ratio of 6.81) and the application of M2S2 (net return upto 341000 ha-1 and ratio of 3.01). This might be due to higher productivity as well as lower cultivation costs. These results closely conform to the findings of economic analysis from the vegetable crop studies (21,22).

Table 7. Influence of organic amendments on economics on brinjal cultivation

Treatment details		Gross return (in lakhs)			Net return (in lakhs)			B:C ratio		
		M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
		Control	100% STCR NPK	75% STCR NPK	Control	100% STCR NPK	75% STCR NPK	Control	100% STCR NPK	75% STCR NPK
S_1	Control	1.84	3.31	3.06	1.61	3.00	2.78	1.57	2.09	1.92
S_2	Vermicompost @ 12.5 t ha^{-1}	4.02	5.05	4.50	2.54	3.50	2.96	2.72	3.26	2.93
S_3	Poultry manure @ 12.5 t ha^{-1}	3.89	4.77	4.42	2.99	3.80	3.46	3.32	3.89	3.61
S_4	MSWC @ 12.5 t ha^{-1}	3.75	4.65	4.29	3.21	4.03	3.68	4.08	4.48	4.12

Conclusion

Adding organic amendments to soil in addition to inorganic fertilizers increases soil fertility and improves brinjal productivity. It is concluded that soil application of 100% STCR NPK fertilizers combined with 12.5 t ha-1 of organic manures like vermicompost, poultry manure and MSWC not only improves the brinjal productivity but also soil fertility status. However, the best treatment in all forms was the application of MSWC combined with inorganic fertilizers, which increased the yield and B:C ratio during brinjal cultivation in the Alfisols of Tamil Nadu. Therefore, we recommend the municipal solid waste compost as an alternative for other organic manures for the production of vegetable crops.

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Authors' contributions

KJP and PM conceived the idea, and wrote the manuscript. PM gave idea and KJP designed the diagrams and tables. JPB revised the manuscript. KJP, PM, LD, JPB and MMI finalized the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

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During the preparation of this work the authors used Grammarly in order to improve the language and readability. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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