

Use of integrated nutrient management to enhance soil fertility and crop yield of hybrid cultivar of brinjal (*Solanum melongena* L.) under field conditions

Abstract

The field experiments were conducted to investigate the effects of integrated nutrient management practices on soil fertility and crop yield of hybrid cultivar of brinjal (*Solanum melongena* L. cv. F1 Hybrid purple long) under field conditions. During the study, ten nutrients treatments viz., without nutrient (control) (T1), recommended dose of fertilizer (RDF) (T2), vermicompost @ 5t ha⁻¹ (T3), sugarcane pressmud compost (SPC) @ 5t ha⁻¹ (T4), farm yard manure (FYM) @ 12.5t ha⁻¹(T5), sewage sludge (SS) @ 2t ha⁻¹(T6), T7 (50 % RDF+vermicompost @ 5t ha⁻¹), T8 (50 % RDF+SPC @ 5t ha⁻¹), T9 (50 % RDF+FYM @ 12.5t ha⁻¹) and T10 (50% RDF+SS @ 2t ha⁻¹) were used for the cultivation of *S. melongena*. The results revealed that different treatments showed significant ($P<0.05/P<0.01$) change in the soil characteristics viz., EC, OC, TKN, PO₄³⁻, Na⁺, K⁺, Ca²⁺, Mg²⁺, Cd, Cr, Cu, Fe, Mn and Zn of the soil. Among various treatments the most plant height, root length, dry weight, chlorophyll content, LAI, number of flowers/plant, fruits/plant, crop yield/plant, crude protein, dietary fiber, total carbohydrates and total sugar of *S. melongena* was recorded with 50% RDF+vermin compost @ 5t ha⁻¹. The agronomical performance of *S. melongena* was observed in the order of T7>T10>T9>T8>T3>T6>T5>T4>T2>T1 treatments. Therefore, sole vermin compost and 50% RDF along with vermicompost @ 5 t ha⁻¹ can be used to obtain the maximum crop yield of *S. melongena*.

Keywords: farm yard manure, recommended dose of fertilizer, sewage sludge, *S. melongena*, sugarcane, press mud compost, vermi compost

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Introduction

The basic concept underlying the integrated nutrient management system (INMS), nevertheless, remains the maintenance and possible improvement of soil fertility for sustained crop productivity on long term-basis and also to reduce inorganic (fertilizer) input cost.¹⁻³ Thus, integrated nutrient supply/management (INS) aims at maintenance or adjustment of soil fertility and of plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of benefit from all possible sources of plant nutrients in an integrated manner.²⁻⁴

Agriculture remains a soil-based industry, there is no way that required yield increases of the major crops can be attained without ensuring that plants have an adequate and balanced supply of nutrients.⁵⁻⁷ The appropriate environment must exist for nutrients to be available to a particular crop in the right form, in the correct absolute and relative amounts, and at the right time for high yields to be realized in the short and long term.⁶⁻⁹ At present, the environmental drawbacks of heavy fertilizer use are confined to some developed countries and a few regions in developing countries.^{6,10} Appropriate and responsible application of fertilizers will help to maintain yields and minimize pollution.^{10,11} By contrast, levels of fertilizer use in most developing countries are so low that there is little likelihood of major environmental problems from their application. In fact, greater application of organic and inorganic fertilizers in these areas could benefit the environment and increase yields.¹¹⁻¹³ Plant growth is the result of a complex process whereby the plant synthesizes solar energy, carbon dioxide, water, and nutrients from the soil. In

all, between 21 and 24 elements are necessary for plant growth.^{13,14} The primary nutrients for plant growth are nitrogen, phosphorus, and potassium (known collectively as NPK).¹⁵⁻¹⁷ When insufficient, these primary nutrients are most often responsible for limiting crop growth. Nitrogen, the most intensively used element, is available in virtually unlimited quantities in the atmosphere and is continually recycled among plants, soil, water, and air. However, it is often unavailable in the correct form for proper absorption and synthesis by the plant. In addition to the primary nutrients, less intensively used secondary nutrients (sulfur, calcium, and magnesium) are necessary as well.¹⁸⁻²² A number of micronutrients such as chlorine, iron, manganese, zinc, copper, boron, and molybdenum also influence plant growth.²³⁻²⁵ These micronutrients are required in small amounts (ranging from a few grams to a few hundred grams per hectare) for the proper functioning of plant metabolism. The absolute or relative absence of any of these nutrients can hamper plant growth; alternatively, too high a concentration can be toxic to the plant or to humans.²⁶⁻³⁰

Eggplant (*Solanum melongena* L.) is identified as one of the most valuable veggies packed with essential nutrients.^{8,10} It is a delicate, tropical perennial often cultivated as a tender or half-hardy annual in temperate climates.¹⁰ It is being widely cultivated throughout the world in tropical and subtropical climates. Nutritionally, eggplant is low in fat, protein, and carbohydrates. It is rich in dietary fiber, sugar, sodium and potassium. It also contains important vitamins like A, B6, C, D and calcium, iron and magnesium. Eggplant is used in the cuisine of many countries.⁸ It is widely used in its native Indian cuisine, like vegetable, chutney, curry, and pickle. Eggplant, due to its texture and bulk, can be used as a meat substitute

in vegan and vegetarian cuisine. The juice of eggplant significantly reduces weight, plasma cholesterol levels, and aortic cholesterol content.^{8,10}

The deficiency of plant nutrients causes different changes in the physiological and biochemical processes within the plant cell resulting in a reduction of growth, delay of development and qualitative and quantitative decrease of yield.^{31–35} The organic sources besides supplying N, P and K also make unavailable sources of elemental nitrogen, bound phosphates, micronutrients, and decomposed plant residues into an available form to facilitate to plant to absorb the nutrients.^{32,33} But, it is also the fact that optimum yield level of maize production can not be achieved by using only organic manures because of their low nutrient content.^{36–38} Efficacy of organic sources to meet the nutrient requirement of crop is not as assured as mineral fertilizers, but the joint use of chemical fertilizers along with various organic sources is capable of improving soil quality and higher crop productivity on long-term basis.^{39–42} Highest productivity of crops in sustainable manner without deteriorating the soil and other natural resources could be achieved only by applying appropriate combination of different organic manures and inorganic fertilizers.^{24,43,44} It is important to identify the best type of available organic resources which can be used as fertilizers and their best combination with appropriate proportion of inorganic fertilizers.^{27,37,42} Sufficient and balanced application of organic and inorganic fertilizers is a major component of INM.^{24,43} Successful INM extension will also require greater monitoring and testing of plants and soils.^{25,31} Monitoring will help ensure that an environment conducive for optimal plant growth and crop yield can be established through nutrient application and soil reclamation.^{29,31,43} There is a lack of prioritized and strategic problem-solving agricultural research that is related to plant nutrition management and the incorporation of mineral and organic sources of plant nutrients into the soil.^{16,21,31} Therefore, the application of targeted, sufficient, and balanced quantities of inorganic fertilizers will be necessary to make nutrients available for high yields without polluting the environment.^{1,3,4,16,29,43} Keeping in view, the present investigation was carried out to study the effects of integrated nutrient management on agronomical attributes of brinjal (*S. melongena* L.) under field conditions.

Materials and methods

Experimental design

The field experiments were carried out in the Experimental Garden of the Department of Zoology and Environmental Sciences, Gurukula Kangri University Haridwar, India (29°55'10.81" N and 78°07'08.12" E) during the year 2013 and 2014. For the cultivation of *S. melongena*, ten plots (each plot had an area of 9 × 9m²) were selected for the ten treatments viz., without nutrient (control) (T₁), recommended dose of fertilizer (RDF) (T₂), vermicompost @ 5t ha⁻¹ (T₃), sugarcane pressmud compost (SPC) @ 5t ha⁻¹ (T₄), farm yard manure (FYM) @ 12.5t ha⁻¹ (T₅), sewage sludge (SS) @ 2t ha⁻¹ (T₆), T₇ (50% RDF+vermicompost @ 5t ha⁻¹), T₈ (50% RDF+SPC @ 5t ha⁻¹), T₉ (50% RDF+FYM @ 12.5t ha⁻¹) and T₁₀ (50% RDF+SS @ 2t ha⁻¹) (Table 1). All the treatments were placed within randomized complete block design.³⁴

Preparation of nursery and transplantation of *S. melongena*

Seeds of a high yield variety of *S. melongena*, cv. F₁ Hybrid purple

long, were procured from Indian Council of Agriculture Research (ICAR), Pusa, New Delhi, and sterilized with 0.01% Thiram. The nursery was prepared before one month of transplantation of *S. melongena*. For the nursery preparation 0.6g seeds of *S. melongena* were sown in the nursery beds (farm yard manure mixed soil). The nursery bed was covered with straw mulch till seeds germinate. The plants were watered as per requirement and other agronomical practices like weeding and hoeing were performed till the plants were transplanted in the field. Four weeks old plants of *S. melongena* were transplanted in 6 rows with a distance of 60×60cm between plants.^{34,45} The plants in each plot were irrigated twice in a month with bore well water and necessary agronomical practices were performed. The insecticide Chlorax20 (Chlorpyrifos 20% EC) was applied (1ml/L water) to control the pests on *S. melongena* during the experiments.

Table 1 Description of various treatments used for the cultivation of brinjal (*S. melongena*)

Treatment	Description
T ¹	Without nutrient (Control)
T ²	Recommended dose of inorganic fertilizer (RDF)
T ³	Vermicompost @ 5t ha ⁻¹
T ⁴	Sugarcane pressmud compost (SPC) @ t ha ⁻¹
T ⁵	Farm yard manure (FYM) @ 12.5 t ha ⁻¹
T ⁶	Sewage sludge (SS)@ 2t ha ⁻¹
T ⁷	50 % RDF+Vermicompost @ 5t ha ⁻¹
T ⁸	50 % RDF+SPC @ 5t ha ⁻¹
T ⁹	50 % RDF+FYM @ 12.5t ha ⁻¹
T ¹⁰	50 % RDF+SS @ 2t ha ⁻¹

Study of crop parameters

The agronomic parameters of *S. melongena* at different stages (0–120days) were determined following standard methods for plant height, root length, number of flowers and crop yield;³⁴ dry weight;⁴⁶ chlorophyll content⁴⁷ and leaf area index (LAI).⁴⁸ The biochemical parameters like crude protein, dietary fiber, total carbohydrate and total sugar in *S. melongena* were determined following standard methods.^{49,50}

Soil and heavy metals analysis

The soil was analyzed after harvest of *S. melongena* for various physico-chemical parameters like electrical conductivity (EC), pH, organic carbon (OC), total Kjeldhal nitrogen (TKN), phosphate (PO₄³⁻), sodium (Na⁺), potassium (K⁺), calcium (Ca²⁺), magnesium (Mg²⁺), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) following standard methods.^{50,51} For analysis of heavy metals, 1.0 g of air dried soil or plants were taken in digestion tubes separately. For each sample 3ml of concentrate HNO₃ was added and digested in an electrically heated block for 1hour at 145°C. To this mixture 4ml of HClO₄ was added and heated to 240°C for 1 hour. The mixture was cooled and filtered through Whatman # 42 filter paper. The volume was made to 50 ml by adding double distilled water and used for analysis. The heavy metals viz., Cd, Cr, Cu, Fe, Mn and Zn were analyzed using an atomic absorption spectrophotometer (PerkinElmer, Analyst 800 AAS, GenTech Scientific Inc., Arcade, NY) following methods.^{50–54}

Data analysis

The values presented in the present study are mean of six replicates. Means were calculated with MS Excel (ver. 2013, Microsoft Redmond Campus, Redmond, WA) and graphs produced with Sigma plot (ver. 12.3, Systat Software, Inc., Chicago, IL). Data were analyzed with SPSS (ver. 16.0, SPSS Inc., Chicago, Ill.). Data were subjected to one-way analysis of variance (ANOVA) to determine the significant effect of various treatments viz., vermicompost, sugarcane pressmud compost, farm yard manure and sewage sludge and their combination with recommended dose of fertilizer (RDF) on soil and agronomical attributes of *S. melongena*

Results and discussion

Characteristics of vermicompost, sugarcane pressmud, farm yard manure and sewage sludge

The soil parameters like OC, TKN, PO₄³⁻, Na⁺, K⁺, Ca²⁺, Mg²⁺, Cd, Cr, Cu, Fe, Mn and Zn are considered as essential macro and micro nutrients and, necessary for the optimum agronomical performance of crop plants.⁸ The availability of these parameters in the soil indicates the fertility of the soil^{10,13} and various organic, inorganic and bio-fertilizers are applied in the soil to maintain their availability for agricultural crops.^{17,32} The chemical characteristics of vermicompost, sugarcane pressmud compost, farm yard manure and sewage sludge are presented in Table 2. The values showed that vermicompost was comparatively had more EC, OC, TKN, PO₄³⁻, Na⁺, K⁺, Ca²⁺, Mg²⁺, Cd, Cr, Cu, Fe, Mn and Zn in comparison to sugarcane pressmud, farm yard manure and sewage sludge. The availability of EC, OC, TKN, PO₄³⁻, Na⁺, K⁺, Ca²⁺, Mg²⁺, Cd, Cr, Cu, Fe, Mn and Zn in vermicompost, sugarcane pressmud compost, farm yard manure and sewage sludge were recorded in the order of vermicompost>sewage sludge>farm yard manure>sugarcane pressmud (Table 2). Thus the results indicated that sugarcane pressmud, farm yard manure and sewage sludge were considerably rich in different macro and micro nutrients required by the crop plants. The findings of the present study are in line of Kumar et al.,⁸ who reported comparatively higher contents of OC (9.20mg Kg⁻¹), TKN (332.89mg Kg⁻¹), PO₄³⁻ (272.55mg Kg⁻¹), Na⁺ (518.30mg Kg⁻¹), K⁺ (978.50mg Kg⁻¹), Ca²⁺ (825.68mg Kg⁻¹), Mg²⁺ (268.60mg Kg⁻¹), Cd (10.76mg Kg⁻¹), Cr (6.12mg Kg⁻¹), Cu (21.20mg Kg⁻¹), Fe (24.88mg Kg⁻¹), Mn (14.50mg Kg⁻¹) and Zn (30.95mg Kg⁻¹) in sewage sludge. Antil et al.,⁵ also reported that different organic manures were found to be loaded with OC, TKN, PO₄³⁻ and K⁺ and their application significantly increased the nutrients and enhance the soil fertility. Therefore, all the treatments used in the present study were found to be loaded with plant nutrients and may enhance the soil fertility.

Effects of integrated nutrients on soil characteristics

During the present investigation, the physico-chemical characteristics of soil after harvest of *S. melongena* with different treatments are presented in Table 3 and Figure 1. The results revealed that different treatments showed significant (P<0.05/P<0.01) change in EC, OC, TKN, PO₄³⁻, Na⁺, K⁺, Ca²⁺, Mg²⁺, Cd, Cr, Cu, Fe, Mn and Zn of the soil. Among various treatments the most values of EC (2.21 dS m⁻¹), OC (26.98mg Kg⁻¹), TKN (266.84mg Kg⁻¹), PO₄³⁻ (70.34mg Kg⁻¹), Na⁺ (75.64mg Kg⁻¹), K⁺ (120.14mg Kg⁻¹), Ca²⁺ (292.36mg Kg⁻¹) and Mg²⁺ (159.67mg Kg⁻¹), in the soil were recorded with

treatment T₇, i.e. 50 % RDF+vermicompost @ 5t ha⁻¹ treatment (Table 3) and this is in the conformity of higher values of these parameters in vermicompost. Moreover, the most contents of Cd (1.68mg Kg⁻¹), Cr (1.26), Cu (2.34mg Kg⁻¹), Fe (4.08mg Kg⁻¹), Mn (1.85mg Kg⁻¹) and Zn (3.95mg Kg⁻¹) of the soil were also observed with treatment T₇, i.e. 50% RDF+vermicompost @ 5t ha⁻¹ treatment (Figure 1). The higher contents of heavy metals in the soil after treatment with T₇ might be due to the presence of more contents of heavy metals in vermicompost. Patil et al.,³⁶ reported that use of FYM in the soil decreased soil pH from 7.99 to 7.65 with each increment of FYM, the soil pH reduced significantly due to organic acid production during its decomposition. Application of organic manures such as FYM, vermicompost, crop residues enhanced the soil available nitrogen, phosphorus and potassium as compared to recommended dose of fertilizers.³⁶ Thus, these treatments were found to be effective to enhance the nutrients in the soil and can contribute to the agronomical growth of *S. melongena*.

Effects of integrated nutrients on agronomical characteristics of *S. melongena*

The mean values of agronomical parameters of *S. melongena* cultivated with different treatments are shown in Table 4. During the present study, the most values of plant height (166.30cm), root length (29.80cm), dry weight (102.36g), chlorophyll content (4.82 mg/gfw), LAI (4.92), number of flowers/plant (60.84), fruits/plant (55.64) and crop yield/plant (6084.25g) of *S. melongena* were recorded with (T₇) i.e. 50% RDF along with vermicompost @ 5t ha⁻¹ in comparison to all treatments. Whereas most values of plant height (135.86 cm), root length (25.67cm), dry weight (85.42g), chlorophyll content (4.66mg/gfw), LAI (4.84), number of flowers/plant (52.74), fruits/plant (46.20), crop yield/plant (5264.75g) of *S. melongena* were recorded with (T₃) i.e. vermicompost @ 5t ha⁻¹ when used solely. Thus, application of 50% RDF with vermicompost significantly (P<0.05) increased the plant height, root length, dry weight, chlorophyll content, LAI, number of flowers/plant, fruits/plant crop yield/plant of *S. melongena* and it is likely due to the presence of optimum contents of various nutrients required by *S. melongena*. The agronomical performance of *S. melongena* was recorded in the order of T₇>T₁₀>T₉>T₈>T₃>T₆>T₅>T₄>T₂>T₁ treatments (Table 4). The findings were in accordance with s³³ who reported that combined application of organics to chilli crop mainly FYM(50%)+poultry manure(50%), vermicompost (50%)+poultry manure(50%), FYM(50%)+neem cake(50%) and poultry manure@7.5t ha⁻¹ recorded significantly higher plant height, number of branches per plant and leaf area. The findings are also in agreement with Sable et al.,⁴¹ who reported higher number of branches and fruit yield with the combination of 50 percent N through neem cake and 50 percent N through vermicompost. Moreover, vermicompost besides being a rich source of micronutrients also acts as chelating agent and regulates the availability of metallic micronutrients to the plants and increases the plant growth and yield by providing nutrients in the available form and based on crop demand. Application of organics viz., FYM@ 10t ha⁻¹ resulted in higher crop yield of cotton (*Gossypium hirsutum* L.) and wheat (*Triticum aestivum* L.) due to the uptake of nutrients like N, P, K, Ca, Mg, S and Fe over RDF alone.¹² Although, all the treatments were recorded to be effective to enhance the plant growth of *S. melongena* but 50% RDF along with vermicompost @ 5t ha⁻¹ was observed most beneficial for the growth and yield of *S. melongena*.

Therefore, integrated nutrients application significantly increased the agronomical attributes of *S. melongena*.

Effects of integrated nutrients on biochemical characteristics of *S. melongena*

The mean values of biochemical parameters of *S. melongena* cultivated with different treatments are shown in Figure 2. During the present study, the most values of crude protein (1.09g/100g), dietary fiber (1.74g/100g), total carbohydrates (4.32g/100g) and total sugar (3.98g/100g) of *S. melongena* was recorded with T₇ (i.e. 50%

RDF+vermicompost @ 5t ha⁻¹) (Figure 2). It may be likely due to the synthesis of these biochemical parameters in presence of optimal uptake of essential nutrients needed by *S. melongena*. The findings are in line of Kumar and Chopra⁸ who reported that the application of sewage sludge significantly increased the content of crude protein, dietary fiber, total carbohydrates and total sugar of *S. melongena*. Accordingly, the use of integrated nutrients specially 50% RDF along with vermicompost @ 5t ha⁻¹ was significantly increased the biochemical characteristics of *S. melongena*.

Table 2 Chemical characteristics of vermi compost, sugarcane press mud compost, farm yard manure and sewage sludge

Treatment	EC (dS m ⁻¹)	pH	OC (mg Kg ⁻¹)	TKN (mg Kg ⁻¹)	PO ₄ ³⁻ (mg Kg ⁻¹)	Na ⁺ (mg Kg ⁻¹)	K ⁺ (mg Kg ⁻¹)	Ca ²⁺ (mg Kg ⁻¹)	Mg ²⁺ (mg Kg ⁻¹)
Vermicompost	3.12ns	7.88ns	14.58**	225.86**	89.64**	136.84**	264.74**	275.69*	96.37**
Sugarcane pressmud compost	2.06ns	7.64ns	6.67*	115.60*	45.37*	94.67*	176.34*	244.36*	72.84*
Farm yard manure	2.26ns	7.36ns	9.74*	156.94**	56.00*	72.61*	155.36*	214.90*	65.48*
Sewage sludge	2.68ns	7.72ns	10.25**	186.94**	68.74**	80.34*	183.90*	236.94*	55.37*

Values reported here are mean of six replicates; *, ** significantly different with each other at P<0.05 and P<0.01 level of ANOVA, respectively; ns-not significant.

Table 3 Effect of integrated nutrient management practices on physico-chemical characteristics of soil used for the cultivation of brinjal (*S. melongena*)

Treatment	EC (dS m-1)	pH	OC (mg Kg -1)	TKN (mg Kg -1)	PO43- (mg Kg -1)	Na+ (mg Kg -1)	K+ (mg Kg -1)	Ca2+ (mg Kg -1)	Mg2+ (mg Kg -1)
T1	0.42	7.48	15.63	144.5	25.86	33.6	50.39	230.8	42.36
T2	1.52ns	7.52ns	18.63ns	160.88*	28.67ns	44.85ns	54.67ns	240.39ns	46.37ns
T3	1.85*	7.78ns	20.34*	200.95**	48.67*	65.67*	95.36*	280.75*	55.20ns
T4	1.62*	7.57ns	17.64ns	195.80*	40.88*	60.34*	78.64*	236.84ns	48.70ns
T5	1.73*	7.50ns	19.68ns	240.64*	44.67*	56.34*	85.70*	265.80*	52.39ns
T6	1.59ns	7.62ns	22.78*	232.55*	64.85*	45.20ns	88.90*	242.77ns	46.24ns
T7	2.21**	7.88ns	26.98*	266.84**	70.34**	75.64**	120.14**	292.36*	159.67*
T8	1.95*	7.82ns	19.65ns	254.75**	54.20*	63.52*	115.64**	267.64*	126.30*
T9	1.99*	7.75ns	21.39*	260.97**	55.62*	64.18*	123.84**	276.34*	130.84*
T10	2.06**	7.83ns	18.75*	244.64**	51.37*	68.30*	125.85**	270.85*	125.60*
F-calculated	3.12	0.24	3.34	24.61	8.69	9.75	14.58	28.39	11.36
CD	2.45	1.04	2.62	10.63	5.14	4.34	9.6	12.34	7.88

Table 4 Effects of integrated nutrient management practices on agronomical attributes of brinjal (*S. melongena*).

Treatment	Plant Height (Cm)	Root Length (Cm)	Dry Weight (G)	Chlorophyll Content (Mg/Gfw)	LAI	Flowers/Plant	Fruits/Plant	Yield/Plant (G)
T1	90.65	15.6	25.6	3.64	4.34	35.6	30.2	3490.85
T2	106.80*	20.34ns	40.05*	3.70ns	4.37ns	40.25ns	35.64ns	3585.60ns
T3	135.86**	25.67ns	85.42**	4.66ns	4.84ns	52.74*	46.20*	5264.75*
T4	120.37*	19.68ns	66.30**	3.72ns	4.40ns	48.36ns	42.50ns	4258.60ns
T5	125.64*	22.40ns	72.84**	3.82ns	4.45ns	50.36ns	45.10ns	4462.35ns
T6	130.75**	23.84ns	77.95**	3.86ns	4.72ns	50.86*	45.68ns	4775.40*
T7	166.30**	29.80*	102.36**	4.82ns	4.92ns	60.84**	55.64*	6084.25*
T8	136.85**	21.32*	82.96**	4.15ns	4.52ns	52.30*	47.60ns	4553.70ns
T9	142.80**	25.96*	88.90**	4.56ns	4.59ns	54.20*	49.30ns	4840.95*
T10	146.50**	26.80*	90.36**	4.64ns	4.80ns	55.90*	50.70ns	5462.40*
F-calculated	34.5	6.44	12.73	0.36	0.17	6.48	4.76	130.94
CD	10.24	5.78	6.21	1.28	1.19	3.86	2.89	28.8

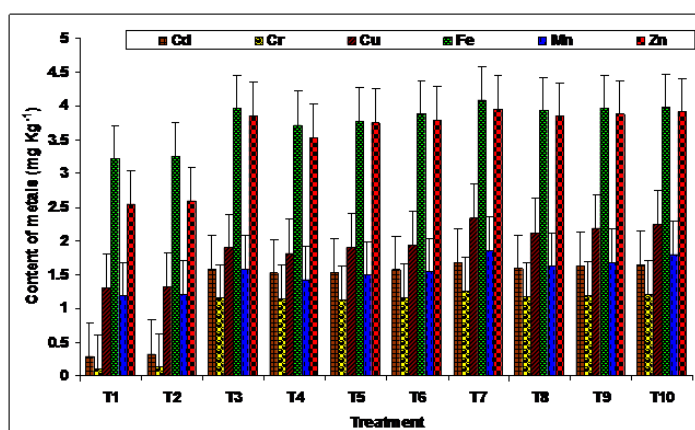


Figure 1: Contents of heavy metals in the soil used for the cultivation of brinjal (*S. melongena*) after use of various treatments. Error bars are standard error of the mean.

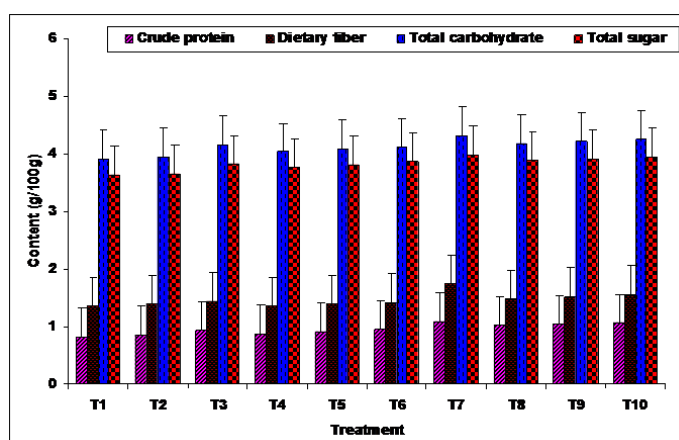


Figure 2: Contents of crude protein, dietary fiber, total carbohydrates and total sugar of brinjal (*S. melongena*) after use of various treatments. Error bars are standard error of the mean.

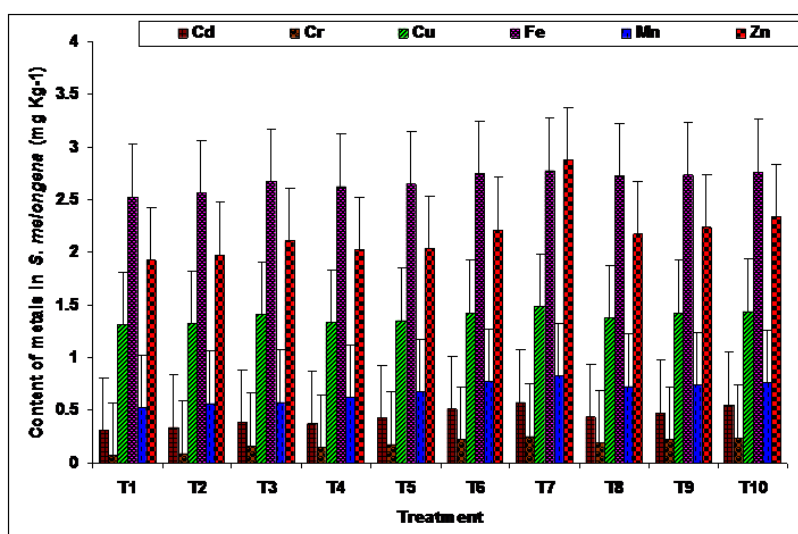


Figure 3: Contents of heavy metals in brinjal (*S. melongena*) after use of various treatments. Error bars are standard error of the mean.

Effects of integrated nutrients on contents of heavy metals in *S. melongena*

The mean contents of Cd, Cr, Cu, Fe, Mn and Zn in *S. melongena* cultivated with different treatments are shown in Figure 3. The results revealed that the most contents of Cd (0.58mg Kg⁻¹), Cr (0.25mg Kg⁻¹), Cu (1.49mg Kg⁻¹), Fe (2.78mg Kg⁻¹), Mn (0.82mg Kg⁻¹) and Zn (2.88mg Kg⁻¹) in *S. melongena* were recorded with T₇ (i.e. 50 % RDF+vermicompost @ 5 t ha⁻¹treatment) and it is likely due to the presence of more contents of these metals in the vermicompost used for the treatment. The contents of heavy metals in *S. melongena* were recorded in the order of T₇>T₁₀>T₆>T₉>T₈>T₃>T₅>T₄>T₃>T₂>T₁ due to the availability of different metals in various treatments (Figure 3). The results are in agreement with Kumar et al.,⁷ who reported the considerably higher contents of Cd (3.96), Cr (2.04), Cu (10.52), Mn (12.64) and Zn (16.54) in spinach (*Spinacia oleracea* L.) amended with sewage sludge. In the present study, the accumulation of Cr, Cu, Mn and Zn except Cd in *S. melongena* was noted below the permissible limit of FAO/WHO standards for Cd (0.20mg Kg⁻¹), Cr (2.30mg Kg⁻¹), Cu (40.00mg Kg⁻¹) and Zn (60.00mg Kg⁻¹).⁵² Although the content of Cd in *S. melongena* was found beyond the prescribed standard limit but it is due to the higher contents of Cd in the sewage sludge and sugarcane pressmud used for the preparation of vermicompost and it can be prevented by replacing the materials used for vermicomposting.

Conclusion

The results of the present study clearly indicated that different treatments showed significant (P<0.05/P<0.01) effect on EC, OC, TKN, PO₄³⁻, Na⁺, K⁺, Ca²⁺, Mg²⁺, Cd, Cr, Cu, Fe, Mn and Zn of the soil. All the treatments were recorded to be effective to increase the macro and micro essential nutrients in the soil in comparison to control. Among all the treatments, the most increase of EC, OC, TKN, PO₄³⁻, Na⁺, K⁺, Ca²⁺, Mg²⁺, Cd, Cr, Cu, Fe, Mn and Zn of the soil was recorded with 50 % RDF+vermicompost@5t ha⁻¹. It was observed that among various

treatments the most plant height, root length, dry weight, chlorophyll content, LAI, number of flowers/plant, fruits/plant, crop yield/plant, crude protein, dietary fiber, total carbohydrates and total sugar of *S. melongena* was recorded with 50% RDF+vermicompost@5 t ha⁻¹. The agronomical performance of *S. melongena* was recorded in the order of T₇>T₁₀>T₉>T₈>T₃>T₆>T₅>T₄>T₂>T₁ treatments. Therefore, sole vermicompost and 50% RDF along with vermicompost@5t ha⁻¹ can be used to achieve the maximum agronomic growth and crop yield of *S. melongena*.

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Conflict of interest

The author declares no conflict of interest.

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