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Growth performance and production economics of eggplant (*Solanum melongena*) in response to vermicompost vis-a-vis a chemical fertilizer application

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ABSTRACT

This study compared the effects of vermicompost and chemical fertilizer on the production and economics of eggplants (*Solanum melongena*). The study consisted of two phases which were carried out along the East Coast of Berbice. Phase one studied the vermicomposting process and phase two was a field trial of vermicompost on eggplants. The treatments used in the study were the control (T_1), vermicompost (T_2), and the NPK fertilizer (T_3). Vermicompost was applied @ 500 g plant^{-1} at transplanting, 250 g plant^{-1} at flowering, and 250 g plant^{-1} at fruiting. However, the recommended dose of NPK fertilizer was used which was 2.5 g plant^{-1} at transplanting and then every 21 days. The results showed that there were no significant differences in the plant height, the number of leaves, the diameter of the main stem, and the number of days it took to reach 50% flowering yet there were significant differences in the root ($P=0.005$) and shoot ($P=0.004$) length of eggplant after applying vermicompost compared the use of the chemical fertilizer. There were no significant differences in the physicochemical properties (pH, EC, OC, N, P, K) of the soil. There was a significant difference in the economics of eggplant cultivation when using vermicompost compared to the chemical fertilizers. The study indicated that vermicompost can be an excellent soil conditioner with indications of better conditions for plant growth, and it is also cost effective.

Keywords: Eggplant, vermicompost, pH, Electrical conductivity, chemical fertilizer

INTRODUCTION

Vermicompost is a dark brown to black material with an amazing structure, porosity, air permeability, drainage, and water retention capacity (Edwards 1988). Vermicompost enhances the physical, chemical, and biological characteristics of the soil as it has a rich source of nutrients such as nitrogen, phosphorus, and potassium (Kale, 1998; Nath *et al.,* 2009; Ansari and Jaikishun, 2011) It also contains phytohormones, enzymes, vitamins, and microorganisms such as *Actinomycetes, Azotobacter, Nitrosomonas* (Ismail, 1997). The amount of readily available water present in the soil increases following the addition of vermicompost, inducing exchanges between nitrogen, potassium, and phosphorus which enhances the growth of plants (Papafotiou *et al.,* 2005; Manivannan *et al.,* 2009). This makes vermicompost an excellent soil enhancer and a biocontrol agent making it one of the best organic fertilizers which is beneficial to the environment when compared to chemical fertilizers. It is a perfect organic fertilizer for most plants because it enhances the growth of plants along with the yield because of the increase in seed germination, stem height, leaf number, leaf area, dry leaf weight, root length, root number, total yield, fruit/plant number, chlorophyll content, pH, micronutrients, macronutrients, the percentage of the carbohydrate content along with the protein content and it also improves fruit and seed quality. Vermicompost increases crop production without polluting the environment and preventing harmful pests at the same time (Joshi *et al.*, 2014). The benefits of vermicomposting do not include the nutrition provided to plants only but it is cost-effective and it develops resistance against pests and diseases which reduces the need to purchase chemical pesticides (Bellitürk, 2018).

When compared to chemical fertilizers, vermicomposting in various organic farming routes such as growing wheat, peanuts, and eggplant, has resulted in higher incomes and a reduction in cultivation costs (Ismail, 1997). Additionally, because of the negative impacts of chemical fertilizers on soil health, organic fertilizers are generally considered to be suitable sources to provide nutrients to the soil (Ntanos and Koutroubas, 2002; Bhardwaj *et al.*, 2019). Development of Bio-formulations and organic fertilizers is one of the recommended natural resource management strategies (Bhardwaj *et al.*, 2020). Vermicompost can be a chemical- fertilizer-alternative that can be used to increase the crop yield of eggplant (*Solanum melongena)* which is an important vegetable crop. Hence, the purpose of this research was to compare the effects of vermicompost, and chemical fertilizer on the production and economics of eggplant.

MATERIAL AND METHODS

This experiment was carried out along the East Coast of Berbice (Skeldon) consisted of two phases. Phase one (1) included the preparation of the vermicompost and phase two (2) was done to compare the use of vermicompost at different rates compared to a chemical fertilizer (NPK fertilizer) in the production and economics of eggplants (*S. melongena*).

Phase 1

Preparation of the culture bed at the vermicompost unit

A vermicompost unit that was present in Skeldon, Corentyne, Berbice was used to prepare the culture. The culture bed had dimensions of 106 cm × 106 cm × 64 cm. According to Ismail (2005), the culture bed was prepared as follows (Fig. 1):

- The first layer which is the basal layer of the vermicompost unit was layered with broken bricks along with another layer of sand which was 10 cm thick.
- The second layer with loamy soil was 10 cm high covering the basal layer, then locally collected earthworms were placed into the soil.
- The third layer with fresh cattle dung which was scattered on top of the soil.
- The fourth layer with dried paddy straw covered the dung which was 10 cm thick.

Fig. 1. Layering of different ingredients for preparing vermicompost in the Vermicomposting Unit (recreated based on Ansari, 2012)

The vermicomposting process was monitored by recording the temperature every day, the contents in the vermicompost unit were kept moist by sprinkling water over it every day or every consecutive day depending on the moisture of the contents, organic material along with cattle dung was added depending on the rate of decomposition of the paddy straw and the vermicompost was harvested at day 90. After harvest, the following parameters were accessed:

Nutrient analysis of the vermicompost for the following macronutrients (N, P, and K) along with the pH, organic carbon, and electrical conductivity.

Phase 2

Experimental design

Field trials were carried out with eggplants (*S. melongena*) using different rates of vermicompost and the recommended rate of the chemical fertilizer. This experiment consisted of a customized version of the split-plot design comprising of three treatments with three replicates resulting in a total of nine experimental units. Each experimental unit consisted of six plants resulting a total of fifty-four plants. The three treatments were as follows: control (T_1), vermicompost (T_2), and chemical fertilizer (T_3).

Preparation of land

The farmland was plowed three times and brought to a fine tilth. After forking the plots and subplots were laid out. Each sub-plot was 2m × 2m with the middle walks being 1.5m and the entire area being 16 m × 10 m.

Sowing of seedlings

Seedlings of the Corentyne Purple eggplant variety (four weeks old) were obtained from a plant shop at the No. 63 village. The seedlings were transplanted with the distance between each plant being 60 cm vertically and 90 cm horizontally. The vermicompost was applied during different stages of planting in treatment two. It was applied at a rate of 500 g plant^{-1} at transplanting, 250 g plant^{-1} at flowering, and 250 g plant^{-1} at fruiting. However, in treatment three, the recommended rate of the chemical fertilizer (NPK fertilizer) was applied at the rate of 2.5 g plant^{-1} at transplanting and then every 21 days.

Irrigation

Initiating at transplanting 12-15 cm of irrigation was given at every five days interval, and its frequency was increased to two times per week at flowering and fruiting.

Pest control

Neem extract was used to control pests in the T_2, which was the vermicompost treated unit. The neem extract was prepared by boiling 500 g of neem leaves in 5000 ml of water and 100 ml of the extract was used on each plant at an interval of every two days. However, in T_3, which was the chemical fertilizer treated unit, pests were controlled with abamectin by using a concentration of 5 ml in 1000 ml, at weekly intervals.

Plant growth and yield parameters

Before harvesting, the data was collected for the height of the plants (cm), the number of leaves, the diameter of the main stem (cm), and the number of days it took to reach 50% of flowering. After harvesting, the assessments were done for the height of the plants (cm), the number of leaves, the root length (cm), the shoot length, the diameter of the main stem (cm), the number of fruits, and the yield of the fruits (kg). The fruit samples were dried in an oven at 46-50 ° C and weighed daily until a constant weight was reached. After drying, the samples were ground for analysis of nitrogen, phosphorus, potassium, magnesium, and iron.

Economics of eggplants (S. melongena) cultivation using verimcompost against a chemical fertilizer

The total cost of the cultivation of eggplant using vermicompost was recorded in Guyana Dollars (1US$= 216 Guyana dollars on 27th August 2020) which was compared with the conventional method (chemical fertilizer) of crops cultivated during the experimental period. The following observations were recorded: Cost of land preparation and irrigation, cost of seedlings and transplanting, cost of harvesting, cost of intercultural operations, cost of foliar spraying of organics/inorganics for pests and diseases, application of neem extract, total cost of crop cultivation, yield in kilograms (kg), and the cost of production per kilogram (kg).

Statistical Analysis

The data obtained from the tests performed on

Table 1. Physicochemical properties of vermicompost (Mean ± SEM)

Parameters	Vermicompost
pH	6.12 ± 0.09
EC (ms/cm)	0.66 ± 0.02
OC (%)	1.40 ± 0.10
N (%)	0.0001 ± 0.00
P (%)	0.0614 ± 0.06
K (%)	0.0257 ± 0.00

the soil, vermicompost, and fruits were subjected to analysis of variance (ANOVA) using the SPSS software ver. 23. The results were evaluated at a 95% confidence level.

RESULTS AND DISCUSSION

Physicochemical properties of the vermicompost

The vermicompost was subjected to some chemical analyses which resulted in the following which can be seen in Table 1. The results obtained show that the vermicompost possesses a nutrient content that is within the required limits which are supported by others (Ismail, 1997; Ansari and Sukhraj, 2010; Ansari *et al.,* 2016). Additionally, it should be noted that work done by other researchers would have results that vary in the nutrient content because they would have used different organic matters for the vermicomposting process (Kaur *et al.,* 2015; Zaefarian and Rezvani, 2016).

Physicochemical properties of the soil

The physiochemical properties of the soil before transplanting and after harvesting is shown in Table 2. The pH of the soil before and after the experiment was slightly acidic to neutral which falls within the required range of 5.5-6.5 for eggplant production (Praca *et al.,* 2004). According to the standard used by the Farm Lab Incorporated, the electrical conductivity was not too high nor low and the organic matter along with its ionic concentration used in the vermicomposting process determines the electrical conductivity of the vermicompost (Atiyeh *et al.,* 2002). The organic carbon in the soil before and after the experiment was high as they were > 0.75% which is also based on the standard used by the Farm Lab Incorporated. Since the organic carbon content was high, it allowed plants to absorb the available nutrients present easily (Lalitha *et al.,* 2000). The same standards from the Farm Lab Incorporated suggests that the N content in the soil at the beginning and end was not too high nor low. The same applies to the P content in the soil at the beginning and end but only for the soil mixed with the vermicompost. Additionally, the P content was high in the soil mixed with the chemical fertilizer at the end. However, the K content was high in the soil mixed with vermicompost which means that vermicompost has a high K content and it was lower in the soil at the beginning of the experiment along with the soil mixed with the chemical fertilizer at the end. The increase in K content in vermicompost treated soil may be due to shifting the balance between potassium forms in the soil from the relatively exchangeable form of potassium to the soluble form of potassium (Bhasker *et al.,* 1992). The N and P values are higher in the soil mixed with the chemical fertilizer because the fertilizer used was the NPK fertilizer which accounts for the higher values. Additionally, the ñ values for these parameters (pH, EC, OC, N, P, K) showed that there are no significant differences within them as they were > 0.05 (0.881, 0.274, 0.478, 0.146, 0.093 and 0.298 respectively).

Vegetative parameters

At harvest, the morphological features of the plants and fruit were recorded for the different treatments given in Table 3. The vermicompost treatment with the best results for the plant height, number of leaves, diameter of the main stem, root

Table 2. Physico-chemical properties of the soil (Mean ± SEM) at the beginning and end of the experiment

Parameters	Beginning	End of experiment	
	Soil	Soil + Vermicompost	Soil + Chemical Fertilizer
pH	6.20 ± 0.58	6.29 ± 0.28	6.36 ± 0.22
EC (ms/cm)	0.42 ± 0.01	0.42 ± 0.03	0.47 ± 0.57
OC (%)	1.49 ± 0.35	1.24 ± 0.78	1.37 ± 0.21
N (%)	0.0031 ± 0.00	0.0036 ± 0.00	0.0060 ± 0.01
P (%)	0.0313 ± 0.00	0.0291± 0.02	0.0427 ± 0.01
K (%)	0.0034 ± 0.00	0.0058 ± 0.00	0.0020 ± 0.00

Table 3. Morphological features of the plant and fruit at harvest (Mean ± SEM)

Week	Treatments		
	Control	Vermicompost	Chemical Fertilizer
Plant height (cm)	109.89 ± 25.43	115.40 ± 9.22	100. ± 18.16
Number of Leaves	111.44 ± 13.35	120.33 ± 13.92	100.89 ± 21.59
Diameter of Main Stem (cm)	2.19 ± 0.50	2.52 ± 0.46	2.19 ± 0.43
Root Length (cm)	47.22 ± 13.81	64.80 ± 16.73	51.00 ± 12.47
Shoot Length (cm)	100.44 ± 9.24	107.53 ± 9.10	92.83 ± 15.99
Number of Fruit per Plant	3.22 ± 1.55	2.07 ± 0.96	2.56 ± 1.10
Average Length of Fruit (cm)	62.06 ± 25.97	40.93 ± 18.45	43.44 ± 20.75
Average Diameter of Fruit (cm)	26.11 ± 11.73	17.93 ± 8.49	18.00 ± 7.93
Weight of Fruit per Plant(g)	1188.89 ± 427. 22	900.00 ± 359.56	758.33 ± 369.92
Average Weight of Fruit (g)	451.72 ± 620.98	448.44 ± 130.44	294.56 ± 112.66

length, shoot length, and the weight of fruit per plant. However, the treatment with the best results for the number of fruits per plant, length of the fruit along with the diameter of the fruit was recorded for the control. Although the control had a better result in terms of the fruit, the weight of the fruit was higher in the vermicompost treatment. Therefore, vermicompost is an excellent organic fertilizer as it yielded positive results for the cultivation of egg-plants and this was also confirmed by other researchers. Other than possessing macronutrients and micro-nutrients, vermicompost possesses a high rate of microbial and enzymatic activities (Manyuchi *et al.,* 2013; Zaefarian and Rezvani, 2016). With the microbial activity being high in vermicompost, plant growth hormones such as gibberellins, auxins, humic acids, and cytokinins are produced which enhances plant growth (Joshi & Vig, 2010; Dominguez, 2011; Rajasekar *et al.,* 2012). According to Jaikishun *et al.,* (2014); Lujan-Hidalgo *et al.*, (2016) vermicompost also consist of a few metabolites and vitamins from the B group which help to promote the growth of plants.

Nutrient content in eggplant

After harvest, eggplants from the different treatments for subjected to a nutrient content analysis which can be seen in Table 4. It can be seen that the NPK content was higher in the chemical fertilizer treatment when compared to the vermicompost treatment which was possible because the NPK fertilizer was used. Other than the NPK content, another macronutrient was tested which was the magnesium content and it can be seen that it was higher in the vermicompost treatment and it was the lowest in the chemical fertilizer treatment. However, when it comes to the micronutrient content, this was higher in the vermicompost treatment which was possible because vermicompost, in general, has micronutrients present which was confirmed by several researchers (Matsubara *et al.,* 2005; Small, 2009; Putra, 2011; Çaglarýrmak and Hepçimen, 2013; Nyadanu *et al.,* 2014).

The bar graph in Figure 2 is showing the macronutrient content in the eggplants for the different treatments after harvest. It can be seen that the N content was higher in the control with vermicompost having the lowest. The highest P content was seen in both the vermicompost and chemical fertilizer treatments with the control having the lowest. The chemical fertilizer treatment had the highest K content with the vermicompost having the lowest. However, the vermicompost had the highest Mg content with the chemical fertilizer having the lowest. The bar graph in Figure 3 is showing the micronutrient content in the eggplants for the different treatments after harvest. It can be seen that the Fe content was highest in the vermicompost treatment and lowest in both the control and chemical fertilizer treatments.

Table 4. Nutrient content in eggplant for the different treatments

Treatment	Macronutrient				Micronutrient
	N (%)	P (%)	K (%)	Mg (%)	Fe (mg/kg)
Control	2.57	0.47	4.21	67.6	0.24
Vermicompost	2.31	0.50	4.06	78.8	0.25
Chemical fertilizer	2.56	0.50	4.56	62.5	0.24

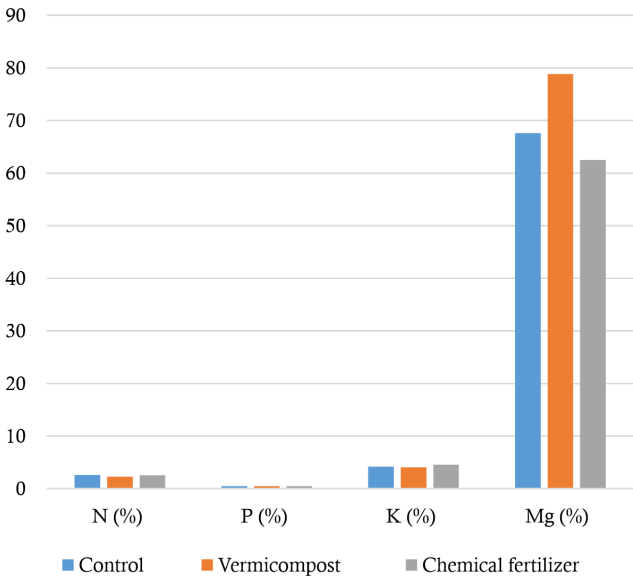

Fig. 2. The macronutrient content in the eggplants for the different treatments

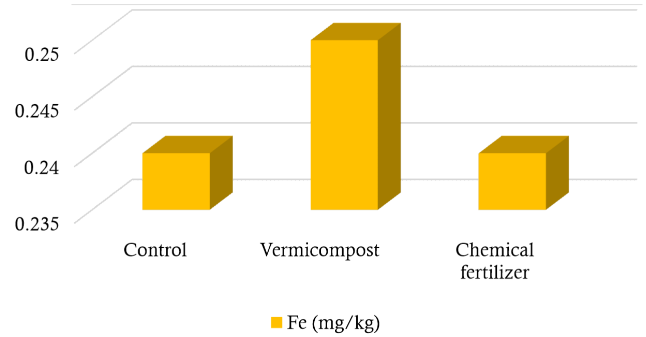

Fig. 3. The micronutrient content in the eggplants for the different treatments

Economics of eggplants using vermicompost against the chemical fertilizer

When the use of vermicompost was compared against the use of the chemical fertilizer to cultivate eggplants, vermicompost proved to be more cost-effective as the total cost of cultivation was $23,130.00 with the cost of production/kg being $1,668.83. However, when using the NPK fertilizer the cost of cultivation was $27,680.00 with the cost of production/kg being $2,042.80 which costs more than the use of vermicompost. Hence, there is a difference in the economics of eggplant cultivation using vermicompost against the chemical fertilizer. Additionally, this correlates to other researches which mentions that the use of vermicompost against fertilizers is cost-effective (Reganold *et al.,* 2001; Ram and Meena, 2014). The economics of both the vermicompost and chemical fertilizer is shown in Tables 5 and 6.

CONCLUSIONS

There were no significant differences in the physicochemical properties (pH, EC, OC, N, P, K) of the soil, but there was a significant difference in the economics of eggplant cultivation with the use

Table 5. Cultivation of eggplants using vermicompost (Cost estimated in Guyana dollars; 1US$= 216 Guyana dollars on 27th August 2020)

COST OF FIELD CULTIVATION (area 12m^2)	
• Surface clearing	$1,000.00
• Plowing of land	$1,500.00
• Formation of furrows and ridges	$1,500.00
COST OF SEEDLINGS AND TRANSPLANTING	
• $10 per seedling	$180.00
• Transplanting	$500.00
COST OF VERMICOMPOST APPLICATION	
• Application of vermicompost for 20 minutes at $250 for 3 days	$750.00
COST OF INTERCULTURAL OPERATION	
• Weeding for 30 minutes at $250 for 20 days	$5,000.00
COST OF FOLIAR SPRAYING OF ORGANICS FOR PESTS AND DISEASES	
• Application of neem extract for 15 minutes at $150 for 38 days	$5,700.00
COST OF IRRIGATION	
• Irrigating for 30 minutes at $250 for 25 days	$6,250.00
COST OF HARVESTING	
• Harvesting	$750.00
TOTAL	$23,130.00
TOTAL WEIGHT OF EGGPLATS	13.86kg

Cost of the production of Eggplants/kg = $1,668.83.

Table 6. Cultivation of eggplants (in Guyana dollars) using chemical fertilizer. (Cost estimated in Guyana dollars; 1US$= 216 Guyana dollars on 27th August 2020)

COST OF FIELD CULTIVATION (area 12m^2)	
• Surface clearing	$1,000.00
• Plowing of land	$1,500.00
• Formation of furrows and ridges	$1,500.00
COST OF SEEDLINGS AND TRANSPLANTING	
• $10 per seedling	$180.00
• Transplanting	$500.00
COST OF CHEMICAL FERTILIZER AND APPLICATION	
• Chemical fertilizer at $200 per pound	$400.00
• Application of chemical fertilizer for 20 minutes at $250 for 5 days	$1,250.00
COST OF INTERCULTURAL OPERATION	
• Weeding for 30 minutes at $250 for 25 days	$6,250.00
COST OF FOLIAR SPRAYING OF ABAMECTIN FOR PESTS AND DISEASES	
• Abamectin at $1000 per bottle	$3,000.00
• Application of abamectin for 15 minutes at $150 for 34 days	$5,100.00
COST OF IRRIGATION	
• Irrigating for 30 minutes at $250 for 25 days	$6,250.00
COST OF HARVESTING	
• Harvesting	$750.00
TOTAL	$27,680.00
TOTAL WEIGHT OF EGGPLANTS	13.55kg

Cost of the production of Eggplants/kg = $2,042.80

of vermicompost when compared to the chemical fertilizers. Indications were there in the study that vermicompost can be a good soil conditioner for better root and shoot growth. It is costeffective and eco-friendly alternative to synthetic chemical fertilizers.

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