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Vermicompost as a soil amendment for tomato production

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Abstract

Soil amendment in many countries is used by farmers to improve soil's physical, chemical and biological properties for better crop growth and development. The study was conducted to evaluate the effect of soil amendment through the use of vermicompost on the growth and yield of tomato. It was conducted at the upland research area of the Cagayan State University, Piat Campus from January to April 2019. Six treatments used as follows: T_1 – Control, T_2 – 80-90-60 kg NPK ha^{-1}, T_3 – 80-90-60 kg NPK ha^{-1} + 5 bags Vermicompost ha^{-1}, T_4 – 80-90-60 kg NPK ha^{-1} + 15 bags Vermicompost ha^{-1}, T_5 – 80-90-60 kg NPK ha^{-1} + 20 bags Vermicompost ha^{-1} and T_6 – 10 bags Vermicompost ha^{-1}. The experiment was laid out following the Randomized Complete Block Design (RCBD) with three (3) replications. Based on the result, the tallest plants at 30 and 60 DAT were obtained by the plants applied with the recommended rate of fertilizer amended with 5 to 20 bags of vermicompost. Application of 80-90-60 kg NPK ha^{-1} amended with 15 to 20 bags vermicompost ha^{-1} produced the most number of fruits, heaviest fruits per plant and per sampling area. The combined application of the recommended rate of inorganic fertilizer at the rate of 80-90-60 kg NPK ha^{-1} amended with 15 to 20 bags of vermicompost not only the heaviest fruits but also obtained the highest ROI with values of 319 and 378.73 percent. This nutrient management practice in tomato production is a good agricultural practice modality that attempts to support the Organic Agriculture Law of 2010. Hence, it is recommended.

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Introduction

In developing countries, the escalating price of inorganic fertilizers is a hindrance to the small and marginal farmers (Mandloi *et al.,* 2008). Accordingly, the use of different soil or amendments has gained tremendous importance in many countries (Mohd *et al.,* 2002). In fact, soil organic amendments remain the only feasible option for smallholder farmers because it is cheap, affordable and capable of improving the physical, chemical and biological properties of the soil (Ahmed *et al.,* 2013; Islam *et al.,* 2017).

Moreover, biological amendments may not only improve soil's physical and chemical properties but also have a positive effect on root growth, such as improving the root rhizosphere conditions (structure, humidity), as well as encouraging an increasing population of microorganisms (Shaheen *et al.,* 2007; Funda *et al.,* 2011).

Profitability of high-value crops, such as tomato (*Solanum lycopersicum* L.), necessitates detailed cultural management to ensure crop required growing conditions. Production of high-quality transplants is a key factor for success. Adequate root and aerial biomass of tomato transplants assure an improved ability to exploit soil resources and higher photosynthetic capacity. Potential consequences are enhanced crop yield and improved fruit quality (Zaller, 2007; Lazcano *et al*., 2009). Low yield is attributed to factors such as low soil fertility, pests, diseases, price fluctuation and poor storage facilities among others (Musokya, 2012; Zziwa and Kabirizi, 2015). Hence, the use of organic amendments such as animal manure, human waste, food wastes, yard wastes, sewage sludge and composts.

The productivity of tomato in the country is very low compared to other countries. The high demand for tomato can only be met by increasing the yield per unit area through cultural management. Therefore, soil amendment is an available strategy for advocating judicious for sustainable tomato cultivation. The positive result of this study will benefit and will be introduced to the tomato growers in Region 02. Hence, this study.

Generally, the study aimed to evaluate the effect of soil amendment through the use of vermicompost on the growth and yield of tomato. Specifically, it aimed to: (1) determine the effect of different rates of vermicompost on the growth and yield of tomato; and (2) Assess the profitability of vermicompost application on tomato production.

Materials and methods

The following materials were used in the study: tomato seed, vermicompost, fertilizer, and seedling tray.

Procurement of seeds

The seeds of tomato were procured by an accredited seed dealer of East-West Seed Company.

Collection of soil samples and analysis

Soil samples were randomly collected within the proposed experimental area with the use of shovel. The soil samples were spread in newspaper and air-dried. One kilogram samples were thoroughly pulverized and cleaned to separate foreign matters. The samples were submitted to the Integrated Laboratory Division, Regional Soils Laboratory DA-RO2, Carig Sur, Tuguegarao City for the soil analysis. The NPK content of the soil was the basis for the fertilizer recommendation for the study.

Land preparation

The area was cleared from stubbles, grasses and stones for thorough land preparation. It was plowed with a tractor and harrowed. The area was left idle for two weeks to allow weeds to decay and to allow weed seeds to germinate before the final plowing. Final harrowing was done before transplanting until the soil was thoroughly pulverized.

Seedling production

Seedling trays were filled with organic fertilizer and garden soil having a 1:1 ratio. The variety of tomato used in the study was Diamante. One seed per cell was sown and watered. The seedlings were watered as the need arose. The seedling trays were placed under partial shade. Fifty grams of urea was dissolved in four liters of water and applied to the seedlings one week after pricking and follow-up watering was done to wash the fertilizer residues on the leaves of the plants. The seedlings were placed under partial shade until ready to transplant.

Experimental design and treatments

After the land preparation, an area of 455 square meters was divided into three blocks, each block measuring 4 meters by 32.5 meters with an alleyway of one meter between blocks. Each block was further subdivided into six plots, each plot measuring 5 meters by 4 meters with an alleyway of half meters between plots. The treatments were arranged following the procedure in the form of Randomized Complete Block Design (RCBD).

The different treatments were: T_1 – Control; T_2 – 80-90-60 kg NPK ha^{-1}; T_3 – 80-90-60 kg NPK ha^{-1} + 5 bags Vermicompost ha^{-1} ; T_4 – 80-90-60 kg NPK ha^{-1} + 15 bags Vermicompost ha^{-1} ; T_5 – 80-90-60 kg NPK ha^{-1} + 20 bags Vermicompost ha^{-1} ; and T_6 – 10 bags Vermicompost ha^{-1}

Making of holes and application of fertilizer

Holes were made at a distance of 75 centimeters between rows and 50 centimeters between hills at 6 centimeters in depth and 10 centimeters wide. The rate of 80-90-60 kg NPK per hectare of inorganic fertilizer based on soil analysis was used as the fertilizer reference for the study. The first application of 4.5 kg per 450 square meters of 14-14-14 and 0.5 kg per 450 square meters of 46-0-0 was done at transplanting. The second application of 8.5 per 450 square meters of 16-20-0 and 1.7 kg per 450 square meters of 0-0-60 was done at 15 DAT and the third application of 8.5 kg per 450 square meters of 16-20-0 and 1.7 kg per 450 square meters of 0-0-60 were done at 30 DAT. The computed amount of inorganic and organic fertilizer per treatment was divided equally by the number of hills. The vermicompost as treatments were applied 7 days before transplanting.

Transplanting and replanting

The seedlings were transplanted two weeks after pricking. One seedling was transplanted per hill. Replanting of missing hills was done five days after transplanting.

Care and management

Cultivation and weed control: Cultivation was done to provide aeration of the soil and to control weeds. Hilling-up was done to prevent the plants from excessive moisture. Hand weeding was done in the area to control the growth of weeds. Irrigation: The plants were watered as the need arose. Crop protection: The occurrence of insect pests and diseases was immediately controlled by chemical control.

Harvesting

The fruits were harvested when they were green and ripe. All samples were tagged to avoid intermixing of samples.

Data gathered

Plant Height (cm): The plant height of ten representative sample plants was measured at 30 and 60 days after transplanting. It was measured from the base of the plants up to the tip of the primary stem.

Number of Fruits per Plant: The number of marketable and non-marketable fruits per treatment were properly counted and recorded every harvest. All the fruits from the first priming up to the last priming per plant were summed up and divided by ten to obtain the average number of fruits per plant.

Weight of Fruits per Plant (g): The fresh fruits were weighed every priming and recorded. After the last priming, the recorded weights of fruits were summed up and divided by ten to obtain the average fresh weight of fruits per plant.

Weight of Fruits per Six Square Meters Sampling Area (g): The fruits taken within the central portion of each plot were weighed every priming and recorded. After the last priming, the recorded weights of marketable fruits were summed up to obtain the weight of marketable fruits per sampling area.

Computed Fruit Yield per Hectare: The computed fruit yield per hectare was computed based on the average yield per sampling area.

Statistical tool

The data were analyzed using STAR, version 2.0.1 2014. Biometrics and Breeding Informatics, PBGB Division, International Rice Research Institute, Los Baños, Laguna following procedures for analysis of variance (ANOVA) for Complete Randomized Design (CRD) to test the significant differences among treatments. The Least Significance Difference (LCD) was used to analyze the mean comparison.

Results and discussion

Plant height (cm)

The height of the plants at 30 and 60 days after transplanting is presented in Table 1.

A significant result was observed on the height of the plants at 30 days after planting wherein the plants applied with 80-90-60 kg NPK ha^{-1} + 20 bags Vermicompost ha^{-1} (T_5), 80-90-60 kg NPK ha^{-1} + 15 bags Vermicompost ha^{-1} (T_4) and 80-90-60 kg NPK ha^{-1} + 5 bags Vermicompost ha^{-1} (T_3) obtained the tallest plants with mean values of 50.08, 49.98 and 49.90 centimeters, respectively.

Table 1. Plant height (cm) at 30 and 60 days after transplanting as affected by vermicomposting.

Treatments	Plant height (cm)	
	30 DAT	60 DAT
T_1 – Control	33.13d	73.17d
T_2 – 80-90-60 kg NPK ha^{-1}	44.19b	90.17b
T_3 – 80-90-60 kg NPK ha^{-1} + 5 bags Vermicompost ha^{-1}	49.90a	97.74a
T_4 – 80-90-60 kg NPK ha^{-1} + 15 bags Vermicompost ha^{-1}	49.98a	97.96a
T_5 – 80-90-60 kg NPK ha^{-1} + 20 bags Vermicompost ha^{-1}	50.08a	98.02a
T_6 – 10 bags Vermicompost ha^{-1}	37.46c	80.87c
ANOVA RESULT	**	**
C.V. (%)	3.35	2.18
HSD	44.12	5.54

Note: Means with common letter/s are not significantly different with each other using Tukeys's Honest Significant (HSD) Test.

**– significant at 1% level.

It was followed by 80-90-60 kg NPK ha^{-1} (T_2) with a height mean of 44.19 centimeters. Next in rank were the plants grown in soil amended with 10 bags of vermicompost ha^{-1} (T_6) with a mean of 37.46 centimeters. The shortest was Control (T_1) with a mean of 33.13 centimeters.

Likewise, a significant result was observed on the height of the plants at 60 days after transplanting, wherein the plants were applied with inorganic fertilizer at the rate of 80-90-60 kg NPK ha^{-1} + 20 bags Vermicompost ha^{-1} (T_5), 80-90-60 kg NPK ha^{-1} + 15 bags Vermicompost ha^{-1} (T_4) and 80-90-60 kg NPK ha^{-1} + 5 bags Vermicompost ha^{-1} (T_3) obtained the tallest plants with mean values of 98.02, 97.96 and 97.74 centimeters, respectively.

It was followed by the plants with a fertilizer rate of 80-90-60 kg NPK ha^{-1} (T_2) with 90.17 centimeters. Next in rank was 10 bags Vermicompost ha^{-1} (T_6) with 80.87 centimeters. The shortest was Control (T_1) with 73.17 centimeters. Differences in plant height were attributed to the effects of inorganic fertilizer and vermicompost.

Table 2. Total number of fruits as affected by vermicompost.

TREATMENTS	Number of Fruits
T_1 – Control	9.00d
T_2 – 80-90-60 kg NPK ha^{-1}	17.67c
T_3 – 80-90-60 kg NPK ha^{-1} + 5 bags Vermicompost ha^{-1}	20.00c
T_4 – 80-90-60 kg NPK ha^{-1} + 15 bags Vermicompost ha^{-1}	23.00b
T_5 – 80-90-60 kg NPK ha^{-1} + 20 bags Vermicompost ha^{-1}	27.00a
T_6 – 10 bags Vermicompost ha^{-1}	11.00d
ANOVA RESULT	**
C.V. (%)	5.35
HSD	2.72

Note: Means with common letter/s are not significantly different with each other using Tukeys's Honest Significant (HSD) Test.
** – significant at 1% level.

The above results were in support of the findings of Rakesh and Adarsh (2010) that the addition of vermicompost to inorganic fertilizer had a significant effect on the growth, fruit and yield of tomato. The organic fertilizers provide the nutritional requirements of plants and also suppress the plant pests populations. Additionally, they increase the microbial activity in soil, anion and cation exchange capacity, organic matter and carbon content of soil. Organic fertilizers increase the yield and quality of agricultural crops in ways similar to inorganic fertilizers (Heeb *et al.,* 2006; Liu *et al.*, 2007).

Table 3. Weight (g) of fruits per plant and per sampling area as affected by vermicompost.

Treatments	Weight of fruits	
	Per Plant (g)	Per Sampling Area (kg)
T_1 – Control	175.00c	2.78c
T_2 – 80-90-60 kg NPK ha^{-1}	453.90b	10.00b
T_3 – 80-90-60 kg NPK ha^{-1} + 5 bags Vermicompost ha^{-1}	434.00b	10.30b
T_4 – 80-90-60 kg NPK ha^{-1} + 15 bags Vermicompost ha^{-1}	853.33a	13.52a
T_5 – 80-90-60 kg NPK ha^{-1} + 20 bags Vermicompost ha^{-1}	1031.67a	16.51a
T_6 – 10 bags Vermicompost ha^{-1}	228.33c	3.65c
ANOVA RESULT	**	**
C.V. (%)	12.58	12.59
HSD	201.37	3.22

Note: Means with common letter/s are not significantly different with each other using Tukeys's Honest Significant (HSD) Test.
** – significant at 1% level.

Number of fruits

The number of fruits affected by vermicompost fertilizer is presented in Table 2. Significant differences among treatment means were observed in the number of fruits wherein the plants applied with a fertilizer rate of 80-90-60 kg NPK ha^{-1} + 20 bags vermicompost ha^{-1} (T_5) obtained the most number of fruits with 27.00. It was followed by 80-90-60 kg NPK ha^{-1} + 15 bags vermicompost ha^{-1} (T_4) with 23.00. Next in rank was 80-90-60 kg NPK ha^{-1} + 5 bags vermicompost ha^{-1} (T_3) and 80-90-60 kg NPK ha^{-1} (T_2) with 20.00 and 17.67. The least was obtained by

10 bags of vermicompost ha^{-1} (T_6) and Control (T_1) with 11.00 and 9.00. Such variation was attributed to the combined effects of inorganic fertilizer and vermicompost as cited by Atiyeh *et al.* (2002) that vermicompost promotes growth due to plant hormone-like activity related to microflora associated with vermicomposting and to metabolites produced as a consequence of secondary metabolism.

Table 4. Computed yield per hectare of tomato as affected by vermicompost.

Treatments	Yield per hectare	
	Kilograms	Tons
T_1 – Control	4633.33	4.63
T_2 – 80-90-60 kg NPK ha^{-1}	16666.67	16.67
T_3 – 80-90-60 kg NPK ha^{-1} + 5 bags Vermicompost ha^{-1}	17166.67	17.17
T_4 – 80-90-60 kg NPK ha^{-1} + 15 bags Vermicompost ha^{-1}	22533.33	22.53
T_5 – 80-90-60 kg NPK ha^{-1} + 20 bags Vermicompost ha^{-1}	27516.67	27.52
T_6 – 10 bags Vermicompost ha^{-1}	6083.33	6.08

Weight of fruits per plant (g) and weight per sampling area (kg)

The weight of fruits per plant and per sampling area as affected by vermicompost fertilizer are presented in Table 3. A significant result was observed on the weight of fruits per plant wherein the application of 80-90-60 kg NPK ha^{-1} + 20 bags vermicompost ha^{-1} (T_5) and 80-90-60 kg NPK ha^{-1} + 15 bags vermicompost ha^{-1} (T_4) obtained the heaviest fruits with 1031.67 and 853.33 grams. It was followed by 80-90-60 kg NPK ha^{-1} (T_2) and 80-90-60 kg NPK ha^{-1} (T_2) with 453.90 and 434.00 grams. The lightest was obtained by 10 bags of vermicompost ha^{-1} (T_6) and Control (T_1) with 228.33 and 175.00 grams. Likewise, a significant result was obtained on the weight of fruits per sampling area wherein the application of 80-90-60 kg NPK ha^{-1} + 20 bags vermicompost ha^{-1} (T_5) and 80-90-60 kg NPK ha^{-1} + 15 bags vermicompost ha^{-1} (T_4) obtained the heaviest fruits with 16.51 and 13.52 kilograms. It was followed by 80-90-60 kg NPK ha^{-1} (T_2) and 80-90-60 kg NPK ha^{-1} (T_2) with 10.30 and 10.00 kilograms.

Table 5. Cost and return analysis of tomato production as affected by vermicompost.

Particulars	Total cost Of production	Gross income (Php)	Net income (Php)	ROI (%)
T_1	37251.50	69499.95	32248.45	86.57
T_2	71293.75	250000.05	178706.30	250.66
T_3	74676.25	257500.05	182823.80	244.82
T_4	80668.50	337999.95	257331.45	319.00
T_5	86218.00	412750.05	326532.05	378.73
T_6	46296.25	91249.95	44953.70	97.10

The lightest was obtained by 10 bags of vermicompost ha^{-1} (T_6) and Control (T_1) with 3.65 and 2.78 kilograms. VC is reported to have hormone-like activity and this has been hypothesized to result in greater root initiation, increased root biomass, enhanced plant growth and development, and altered morphology of plants grown in VC amended soil (Muscolo *et al.*, 2009). Using phytohormone bioassays, compounds with gibberellin, cytokinin and auxin-like activity have been detected in vermicomposted urban and sewage waste (Canellas *et al.*, 2002).

Computed yield per hectare

The computed yield per hectare as affected by vermicompost fertilizer is presented in Table 4. The yield of tomato is arranged in descending order: Treatment 5 had 27516.67 kilograms (27.52 tons), Treatment 4 had 22533.33 kilograms (22.53 tons), Treatment 3 had 17166.67 kilograms (17.17 tons), Treatment 2 had 16666.67 kilograms (16.67 tons), Treatment 6 had 6083.33 kilograms and Treatment 1 had 4633.33 kilograms (4.63 tons).

Cost and return analysis

The cost and return analysis of tomato production as affected by vermicompost fertilizers is presented in Table 5. The return on investment in every treatment is arranged in descending order: T_5 had 378.73 percent, T_4 319.00 percent, T_2 had 250.66, T_3 had 244.82 percent, T_6 had 97.10 percent and T_1 had 86.57 percent.

Conclusion and Recommendations

Based from the result of the study, the following conclusions were drawn: application of vermicompost at 20 bags vermicompost per hectare along with 80-90-60 kg NPK ha^{-1} had the highest yield and highest return on investment, the application of 10 bags of vermicompost per hectare is as good as no application at all and the application of 5 bags of vermicompost per hectare along with the 80-90-60 kg NPK ha^{-1} will have the same result when applying purely 80-90-60 kg NPK ha^{-1}. Further, the application of vermicompost at 20 bags vermicompost per hectare along with 80-90-60 kg NPK ha^{-1} is recommended because it obtained the highest yield and highest ROI with 378.73 percent. Also, a follow-up study on the use of vermicompost as a soil amendment for other high-value crops.

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