INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 25, No. 1, p. 50-61, 2024

RESEARCH PAPER OPEN ACCESS

Growth response and changes of soil chemical properties with application of vermichar in bell pepper production

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Key words: Vermichar, Soil Amendment, Organic Fertilizer, Bell Pepper, Production

http://dx.doi.org/10.12692/ijb/25.1.50-61 Article published on July 03, 2024

Abstract

This study was conducted to evaluate the efficacy of vermichar as organic soil amendment on bell pepper and its effect on soil chemical properties. The study was laid out using the Randomized Complete Block (RCB) design to test the following treatments: T1-Control, T2-90-60-30 kg NPK, T3-90-60-30 kg NPK plus 5 bags vermichar, T4-90-60-30 kg NPK plus 10 bags vermichar, T5-90-60-30 NPK plus 15 bags vermichar and T6-10 bags vermichar. The experiment was established at the College of Agriculture, Isabela State University, Echague, Isabela from November 2023 to March 2024. Result of the study shows that the application of vermichar improves soil pH, soil nitrogen (0.01-0.22%), soil P (160.14-519.24 ppm), K (214-310ppm), Co (2.71-6.40ppm), Zn (2.89-18.93ppm). In addition, no significant effect was also observed in terms of iron and manganese when soil was applied with 5 10 15 bags of vermichar. Growth of bell pepper was also affected by the increased rate of vermichar application due to the inherent nutrient present in the material. In terms of crop productivity, bell pepper applied with 10 to 15 bags plus the addition of recommended amount of NPK recorded the highest number of fruit and yield resulting also to have the highest return of investment compared to control plants.

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Introduction

Fertilizers are very important inputs in crop production when other inputs such as weed control, good land preparation and high yielding varieties were right. Crop yields can be doubled through balanced use of chemical fertilizers. In fact, the effect can also be more when combined with organic fertilizers that provide slow release of other nutrients not supplied through chemical fertilizer sources. The purpose of fertilizer use is to remove the limitation to crop growth that would be caused by an inadequate supply of nutrients in the soil (Alan, 1993). However, there are some organic materials and soil conditioners used to improve soil physical and chemical condition and yields. They serve as growth regulator, stimulating hormones or biostimulant. They are also fertilizers additives. Growth regulator in form of organic compound is widely used to improve production and quality of agricultural crops. It also helps the crop to maximize absorption of nutrient elements from the soil. Organic compounds which contain hormone have been found to play important role in the vegetative growth and reproduction of many crops including pepper (Onofeghara, 2001). However, the effect of the compounds on the crops may be positive or negative depending on the concentration applied. Several studies have been report-ed on the use of organic compounds to enhanced crop production.

Agricultural wastes are source of organic fertilizers to provide essential plant nutrients. These wastes such as corn cobs provide a beneficial impact and a commercial value as it has a potential to be converted into vermichar. Among organic fertilizers, the use of vermichar is quite a novel approach having potential benefits to both environment and agriculture. The rapid increase in the volume of waste is one aspect of the environmental problem that hinders global development. With the passage of the Philippine Organic Agriculture Act (RA 10068), it mandates the promotion and implementation of the organic farming practices that will condition and enrich soil fertility, increase farm productivity, reduce pollution, and save the environment. The incorporation of organic amendments to a problematic soil is looked upon as an essential management strategy to enhance the restoration of degraded soils, provide a better soil environment for soil microorganism, and the plants. Organic fertilizers have been known to improve biodiversity and long-term productivity of soil and may prove a large depository for excess carbon dioxide. The continuous use of organic fertilizers has been found to increase soil organic matter, reduce erosion, better water infiltration and aeration, higher soil biological activity, and increased crop yields. The benefits derived from organic fertilizers, the availability of raw materials in the locality and the high costs of chemical fertilizers favor the manufacture of organic fertilizers.

This study explores the possibility of utilizing waste biomass to prepare vermichar which can be used as soil supplements in plant growth. In this study, it explores the production of vermichar which is the synergy between vermiculture (worm farming) and biochar (porous charcoal soil improver). The physiological, morphological, and biological parameters of these soil supplements will be analyzed. Earthworm's uses to produce vermiculture are *Eugenia eudrilus* and *Eisenia foetida*. The plant used for the study is bell pepper. According to analysis, vermichar is a very good supplement for the soil which increases the N, P, K, C, and organic content of the soil, which is followed by biochar to grow a healthy plant. Using this soil supplement the fertility of the soil is protected and the yield is high. From the above work, biochar, as well as vermichar, has a great role in plant growth and in increasing soil fertility. The potential of vermchar as viable soil amendments and nutrient sources for bell pepper production is explored in this study. The study was conducted to evaluate the efficacay of vermichar as organic soil amendment on fruiting vegetable particularly on bell peper and its effect on soil chemical properties. Specifically, it aims to: (1) analyze the change in the nutrient content of soil applied with vermichar; (2) evaluate the growth improvement of bell pepper grown to soil amended with vermichar; and, (3) estimate the yield increment

of bell pepper accrued to vermichar application.

Methodology

Production of vermichar

Biochar was produced via pyrolysis using poultry manure-corn cobs at a ratio of 60:40. The vermicast was obtained from the vermicomposting facility of the University. VermiChar was produced by mixing homogeneously the vermicast and biochar in equal amount (50:50). One-half kilogram sample of the vermichar products was brought to Regional Soil Analytical Laboratory, Tuguegarao City for analysis of pH, organic matter content, total nitrogen, available phosphorus, exchangeable potassium and other micronutrients.

Collection of soil samples and analysis

Soil samples were randomly collected from the experimental area before and after the experiment. The soil samples were processed by pulverizing, air drying, grinding, and screening. A one-kilogram of the composite soil sample was set aside and was also submitted at the Integrated Soils Laboratory – Cagayan Valley Research Center, City of Ilagan, Isabela for the analysis of pH, OM, P, K, and micronutrients.

Land preparation

An area of 612 square meters was cleaned before plowing. It was initially plowed with a tractor and harrowed. The area was left idle for two weeks to allow weeds to decay and allow weed seeds to germinate before the final plowing. Final harrowing was done using the animal–drawn plow before transplanting until the soil was thoroughly pulverized.

Seedling production

The seeds of pepper were secured from an accredited seed dealer in the Santiago City. Seedling trays were prepared and filled with organic fertilizer and garden soil. Seeds were sown in each of the 128 holes and was covered with fine soil and watered using a sprinkler. The seedlings were watered as the need arises. The seedling trays were placed in the nursery where there is 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 using the sprinkler was done after the application of fertilizer no wash-out the residue of fertilizer on the leaves of the plants. The seedlings were placed under partial shade until ready to transplant.

Transplanting and replanting

Holes were made at a distance of 50 centimeters between rows and 50 centimeters between hills. The seedlings were transplanted two weeks after pricking. One seedling was transplanted per hill. Replanting of missing hills were done five days after transplanting to maintain equal number of plants per plot.

Experimental design and treatments

The experimental area was divided into three blocks and each block have a dimension of 5 meters x 36 meters. An alley way of one meter between blocks was provided. Each block was further subdivided into six equal plots. Each experimental unit has an area of 20 square meters with a dimension of 5 m x 4 m and was spaced one half meter apart. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The experimental lay out is shown in Figure 1. The following were the treatments evaluated in this study:

T_1- Control
T_2- 100-30-30 kg NPK ha^{-1}
T_3- 100-30-30 kg NPK ha^{-1} + 5 bags of vermichar ha^{-1}
T_4- 100-30-30 kg NPK ha^{-1} + 10 bags of vermichar ha^{-1}
T_5- 100-30-30 kg NPK ha^{-1} + 15 bags of vermichar ha^{-1}
T_6- 10 bags of vermichar ha^{-1}

Application of fertilizer

Results of the soil analysis was the basis for the amount and kind of fertilizers applied in all the treatments. The reference products for this study were complete fertilizer (14-14-14), and urea (45-0-0). One-half of the recommended amounts of nitrogen and full amount of the phosphorus and potassium were applied as basal (10 DAT) while the remaining

one-half of nitrogen was side dressed at 25 days after planting. The vermichar at the rate of 5, 10 and 15 bags ha^{-1} were thoroughly mixed with the inorganic fertilizer before planting. The computed amount of fertilizer per treatment was divided equally with the number of holes and applied accordingly in the assigned plots**.**

Care and management of the crop

Hand weeding was done to control weeds during the period of the trial. Cultivation was done regularly planting using a spade. Regular monitoring of the plants was done to prevent disease outbreak. Infected plants showing unusual signs and symptoms were immediately removed from the area. Insect infestation was managed by applying insecticides to the target insect pest following the manufacturer's recommendation.

Harvesting

Ten representative plant samples were randomly selected from each plot for the data gathering. The fruits were harvested when they reached the desired marketable size. Harvesting was done every week. All the fruits obtained from the 10 sample plants picked and the number of fruits and corresponding weights were record. Five priming was done.

Data gathered

1. Chemical properties of vermichar- this was taken through laboratory analysis. Sample materials was submitted to the DA CVIAL to determine the pH, OM, N, P, K, and micronutrients present. This was done before the conduct of the study.
2. Soil-chemical properties- this was done by subjecting soil sample through laboratory analysis to assess the existing chemical properties of the soil prior and after the application of vermichar.
3. Plant Height. The plant height of ten representative sample plants was measured at 30, 60 and 90 days after transplanting. It was measured from the base of the plants up to the tip of the primary stem.
4. Number of Fruits per Plant. The number of fruits plant were properly counted and recorded every priming. All the fruits from the first priming up to the fifth priming was summed up and divided by ten to obtain the average number of fruits per plant.
5. Weight of Marketable Fruits per Plant. The marketable 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 average fresh weight of fruits per plant.
6. Weight of Marketable Fruits per Four Square Meters Sampling Area. 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.
7. Computed Fruit Yield per Hectare. The computed fruit yield per hectare was computed based on the average yield per net plot.
8. Cost and Return Analysis- this was accounted by using the formula below:

$$\text{Return of Investment} = \frac{\text{Total Sales - Total Cost of Production}}{\text{Total Cost of Production}} \times 100$$

Statistical analysis

Data were subjected to statistical analysis using the Statistical Tool for Agricultural Research (STAR) package following the RCBD experimental design and the differences among treatment means were compared using the Tukey's HSD Test at 5% significant level.

Results and discussions

Characteristics of vermichar

The formulated vermichar products were analyzed for SOM and N, P, K. Table 1 presents the nutrient content of the soil amendments.The vermichar derived from the combination of vermicast and biochar showed high organic matter content with 11.86 percent and organic carbon of 6.87 percent. Organic matter serves as a reservoir of nutrients and water in the soil, aids in reducing compaction and surface crusting, and increases water infiltration into the soil. Organic matter contributes to plant growth through its effect on the physical, chemical, and biological properties of the soil.

Table 1. Nutrient Composition of Vermichar.

	OM	N	P	K	NPK
	(%)	(%)	(%)	(%)	
Vermichar (50:50)	11.86	0.59	4.41	0.45	5.33

The presence of organic carbon in a compost helps improve the physical and chemical properties of soils. Total nitrogen is low at 0.59 percent, phosphorus is 4.41 percent and potassium is 0.45 percent. Total NPK of the vermichar is 5.33 which is higher than the 5% required for a material to be considered organic (PNS for Organic Fertilizer).

The C/N ratio of the product is 11.64 C g^{-1} N which is considered narrow and implies that the product is preferable and acceptable, as ratio below 20 is an indicative of an acceptable maturity, while ratio of 15 or even less is preferable (Inbar *et al.*, 1990). Organic amendments with low C:N ratio will decompose much faster than residue with a high C:N ratio. This indicated that the vermichar and resulting soil organic matter fractions were low in C and high in nitrogen. The total quantity of biomass produced by the vermichar, its C:N ratio, and how it is managed will determine how much soil organic matter is likely to increase. The vermichar contains Cu (35 ppm), Zn (247.50 ppm), Mn (555) and Fe (38,337 ppm), and probably contains a number of other micronutrients which were not included in the analysis. These micronutrients are not present in the ordinary formulations of inorganic fertilizer sold in the market.

Table 2. Soil pH as influenced by vermichar application.

	TREATMENTS	Soil pH
T_1	Control	6.19 b
T_2	90-60-30 kg ha^{-1} NPK	7.93 a
T_3	90-60-30 kg ha^{-1} NPK + 5 bags ha^{-1}	7.99 a
T_4	90-60-30 kg ha^{-1} NPK + 10 bags ha^{-1}	7.92 a
T_5	90-60-30 kg ha^{-1} NPK + 15 bags ha^{-1}	7.67 a
T_6	Vermichar @10 bags ha^{-1}	7.84 a

Means followed by the same letter are not significantly different at the chosen level of significance (0.05).

Effect of vermichar on selected soil properties

Soil pH

Soil chemical analysis showed that the addition of vermichar induced a significant increase of pH values from 6.19 (T1) to 7.99 (5 bags), 7.92 (10 bags) and 7.67(15 bags). On the contrary, the alkalinity value still maintains and higher pH with sole application of vermichar (7.84) compared to T1 (6.19) as shown in Table 2. There is a significant increase in the soil pH of soils amended with the vermichar at different rates.

The pH of soil amended with 5 bags vermichar (T_3) has the highest with 7.99. Application of vermichar alone increased the soil pH by 1.65 units, while 90-60-30 kg NPK + 15 bags vermichar (T_5) and 90-60-30 kg NPK + 10 bags vermichar (T_4) improve the pH by 1.48 and 1.73 units with respect to T1. Surprisingly, lowering the rate at 5 bags vermichar with 90-60-30 kg NPK (T_3) still increase pH by 1.8. The result indicates that vermichar has the potential to increase pH, hence important in acidic soils.

Organic Matter

The change in organic matter content of soils amended with three rates of vermichar was visibly indicated in Table 3. Addition of organic matter in acidic soil increases the pH to be optimum for plant growth. Many studies have shown that biochar improves the physic-chemical properties of soil, particularly maintaining the soil organic matter levels (Chan *et al.*, 2007). Furthermore, the application of organic materials to soils is a practical method to aid in the long-term maintenance of the soil organic carbon contents and soil fertility.

Table 3. Macronutrient Composition of Soil applied with Vermichar.

TREATMENT	Chemical Properties			
	SOM (%)	N (%)	P (ppm)	K (ppm)
T_1 – Control	3.41 b	0.17 b	13.33 d	482.79 b
T_2 - 90-60-30 kg ha^{-1} NPK	5.79 ab	0.29 ab	402.69 ab	1970.05 a
T_3 - 90-60-30 kg ha^{-1} NPK + 5 bags ha^{-1}	3.57 b	0.18 b	173.47 cd	1518.78 a
T_4 - 90-60-30 kg ha^{-1} NPK + 10 bags ha^{-1}	7.85 a	0.39 a	532.85 a	1983.32 a
T_5 - 90-60-30 kg ha^{-1} NPK + 15 bags ha^{-1}	4.67 b	0.23 b	299.05 bc	1634.91 a
T_6 – Vermichar @10 bags ha^{-1}	4.89 b	0.24 b	384.43 abc	1611.68 a

Means followed by the same letter are not significantly different at the chosen level of significance (0.05).

The application of organic material to soils can maintain SOM levels and soil aggregation stability (Kimetu and Lehmann, 2010) because these contain recalcitrant C from microbial degradation and by a charged surface with organic functional groups. All the soils applied with vermichar regardless of the rate increased the soil organic matter by 1.48 percent (vermichar alone), while the addition of 5, 10 and 15 bags vermichar to 90-30-30 kg NPK improved the soil organic matter by 0.16 percent (vermichar at 5 bags), 3.41 percent (vermicast at 10 bags) and 1.26 percent (vermichar at 15 bags). The increased in the soil organic matter content was associated in the organic material application. Organic matter plays an important role in maintaining soil fertility as buffer agent of toxic micro elements present in soil.

Nitrogen

Table 3 further indicates that there is a significant difference in the nitrogen contents of the organic-treated soils and the control. Unamended soil had 0.17 percent nitrogen after the experiment, while vermichar application improved it by 0.07 percent. Application of vermichar increased soil nitrogen by 0.22 percent (vermichar at 10 bags), and vermichar 15 bags (T_5) had increased by 0.06 percent while vermichar at 5 bags had the least increment at 0.01 percent.

Table 4. Micronutrient composition of soil applied with vermichar.

TREATMENT	Chemical Properties			
	Cu	Fe	Mn	Zn
T_1 - Control	4.17 ab	122.38	15.93	2.89 c
T_2 - 90-60-30 kg ha^{-1} NPK	4.41 ab	47.53	15.07	20.00 a
T_3 - 90-60-30 kg ha^{-1} NPK + 5 bags ha^{-1}	2.71 b	30.53	10.13	16.00 ab
T_4 - 90-60-30 kg ha^{-1} NPK + 10 bags ha^{-1}	6.40 a	83.47	20.33	18.93 ab
T_5 - 90-60-30 kg ha^{-1} NPK + 15 bags ha^{-1}	3.99 ab	57.13	15.80	13.47 b
T_6 – Vermichar @10 bags ha^{-1}	4.20 ab	44.13	15.27	16.00 ab

Means followed by the same letter are not significantly different at the chosen level of significance (0.05).

Available phosphorus

The function of phosphorus in plants is very important. It helps a plant convert other nutrients into usable building blocks with which to grow. Adequate phosphorus nutrition enhances many aspects of plant development including flowering, fruiting and root growth. The phosphorus contents of soils amended with organic materials significantly increased as evident by the P values in soils applied with vermichar higher by 371.10 ppm, while addition of 5 kg vermichar 160.14 ppm, 10 kg vermichar 519.52 and 15 kg vermichar by 285.72 ppm relative to the untreated soil. The untreated soil (control) obtained the lowest P content with a value of 13.33 ppm.

Phosphorus is one of the main three nutrients. Phosphorus is one of the most important elements for plant growth and metabolism. It plays key roles in many plant processes such as energy metabolism, the synthesis of nucleic acids and membranes, photosynthesis, respiration, nitrogen fixation and enzyme regulation (Raghothama, 1999).

Exchangeable potassium

Table 3 further shows the potassium contents of the amended soils after the trial. Except with vermichar alone (T6) which improve the potassium content of the soil by 1128 ppm, the application of 90-30-30 kg NPK plus vermichar indicated an improvement with 214, 310, and 238 precent with the application of 5, 10 and15 bags vermichar, respectively as supplement to 90-30-30 kg NPK. From the original K level of 482.79 ppm, organic soil amendment improves the potassium availability in the soils. The vermichar-amended soils indicated the greatest potential to improve potassium level relative to the control.

Table 5. Height (cm) of bell pepper applied with three levels of vermichar.

TREATMENTS		PLANT HEIGHT (cm)		
		30 DAT	60 DAT	90 DAT
T_1	Control	33.86 c	60.63 c	69.77 e
T_2	90-60-30 kg ha^{-1} NPK	38.89 b	73.70 b	83.97 d
T_3	90-60-30 kg ha^{-1} NPK + 5 bags ha^{-1}	39.10 b	73.20 b	90.43 c
T_4	90-60-30 kg ha^{-1} NPK + 10 bags ha^{-1}	39.44 a	81.50 a	99.60 b
T_5	90-60-30 kg ha^{-1} NPK + 15 bags ha^{-1}	42.34 a	82.97 a	110.07 a
T_6	Vermichar @10 bags ha^{-1}	34.80 bc	64.63 c	80.50 d
	CV (%)	4.25	2.42	1.60

Means followed by the same letter are not significantly different at the chosen level of significance (0.05).

Micronutrient content of soil

Table 4 shows the micronutrient contents of the amended soils after the experiment. There is a significant increase in the copper and zinc contents of the soils amended with the vermichar at different rates. For copper, the maximum value of 6.40 ppm is noted on the addition of 10 bags vermichar as supplement to 90-60-30 kg NPK, but comparable to 3.99 ppm (15 bags vermichar) and 4.20 ppm (vermichar alone).

The minimum value of 2.71 ppm is noted on 90-60-30 kg NPK plus 10 bags vermichar. For zinc, the maximum value of 18.93 ppm is noted on soils amended with 10 bags vermichar along with inorganic fertilizer, but comparable to all other treatments except the control with 2.89 ppm considered the least.

While there is no significant effect on iron and manganese content of the soil with or without addition of vermichar. Addition of vermichar had no significant effect on iron and manganese with values ranged from 30.53 to 122.38 ppm (iron) and 10.13 to 20 33 ppm (manganese).

Effect of vermichar on growth and yield of bell pepper

Plant Height

The average height of bell pepper applied with vermichar and inorganic NPK at 30 60 and 90 DAT is presented in Table 5. The average plant height is 38.07 cm with means varied among each other at 4.25 percent. Data showed that the plants applied with 90-60-30 kg NPK plus 15 bags (T_5) and 10 bags (T_4) of vermichar were the tallest with respective mean of 42.34 and 39.44 cm, this was followed by the plants supplied with 90-60-30 kg NPK plus 5 bags vermichar (T_3) with 39.10 cm but comparable to the plants applied with 1.0RR (T_2) with mean of 38.89 cm and vermichar alone (T6) with 34.80 cm. The shortest plants at 33.86 cm were on the control plots. The data implies that the addition of 10 to 15 bags of vermichar in Treatment 4 and Treatment 5 enhanced the height growth of the plants. For Treatment 3 (5 bags) the early height growth of the plants was accrued to the NPK from the inorganic source as manifested by the non-significant variation in the mean height of plants in Treatment 2 and Treatment 3. The plants applied with vermichar alone (T_6) with a mean height of 34.80 cm were comparable to the

plants in Treatment 2 (90-60-30 kg NPK) and Treatment 3 (90-60-30 kg NPK + 5 bags vermichar) which indicates that the vermichar in Treatment 6 significantly enhanced the height growth of the plants. This is further validated by the non-significant variation between Treatment 6 and the control plots where no vermichar was applied, with mean height of 33.86 cm.

Table 6. Number of branches per plant of bell pepper applied with three levels of vermichar.

	TREATMENTS	Number of Branches
T_1	Control	4.77 e
T_2	90-60-30 kg ha^{-1} NPK	5.97 cd
T_3	90-60-30 kg ha^{-1} NPK + 5 bags ha^{-1}	6.27 bc
T_4	90-60-30 kg ha^{-1} NPK + 10 bags ha^{-1}	6.40 b
T_5	90-60-30 kg ha^{-1} NPK + 15 bags ha^{-1}	6.93 a
T_6	Vermichar @10 bags ha^{-1}	5.73 d
	CV (%)	2.09

Means followed by the same letter are not significantly different at the chosen level of significance (0.05).

Analysis of variance showed that the application of vermichar exhibited significant effects on the height growth of the plants at 60 days after planting. The tallest are the plants applied with inorganic fertilizers (90-60-30 kg NPK) plus 10 and 15 bags of vermichar with 81.50 and 82.97 cm, respectively. The application of 5 bags vermichar with 90-60-30 kg NPK with mean of 73.20 cm showed no significant effect on the plant height as revealed by the comparable mean obtained in Treatment 2 (90-60-30 kg NPK) with 73.70 cm. The sole application of vermichar at 10 bags with mean of 64.63 cm showed no effect on the height growth of the plants, as manifested by the comparable figure obtained with the non-amended crops with 60.63 cm. At 90 days, the tallest plants were those applied with 15 bags vermichar and 90-60-30 kg NPK (T5) at 110.07 cm. This was followed by the plants amended with 10 bags vermichar with inorganic fertilizer (T4) at 99.60 cm, 5 bags of vermichar plus inorganic fertilizer (T3) with 90.43 cm. The application of vermichar alone (T6) showed its potential to affect the height growth of the plants with mean of 80.50 cm, since its comparable to the sole application of 90-60-30 kg NPK with 83.97 cm. The shortest plants are those in the control plots with 69.77 cm. Such differences in the plant height between T_6 (vermichar) and T_1 (control) were attributed to the vermichar applied. The height growth of the plants is significantly encouraged by the application of 5-15 bags vermichar along with inorganic NPK (Chong, 2005; Kalantari *et al.,* 2009). It also contains biochemical substances that promote plant growth, improves the root structure, flowering capacity of crops.

Table 7. Number of fruits of bell pepper applied with three levels of vermichar.

	TREATMENTS	Number of Fruits per Plant
T_1	Control	50 d
T_2	90-60-30 kg ha^{-1} NPK	79 c
T_3	90-60-30 kg ha^{-1} NPK + 5 bags ha^{-1}	92 bc
T_4	90-60-30 kg ha^{-1} NPK + 10 bags ha^{-1}	107 b
T_5	90-60-30 kg ha^{-1} NPK + 15 bags ha^{-1}	131 a
T_6	Vermichar @10 bags ha^{-1}	59 d
	CV (%)	8.40

Means followed by the same letter are not significantly different at the chosen level of significance (0.05)

Number of Branches

In general, the number of branches of bell pepper vary among treatments as presented in Table 6. The plants amended with vermichar as addition to 90-60-30 kg NPK in Treatments 5 (5 bags) produced the greatest number of branches at 6.93. This was followed by Treatment 4 (10 bags) and Treatment 3 (5 bags) with respective mean of 6.40 and 6.27. However, the number of branches between Treatment 2 (90-60-30 kg NPK) with 5.97 and Treatment 3 (90-60-30 kg NPK plus 5 bags vermichar) were comparable. This implies that 5 bags of vermichar as supplement to 90-60-30 kg NPK was not enough to improve the productivity of the bell pepper in terms of branch production. The sole application of vermichar at 10 bags proved to be effective as nutrient source since plants produced more branches (5.73) than the non-amended soils (T1) with 4.77. However, Treatment 6 did not outdone Treatment 2, which indicates that sole application of vermichar is not enough to be comparable with the effect of inorganic fertilizer. The result implies that addition of soil amendment (10-15 bags) to inorganic NPK (90-60-30 kg/ha) effectively boosted the formation of branches of the bell pepper. Vermichar releases nutrients slowly and steadily into the system which enables the plant to absorb the essential nutrients for plant growth and development and also provides additional substances that are not found in chemical fertilizers (Kale, 2018).

Table 8. Weight of marketable fruits of bell pepper applied with three levels of vermichar.

TREATMENTS		Weight (g) of Marketable Fruits	
		g/plant	kg/4 m²
T_1	Control	269.43 c	3.23 c
T_2	90-60-30 kg ha^{-1} NPK	405.87 bc	4.87 b
T_3	90-60-30 kg ha^{-1} NPK + 5 bags ha^{-1}	423.87 bc	5.05 b
T_4	90-60-30 kg ha^{-1} NPK + 10 bags ha^{-1}	557.03 ab	6.69 ab
T_5	90-60-30 kg ha^{-1} NPK + 15 bags ha^{-1}	650.57 a	7.81 a
T_6	Vermichar @10 bags ha^{-1}	288.93 c	3.47 c
	CV (%)	14.96	15.19

Means followed by the same letter are not significantly different at the chosen level of significance (0.05).

Number of Fruits per Plant

The analysis of variance revealed a highly significant result in terms of number of fruits per plant of bell pepper as affected by the application of vermichar as shown in Table 7. The data showed that the plants applied with inorganic NPK (90-60-30) with 15 bags of vermichar (Treatment 5) produced the greatest number of fruits per plant at 131. This was followed by the plants supplied with inorganic fertilizer plus 10 bags (Treatment 4) and 5 bags (Treatment 3) of vermichar with 107 and 92 fruits per plant, respectively. However, the latter did not vary with Treatment 2 (90-60-30 kg NPK) with 79 fruits per plant. Treatment 6 (10 bags vermichar), however revealed that plants produced comparable number of fruits with the unamended crops (T1) with mean of 59 and 50, respectively. The result of the study implied that higher rate of vermichar contains most nutrients in plant-available forms (Orozco *et al.*, 2006) that can influence the growth and production of fruits per plants (Edwars, 1998).

Weight (g) of Marketable Fruits per Plant

The response of bell pepper in terms of weight of fruits per plant and weight of fruits per 4 m² sampling area as influenced by the application of vermichar is shown in Table 8. There is a significant difference on the weight of fruits obtained from the different bell pepper plants where inorganic fertilizers and vermichar were applied. The data showed that application of vermichar at 15 bags (T_3) and 10 bags (T4) as supplement to 90-60-30 kg NPK produced the fruits with the heaviest in weight at 650.57 and 557.03 grams per plant, respectively.

Table 9. Fruit yield of bell pepper applied with three levels of vermichar.

	TREATMENTS	Yield (t/ha)
T_1	Control	8.08 c
T_2	90-60-30 kg ha^{-1} NPK	12.18 b
T_3	90-60-30 kg ha^{-1} NPK + 5 bags ha^{-1}	12.63 b
T_4	90-60-30 kg ha^{-1} NPK + 10 bags ha^{-1}	16.72 ab
T_5	90-60-30 kg ha^{-1} NPK + 15 bags ha^{-1}	19.52 a
T_6	Vermichar @10 bags ha^{-1}	8.67 c
	CV (%)	15.18

Means followed by the same letter are not significantly different at the chosen level of significance (0.05).

The latter, however is comparable to the fruits obtained on plants supplied with 5 bags vermichar plus inorganic fertilizer (T3) with 423.87 grams per plant. The addition of 5 bags vermichar, however, indicated a not significant variation with the reference check or the sole inorganic fertilizer. The comparable result obtained from Treatment 3 and Treatment 2 indicate that 5 bag of vermichar is not enough to increase the production of fruits. The plants supplied with vermichar alone produced an average of 288.93 grams per plants, comparable to the weights of the fruits obtained in the control plots with a mean of 269.43 grams considered the least. This implies that the soil amendment at 10-15 bags per hectare as supplement to inorganic fertilizer improves the fruiting capacity of bell pepper.

Table 10. Cost and Return Analysis for One Hectare of bell pepper applied with vermichar.

TREATMENTS		ROI (%)
T_1	Control	313.32
T_2	90-60-30 kg ha^{-1} NPK	345.16
T_3	90-60-30 kg ha^{-1} NPK + 5 bags ha^{-1}	339.37
T_4	90-60-30 kg ha^{-1} NPK + 10 bags ha^{-1}	435.50
T_5	90-60-30 kg ha^{-1} NPK + 15 bags ha^{-1}	485.96
T_6	Vermichar @10 bags ha^{-1}	281.50

Yield per sampling area (kg/4 m^2)

The results of the analysis on the effect of the application of vermichar on fruit yield per sampling area is presented in Table 8. The yields obtained from the experimental plots were significantly different from among each other with the average yield of 5.18 kilograms. In terms of the yield per sampling area of 4 m^2, the same trend of result was observed. The result proved that vermichar is rich in both macronutrients and micronutrients (Shinde *et al.*, 2022), besides having plant growth promoting substances, humus forming microbes and nitrogen fixers (Bano and Kale, 1986).

Computed Fruit Yield

The computed fruit yield per hectare as influenced by application of the inorganic fertilizers supplemented with vermichar is presented in Table 9. The data generally indicated that the application of vermichar significantly improved the fruit yield. The fruit yield obtained from the different treatments varied among each other by 12.96 percent and mean ranged from 8.08 to 19.52 tons per hectare. Sole application of 90-60-30 kg NPK yielded 12.12 ton/ha. The addition of 10 bags (T4) and 15 bags (T5) of vermichar increased the yield by 37.27 and 60.26 percent, corresponding to 4.54 and 7.34 tons of additional fruit. Lowering the rate of vermichar to 5 bags (T3) increased the yield by 3.69 percent only, which corresponds to additional fruit yield of 0.45 tons. Sole application of vermichar at 10 bags (T6) increased the fruit yield by 7.30 percent or 0.59 tons. This do not vary much with the yield obtained in the control plots. This implies that 5 bags of vermichar as addition to 90-60-30 kg NPK was not enough to further enhanced the fruiting capacity of bell pepper.

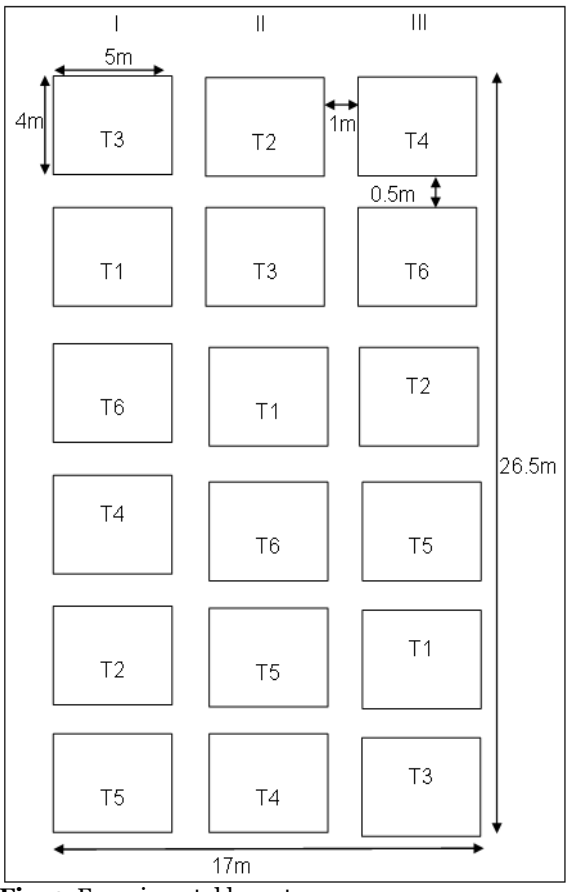

Fig. 1. Experimental layout.

Cost and Return Analysis

Table 10 shows the comparison of production cost, gross income, net income and return of investment (ROI) for a one-hectare bell pepper production applied with and without vermichar utilizing the computed yields per treatment. The application of 15 bags vermichar as addition to inorganic NPK (90-60-30 kg) in Treatment 5, revealed the highest ROI of 485.96, while lowering the rate of vermichar to 10 bags per hectare in Treatment 4 manifested ROI of 435.50 percent. This was followed by Treatment 2 (90-60-30 kg NPK) with 345.16 percent. The addition of 5 bags of vermichar generated much lower ROI of 339.37 percent; while the control plots had 313.32 percent. The sole application of 10 bags vermichar realized ROI of 281.50 percent considered the lowest. Based on the generated return on investments, it implies that application of 10 to 15 bags vermichar in addition to inorganic NPK proved to be the best rate of vermichar as it significantly boosted the productivity of bell pepper and realized the highest return.

Conclusion

Vermichar derived from the combination of biochar and vermicast contains important nutrients necessary for the growth and development of bell pepper. It likewise improved the chemical properties of soils particularly the soil pH, soil organic matter, nitrogen, phosphorus, potassium and some micronutrients. The application of the recommended rate of inorganic fertilizer with the supplementation of 10-15 bags of vermichar significantly improved the agronomic characteristics of bell pepper such as plant height, number of branches, number and weight of fruits which redound to higher fruit yields in per plant, sampling area and hectare bases, plus manifested the highest return of 435.50 to 485.96 percent.

In as much as the application of vermichar at 10 - 15 bags/ha significantly improved the fruit yield and registered highest ROI, it can therefore be recommended as nutrient management modality for bell pepper production. A similar study, however, should be conducted in the next season to validate and come up with a more reliable and conclusive result.

References

Alan W. 1993. Soil and environment. Cambridge Low price edition. Cambridge University Press, p. 144.

Chan KY, Zwieten LV, Meszaros I, Downie A, Joseph S. 2007. Agronomic Values of Green Waste Biochar as a Soil Amendment. Australian Journal of Soil Research **45,** 629–634.

Chong RS. 2005. Using organic fertilizers. Food and Fertilizer Technology Center.

Edwars A. 1998. Characterization of Biochars to Evaluate Recalcitrance and Agronomic Performance. Bioresour Technol **114,** 644–653.

Kalantari S, Hatami S, Ardalan MM, Alikhani HA, Shorafa S. 2010. The effect of compost and vermicompost of yard leaf manure on growth of corn. African Journal of Agricultural Research **5(11),** p 1317-1323.

Kale RD, Bano K. 1986. Field Trials with Vermicompost: An Organic Fertilizer. Proceedings of National Seminar on Organic Wate Utilization by Vermicomposting, GKVK Agricultural University, Bangalore.

Kale VA. 2008. Utilization of various combinations of soybean and jowar straw based complete feed in Osmanabadi kids. Asian Journal of Animal Sciences **3(2),** 196-197.

Kimetu J, Lehmann S. 2010. Stability and stabilization of biochar and green manure in soil with different organic carbon contents. Australian Journal of Soil Research **48,** 577-585 p.

Onofeghara FA. 1981. The effects of growth substances on the flowering and fruiting of Lycopersicon esculentus and Vigna unguiculata. Phyton **40(1),** 107-116.

Orozco PG, Abiodun BJ, Ajayi AE, de Giesen NV. 2016. Effects of charcoal production on soil physical properties in Ghana. Journal of Plant Nutrition and Soil Science **171(4),** 591-596.

Raghothama KG. 1999. Phosphate acquisition. Ann. Rev. Plant Physical. Plant Mol. Bio. **50**, 665-693.

Shinde R, Shani DK, Mahapatra P, Singh CS, Naik SK, Thombare N, Singh AK. 2022. Management of crop residues with special reference to the on-farm utilization methods: a Review. Industrial Crops and Products **181,** 114772.