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Growth and yield performance of tomato (*Lycopersicum esculentum* L.) using vermicast as soil amendments

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Abstract

The study was conducted to look into the efficacy of vermicast as soil amendments on the growth and yield performance of tomato (*Lycopersicum esculentum* L.). It aimed to determine vermicast's effect on the fruit quality of tomato and to determine which among the treatments gives significant results. The experiment was laid out in a Randomized Complete Block Design (RCBD) with five (5) treatments replicated three (3) times. Treatment effectiveness was based on plant height, number of flowering days, weight yield per hectare, ROI, physico-chemical of tomato and NPK soil content. Results revealed that 10 bags of vermicast per hectare in combination with inorganic fertilizer (90-0-0Kg N ha1) was a good soil amendment or nutrient source because it improved soil quality, fruit quality, and physic-chemical properties of tomato, thus, producing better yield and cost return.

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Introduction

Tomato (*Lycopersicum esculentum L.)* locally known as *kamatis* in the Philippines, is an edible, red berry-type fruit of the nightshade *Solanum lycopersicum*. It is grown both for home consumption and for commercial trade. Tomato is one of the world's major vegetable with a worldwide production of 182.3 million of tonnes in the year 2017 FAOSTAT, (2019). It can be eaten raw, ingredient in many dishes, sauces, drinks, and mostly in salads. Sometimes, it is also considered as culinary vegetable. Essentially, tomato has multiple nutritional facts. A cup of fresh tomato weighing 42 grams as appetizer for lunch and dinner can give 10.8 kilocalories for energy, 0.36 grams of protein, 0.12 grams of fat, 12.4 milligrams of calcium, 10.4 milligrams of phosphorus, 0.4 milligrams of iron, 152 micrograms of beta carotene, 0.02 milligrams of thiamine, 0.012 milligrams of riboflavin, 0.24 milligrams of niacin, and 13.6 milligrams of vitamin C, (FNRI, 2018).

Stated in the Tomato Production Guide of the Department of Agriculture Region 2 that most used variety of tomato in the Philippines is Diamante, a hybrid variety for year round tomato production. It is a heat tolerant variety allowing better fruit set even under hot condition, early maturing, and high level of resistance to bacterial wilt and with excellent prolificacy that results to very high yield levels. The fruits are round in shape, over 40 grams in weight, and have a very thick flesh.

Asia is the world leader in consumption with 159Kg per year, while the Latin America ranks last with a per capita consumption of only 55Kg per year by the agri benchmark (2014). Philippine Nutrition Facts And Figures (2015), reported that tomato is in the top 30 commonly consumed food items, mean intake and proportion of households consuming by wealth quintile.

Tomatoes are excellent source of nutrients to suffice body ailments and part of balanced diet (Li and Xu, 2014; Pouchieu *et al.*, 2014). Chadha *et al.* (2011) conducted research and development activities to increase access to and improve consumption of diverse and nutrient-rich vegetables, particularly in areas where malnutrition is prevalent. Tomatoes have become well-known as an important source of lycopene, which is a powerful antioxidant that acts as an anti-carcinogen and also provide vitamins and minerals. One medium ripe tomato (~145 grams) can provide up to 40 percent of the Recommended Daily Allowance of Vitamin C and 20% of Vitamin A. They also contribute B vitamins, potassium, iron and calcium to the diet. Tomato has been recently gaining attention in relation to the prevention of some human diseases. This interest is due to the presence of carotenoids and particularly lycopene, which is an unsaturated alkali compound that appears to be an active compound in the prevention of cancer, cardiovascular risk and in slowing down cellular aging (Gerster, 1997; Di Cesare *et al.,* 2012; abdel-Monaim, 2012 Salem) as cited by M. Al-Amri, (2013). Fertilizer is indispensable in crop production since it is needed by crop to complete their life cycle. Zhang, S. *et al.* (2016) stated that soil organic material is the major nutrient elements for plant. Fertilizer plays a very important role in improving soil aggregation soil aeration, stable soil temperature and better water holding capacity. The use of organic fertilizers is increasingly becoming popular among vegetable growers in Region 02. In a survey conducted by Padilla *et al.* (2017), they reported approximately 53% of the respondents used organic fertilizer at least once in their farming operations.

Tomato can be grown in the backyard and in commercial scale for community consumption and for industrial use (product processing), respectively. With the many uses and great potentials of tomatoes, there is a pressing need to improve its productivity without compromising the quality of produce. Catedral (2019), underscored the importance of good field planning in achieving a successful vegetable farming venture. He also discussed that food security start at home and he encouraged to practice organic farming in the backyards. Organic farming is a method of farming that involves the use of ecologically friendly techniques for producing crops.

Given all factors of crop production at their optimum, healthy soil is the key to successful organic crop production. Plants require good quality soil with enough amounts of essential nutrients to grow well and produce more yields. There are many different ways (mitigation) to feed the soil for it to supply nutritional requirements of plants to ensure better production or yield, such as the application of organic fertilizer or any soil ameliorants. Organic fertilizers increase the yield and quality of agricultural crops in ways similar to inorganic fertilizers (Heeb *et al.,* 2006; Liu *et al.*, 2007). They take the place of inorganic fertilizers in sustainable agriculture system.

The main sources of the organic fertilizers are decomposed livestock manures, plant residues, and organic-based concoctions like Fish Amino Acidm (FAA), Indigenous Microorganisms (IMO) etc., and processed industrial wastes. Organic-based fertilizers can provide nutritional requirements of plants as they increase the microbial activity in soil, anion and cation exchange capacity, organic matter and carbon- content of soil. The Asia Regional Organic Standard (AROS) stated that, intervention and inputs that are being mandated are towards using Organic agriculture (OA), which regulate and mandate the use of organic fertilizer for crop production. OA farming aims to employ long-term ecological, system- based organic management, assuring long-term, biologically-based soil fertility. It considers the medium and long term effect of agricultural inventories on the agro- ecosystems. Organic agriculture takes pro-active approach as opposed to treating problems after they emerged. The impact of organic agricultural system on natural resources favours interactions with the agro-eco system that is vital for both agricultural and nature conservation.

Composting in the presence of earthworms led to stronger transformation of buffalo manure than regular composting. Vermicompost (VC) is rich in N-containing compounds and depleted in polysaccharides. It further contain stronger modified lignin compared to regular compost. The amendment of compost and vermicompost led to significant modification of the soil organic matter after 2 months of exposure to natural weather conditions. Compost and vermicompost amendments both enhanced aggregation and increased the amount of organic matter stable aggregates, (Phuong *et al.*, 2010).

Vermicompost contains most nutrients in forms that are available for plants such as nitrates, phosphates, and ex-changeable calcium and soluble potassium. Usually, the vermicompost contains most of the essential minerals. Based on the Revised Philippine National Standard for Organic Soil Amendments 2016, as cited by Fusilero 2018, stated that the NPK concentrations of goat manure and vermicompost are enough to improve the physical and chemical properties of the soil. It was also stated that the NPK concentration of 2.5% to 5% can enriched the microbial activity in the soil.

Singh (2015) stated that vermicompost is an excellent soil amendment and bio- control agent which make it the best organic fertilizer and more eco-friendly as compared to chemical fertilizer. Vermicompost is ideal organic manure for better growth and yield of many plants. It can increase the production of crops and prevent them from harmful pest without polluting the environment. Application of VC increased seed germination, stem height, number of leaves, leaf area, leaf dry weight, root length, root number, total yield, number of fruits/plant chlorophyll content, pH of Juice, TSS of juice, micro and macro nutrients, carbohydrate (%) and protein (%) content and improved the quality of the fruits and seeds according to Joshi *et al.* (2014). Vermicompost is a miracle plant growth promoters much superior to conventional composts and chemical fertilizers (Sinha Bharambe, 2007). Atiyeh *et al.* (2002) found that the conventional compost was higher in ammonium, while the VC tended to be higher in nitrates, which is the more available form of nitrogen (N) to promote better growth and yield.VC had higher N availability than the conventional compost on a weight basis as the supply of several other nutrients e.g. P, K, sulfur and magnesium were significantly increased by adding VC as compared to conventional compost to soil.

Furthermore, compost has high nutritional value with high concentrations of especially nitrogen, phosphorous and potassium, while the contamination by heavy metals and other toxic substances are very low Asghar, (2002). Previous studies showed that the combination of compost with chemical fertilizer further enhanced the biomass and grain yield of crops Sarwar, (2007); Sarwar, (2008).Moreover, several examples in the literature show that compost and vermicompost are able to enhance the growth of a wide range of plant species further what can be expected because of the supply of nutrient Edwards, (2004); Grigatti (2007).

On the other hand, vermicast is a product of decomposition from organic matter performed by an earthworm (African Night Crawler). It has a massive concentration of nitrogen in available forms that plants can utilize. It enhances and reconditions the soil (del Amen, 2013). Ansari and Ismail (2012) reported that worm's vermicast contains 7.37% nitrogen and 19.58% phosphorus as P_2O_5.

Nutrient content of vermicast varies with earthworm feed type, but feeding waste to earthworms does cause nitrogen mineralization, followed by phosphorous and sulfur mineralization after ingestion. A typical nutrient analysis of casts is C:N ratio 12–15:1; 1.5%–2.5% N, 1.25%–2.25% P_2O_5 and 1%–2%, K_2O at 75%–80% moisture content. The slow-release granules structure of earthworm casts allows nutrients to be released relatively slowly in sync with plant needs, Sinha *et al.* (2003).

With the spiralling prices of inorganic fertilizers and the implication of its continuous usage on the soil and the environment, there is a need to find ways to possibly lessen the cost of production but not necessarily compromising the productivity and quality of produce through the soil enhancements like vermicast. In addition, the growing appreciation of organically grown crops like tomatoes by vegetable consumers for their nutritional and health benefits in the local market calls for raising the supply (via improved yield) to meet the growing demand. The purpose of this study was to evaluate tomato growth and yield performance when vermicast was used as a soil supplement and to identify which of the treatments would improve soil attributes under CSU-Piat conditions.

Material and methods

The general objective of the study is to evaluate the agronomic characteristic and yield performance of Tomato (*Lycopersicum esculentum* L.) using vermicast as soil amendment under CSU-Piat condition.

Specifically, the study aimed to:

1. Determine the agronomic characteristics of tomato applied with vermicast as soil amendment;
2. Determine the fruit quality of tomato as affected by the application of vermicast as soil amendments;
3. Determine the yield performance of tomato applied with vermicast as soil amendments;
4. Determine the effects of vermicast as soil amendment; and
5. Determine the cost of production.

Research Design

The experiment was laid out in a 500m² area divided into five treatments with 3 blocks following the Randomized Complete Block (RCBD) design. Each block was subdivided into equal plots measuring 5m x 4m each for the treatments. The study was conducted at the Nature Farm of Cagayan State University, Piat Campus from February 6, 2019 to June 24 2020 with an alleyway of one (1) meter between blocks and 0.5 meter between plots were provided. The treatments are as follows:

Treatment	Description	Rate per Plot
Treatment 1	Control	(Recommended Rate) RR
Treatment 2	Full Vermicast	2.5Kg/plot or 10 bags/ha
Treatment 3	½ RR + Vermicast	0.5Kg/plot + 2.5Kg/plot
Treatment 4	¾ RR + Vermicast	0.75Kg/plot+ 2.5Kg/plot
Treatment 5	FULL RR + Vermicast	1Kg/plot + 2.5Kg/plot

Materials and Procedure

The following materials were used in the study: tomato seeds variety diamante, organic fertilizer (Vermicast), soil, measuring device, weighing scale, bamboo sticks, placards, sprayer, straw lace, blender, and record notebook.

Soil Analysis

Soil samples were randomly collected from the experimental area with the use of shovel. Samples were collected at 10 strategic sites at a depth of 15 cm.

Collected soil samples were air dried, pulverized, mixed thoroughly and then a composite sample of approximately one (1)Kg was submitted to the Cagayan Valley Integrated Agricultural Laboratory (*CVIAL*) at Carig, Tuguegarao City, Cagayan for analysis. The result was used as basis for the fertilizer treatment formulation of the study.

Cultural Management

The different cultural management practices were based from the Tomato Production Guide in Region 2 (2017) were as follows:

Land Preparation

The experimental area was thoroughly prepared by plowing with the use of 4-wheel tractor. Disk harrowing was done twice at one week interval to kill weeds and for good soil tilth.

Transplanting

To minimize transpiration and transplanting shock of the seedlings, transplanting was done late in the afternoon to avoid immediate exposure of seedlings to intense sunlight. Planting distance was 75x50cm at one seedling per hill.

Irrigation

Since tomato is very sensitive to flooding, irrigation was done only when need arises i.e. just to moisten the root zone from transplanting up to the last harvest. This was done early in the morning and late in the afternoon. To avoid bias, each plant was applied with one (1) litter of water per hill for every irrigation schedule. According to Shuttleworth (2015), descriptive research design is a scientific method which involves observing and describing the behavior of a subject without influencing it in any way.

Mulching

Rice hulls were collected from Tuao, Cagayan. Four (4) sacks of rice hulls were scattered around the base of the plant to minimize soil moisture and prevent weed growth.

Trellising or Staking

Tomatoes were provided with trellis or pole with a height of one meter for upward growth support 15 days after transplanting (DAT) using locally available materials like nylon string and poles. This was done by tying the main branch of the plants to the stakes or poles to keep them in place. The tie was not tight enough so as not to hamper translocation of food nutrient of plants.

Weeding

Weeding was done by physical/manual method i.e. uprooting the weeds as they emerged to prevent the possible niche of insect pests.

Application of Fertilizer

Holes were made at a distance of 75x50 cm at 6 cm depth and 10 cm wide. The rate of fertilizer application was based from the result of the soil analysis conducted at the CVIAL Soils Laboratory (Appendix Table). The computed amount of inorganic and organic fertilizer per treatment was divided equally by the number of hills. Furthermore, vermicast as organic fertilizer was applied 7 days before transplanting.

Harvesting

Harvesting were done when first bloom of red color appears on the skin of the tomato fruit, this was grasped firmly by holding the stem with one hand and the fruit with the other. This was done from 4^{th} to 12 weeks.

Data Gathered

The data gathered in this study were categorized into agronomic characteristic and yield performance. Both parameters are considered as the variable factors in this experiment. Data collected were as follows:

Number of Days to Flowering

This was gathered by counting the number of day**s** from transplanting to until 50% of the plants have already produced flowers.

Height at Maturity (cm)

The plant height was taken by measuring the sample plants from the base up to tip of the apical branch at 7 days after transplanting (DAT), 30 DAT, 60 DAT.

Number of Fruits Per Plant

A cumulative count was used from the first priming to last priming.

Weight of Fruit

The weights of fruits were gathered by weighing all the harvested fruits per plant and by dividing to the total number of fruits.

Soil Quality after Application of VC

This was done by collecting soil samples before and after of the study and submitted to the Cagayan Valley Integrated Agricultural Laboratory (CVIAL) to determine the nutrient composition of NPK. Descriptive research design is also a valid method for researching specific subjects and as a precursor to more quantitative studies.

Moreover, this study is correlational in nature for it sought to determine the associating factors for teachers' productivity level. In view of the above mentioned statement, this study used the descriptive-correlational research design.

The descriptive parts of the study were the inputs gathered from the answered survey questionnaires of the respondents particularly on their happiness index and the personality attributes test. Meanwhile, the correlational part of this study was on the identification of significant associations between the independent and dependent variables of the study.

Approximate Nutrient Analysis of Tomato

Fruit samples were submitted to the Cagayan Valley Integrated Agricultural Laboratory (CVIAL) to determine the following: Crude Protein (%), Crude Fat (%), Crude Fiber (%), Moisture (%) and Ash (%).

Computed Fruit Yield (tons/ha)

This was taken by getting the cumulative weights of the yield (kg/harvest area) obtained from the different primings per harvest area per plot. The yield from the harvest area was projected to tons per hectare using the formula;

Actual weight x 10,000 / Harvest area = Yield per Hectare

$$\frac{\text{Actual Weight (10,000)}}{\text{Harvest Area}}$$

Cost and Return Analysis

This was done by subtracting the costs of the inputs from the gross sales of harvested fruits.

Data Analysis

The data obtained from this experiment were subjected to the Statistical Tools for Agriculture Research (STAR) and Microsoft excel using the analysis of variance (ANOVA) with 5% and 1% level of significance. This means that making the correct decision in the analysis is 95% and 99% whether there is a significant difference or no significant difference between treatments.

Results and discussion

Number of Days to 50% Flowering

The flower of the crops is an indicator of growth of plants thus number of percentage of flowering encourages more production. The plants started to bear flowers at 35 days after transplanting and achieved fifty percent flowering at 55 days after transplanting. However no significant difference was observed among treatments tested based on the analysis of variance on the number of days to 50% flowering.

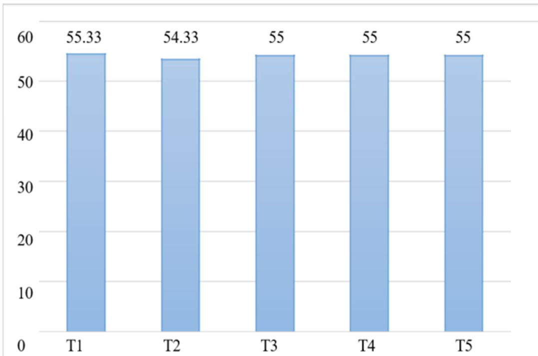

Fig. 1. Number of Days to 50% Fowering.

Plant Height at 7, 30 and 60 Days after Transplanting

Table 1 shows the result of plant height observed at 7, 30 and 60 days, as gleaned in the table at 7 DAT, T2 and T3 obtained highest plant height with an mean of 24.73cm and 24.37cm, this was followed by T5, T4, and T1 with a means result of 22.77cm, 21.70cm, and 20.97cm respectively, analysis of variance shows no significant differences among the treatments after 7DAT.

At 30 DAT, plants applied with 90-0-0Kg N ha^{-1} + 10 bags Vermicompost ha^{-1} (T5), 68-0-0Kg N ha^{-1} + 10 bags Vermicompost ha^{-1} (T4) and 45-0-0Kg N ha^{-1} + 10 bags Vermicompost ha^{-1} (T3), 10 bags Vermicast ha^{-1} (T2) obtained the tallest plants height with mean values of 50.01cm, 49.90cm 48.8cm, and 47.25cm respectively shortest plant height was obtained to 90-0-0Kg N ha^{-1} (T1) with a mean of 44.66 centimeters.

Comparison among treatments mean there were significant differences among the treatments applied in tomato, as shown in the table, T3, T4, and T5 are comparable to each other but significantly difference with treatment 1. This means that application of vermicast in combination of inorganic fertilizer boost growth of tomato under CSU Piat condition.

On the 60 DAT, Treatment 5 (90-0-0Kg N ha^{-1} + 10 bags Vermicompost ha^{-1}) obtained the highest plant height with a mean of 97.96cm, followed by 68-0-0Kg N ha^{-1} + 10 bags Vermicompost ha^{-1} (T4), 90-0-0Kg N ha^{-1} (T1) and 45-0-0Kg N ha^{-1} + 10 bags Vermicompost ha^{-1} (T3) with a mean averages of 97.74cm, 90.30cm, and 90.17 respectively. 10 bags Vermicast ha^{-1} (T2) garnered the lowest mean in term of plant height at 60 DAT.

Based on the study it was observed that the application of (90-0-0Kg N ha^{-1} + 10 bags Vermicompost ha^{-1}) or Treatment 5, contributes significant result in terms of height of the test plants from 7, 30, and 60 DAT.

The above results were in support to the findings of Rakesh and Adarsh (2010) that addition of vermicompost to inorganic fertilizer has 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 1. Plant Height at 7, 30 and 60 Days After Transplanting Applied with Vermicast as Soil Amendment under CSU-Piat Condition.

Treatments	Plant Height (cm)		
	7 DAT	30 DAT	60 DAT
T_1– 90-0-0Kg N ha^{-1}	20.97	44.66^{b}	90.30^{b}
T_2– 10 bags Vermicast	24.73	47.25^{ab}	80.87^{c}
T_3– 45-0-0Kg N ha^{-1} + 10 bags Vermicast ha^{-1}	24.37	48.81^{a}	90.17^{b}
T_4– 68-0-0Kg N ha^{-1} + 10 bags Vermicast ha^{-1}	21.70	49.90^{a}	97.74^{a}
T_5– 90-0-0Kg N ha^{-1} + 10 bags Vermicast	22.77	50.01^{a}	97.96^{a}

*Means with the same letter are not significantly different

The approximate Nutrient Analysis of Tomato

Tomatoes have an excellent source of nutrients to suffice body ailments and part of balanced diet (Li and Xu, 2014; Pouchieu *et al.*, 2014). This study, chemical composition of fruit samples were analyzed which includes the crude protein, crude fiber, crude fats, moisture and ash (Table 2) as affected by vermicast as soil amendments in combination to Inorganic fertilizer under CSU-Piat condition, data obtained that T1 – 90-0-0Kg N ha^{-1} garnered the highest percentage of the physico-chemical characteristics of the fruit in terms of Crude protein (4.15%), Crude Fiber (2.94%), Crude Fat (0.67), and Ash (1.85%) except on the Moisture content with a percentage of 3.55%. These results is accordance to Gonzales *et al.* 2011, that tomato peel has higher amounts of protein, lipid and lower content of ash when nutritional requirements are present or introduced well in the soil. It is clearly stated in the table that the nutritive values of tomato is differ from the different application of treatments. On the other hand as gleaned in the table, 45-0-0Kg N ha^{-1} + 10 bags Vermicast (T3), obtained the lowest percentage on the physico-chemical analyses of the fruit in terms of Crude protein (1.21%), Crude Fat (0.20%), Moisture (3.20% and Ash (0.70%) except on the Crude Fiber with a percentage of 1.49%. Study observed that decreasing amount of the recommended rate of application decreases the physio chemical quality of the test plant. Moreover, rainfall and water supply during the maturation stage of tomato is a limiting factor for fruits. The moisture content was observed in the application of, 90-0-0Kg N ha^{-1} + 10 bags

Vermicast (T5), 68-0-0Kg N ha-¹ + 10 bags Vermicast (T4), and 10 bags Vermicast ha⁻¹ with a means average of 5.00%, 4.25% and 4.05%. This indicates that the vermicasts is a good factor for retention or water holding capacity which is beneficial needs of the crops, Karthikeyan *et al* (2014).

Table 2. Nutrient Analysis of Tomato as Affected by Vermicast as Soil Amendments.

Treatments	Crude Protein%	Crude Fiber%	Crude Fat %	Moisture %	Ash%
T1-90-0-0Kg N ha⁻¹	4.15	2.94	0.67	3.55	1.85
T2 – 10 bags Vermicast ha⁻¹	1.73	1.29	0.27	4.05	0.74
T3 – 45-0-0Kg N ha- + 10 bags Vermicast	1.21	1.49	0.20	3.20	0.70
T4 – 68-0-0Kg N ha-1 + 10 bags Vermicast	1.21	1.5	0.21	4.25	0.76
T5 – 90-0-0Kg N ha-1 + 10 bags Vermicast	1.56	1.13	0.28	5.00	0.79

Number of Fruits/Plant

Figure 4 shows the number of fruits/plants as affected by the application of vermicast as soil amendments. Results revealed that T5 (90-0-0Kg N ha-¹ + 10 bags Vermicast ha-¹) produced the most number of fruits per hill with a mean of 27.0, closely followed by T4 (68-0-0Kg N ha-¹ + 10 bags Vermicast ha-¹), T3 (45-0-0Kg N ha-¹ + 10 bags Vermicast ha-¹), T1 (90-0-0Kg N ha-¹) and T2 (10 bags Vermicast ha-¹) with a mean of 23, 20, 18 and 12, in the same order.

Analysis of variance revealed highly significant difference among treatments. On comparison among means, when T5 compared to T4 no significant difference exist but when T5 was compared to T3, T2 and T1 significant difference was observed. 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. Organic sources offer more balanced nutrition to the plants, especially micro nutrients which positively affect number of fruits in plants (Miller, 2007).

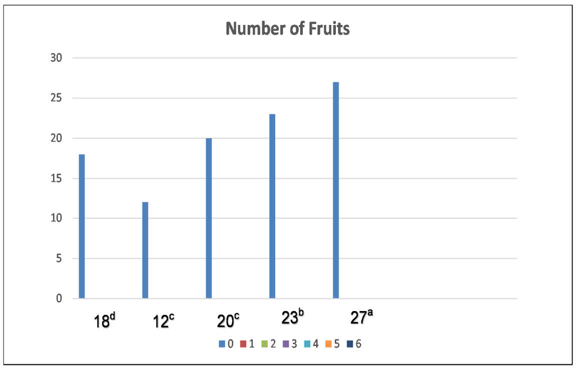

Fig. 4. Number of Fruits as Affected by the Application of Vermicast as Soil Amendments.

Weight of Fruits/Plant

The weight of fruits per plant as affected by the application of vermicast as amendments was reflected in Figure 5. Significant result was observed on the weight of fruits per plant wherein the application of 90-0-0Kg N ha⁻¹ + 10 bags vermicast ha⁻¹ (T5) obtained the heaviest fruits with 1050 grams. It was followed by 68-0-0Kg N ha⁻¹ + 10 bags vermicast ha-¹ (T4) and 45 -0-0Kg N ha⁻¹ (T3) with 734 and 587 grams. The lightest was obtained by pure vermicompost (T2) and Control (T1) with 261.67and 188.33 grams. This implies that crops are given better nutrition which might increase the weight of fruits of tomato. This means that 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 emended soil (Muscolo *et al.*, 2009). Using phytohormone bioassays, compounds with gibberellin, cytokinin and auxin-like activity have been detected in vermicompost urban and sewage waste (Canellas *et al.*, 2002).

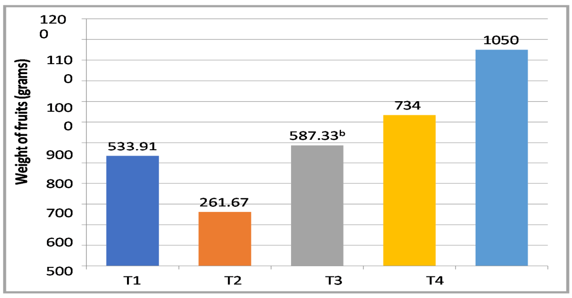

Fig. 2. Weight of Fruits (grams) as Affected by the Application of Vermicast as Soil Amendment.

Computed Yield (tons/ha)

Table 3 shows the computed yield (tons/ha) as affected by the application of vermicast as soil amendments. Result further shows T5 (90-0-0Kg N ha-1 + 10 bags Vermicast ha^{-1}) produced the highest yield of 4.58 tons ha^{-1} followed by T4 (68-0-0Kg N ha^{-1} + 10 bags Vermicast ha^{-1}), T1 (90-0-0Kg N ha^{-1}), T3 (45-0-0Kg N ha^{-1} + 10 bags Vermicast ha^{-1}), with a mean yield of 3.74 tons ha^{-1}, 3.71 tons ha^{-1}., and 3.09 tons ha^{-1}. T2 (10 bags Vermicast ha^{-1}) had the lowest yield of 1.63 tons ha^{-1}. Statistical analysis reveals highly significant difference among treatments tested. In the comparison among treatment means, results revealed that when T1 compared with the different treatments significant difference was observed.

This means that applying vermicast in tomato obtained positive impact on the yield of tomato. This result is in conformity with the study of Satyanarayana *et al.* (2002) found significant increase in rice yield due to the application of inorganic fertilizers. Combined application of different doses of vermicast and inorganic fertilizer has significant effect on grain yield of rice. The yield advantages due to integration of organic sources and inorganic fertilizers over chemical fertilizers alone might be due to the availability of nutrients for a shorter period as mineralization of nitrogen is more rapid and in turn the losses of inorganic nitrogen due to volatilization, denitrification and leaching etc., would be more. Sarwar *et al.* (2008); Ali *et al.* (2012) also claimed increased yields of rice with the use of vermicast or in combination with chemical fertilizers.

Table 2. Computed Yield (tons/ha) as Affected by the Application of Vermicast as Soil Amendment.

Treatment	Mean
T1-90-0-0Kg N ha-1	3.71 b
T2-10 bags vermicast/ha	1.63c
T3-45-0-0Kg N/ha + 2.5 bags vermicast/ha	3.09b
T4-68-0-0Kg N/ha+2.5 bags vermicast/ha	3.74b
T5-90-0-0Kg N/ha+2.5 bags vermicast/ha	4.58a

*Means with the same letter are not significantly different.

The Effects of Vermicast as Soil Amendments

Soil Ph

It is used to measure the soil acidity or alkalinity and important indicator of soil health that affects the growth and yield of crops (USDA). Table 4. presents the pH val ue before and after harvest. The results of soil pH is arranged in descending order: Before soil was tested soil pH had 6.52, T4 with the application of 68-00 N/ha + 10 bags vermicast/ha (5.77), T3 with 90-0-0Kg N ha^{-1} + 10 bags Vermicast (5.7), T2 with pure vermicast (5.55), and T5 90-0-0Kg N ha^{-1} + 10 bags Vermicast (5.25). Results show that the soil pH has decrease when recommended rate and vermicast were applied which ranges from 6.52 to 5.06. This results might be the effects of applying inorganic fertilizer. This results is in consonant to the explanations of Liu *et al.* 2020, first and subsequently application of urea may converted into ammonium or ammonia in the soil which decrease the pH value and it is either be ammonium can decrease soil pH by completing the exchange sites of the soil solid phases with base cations.

Available Nitrogen/Organic matter

The initial total nitrogen from the soil sample gathered in the Cagayan State University Nature Farm experimental area is 0.72. It is clearly shows in the result that vermicast alone and in combination with the inorganic fertilizer which obtained the highest available nitrogen after application. Treatment 5 and treatment 1 got the same percentage of 1.03, with the application of 90-0-0Kg N/ha + 10 bags of vermicast/ha, respectively. The application of full vermicast, 45 -0-0Kg N ha^{-1} (T3) and 68-0-0Kg N ha^{-1} + 10 bags vermicast ha^{-1} (T4) resulted with the same results of 0. 93.

This result supports the claimed of Ofori *et al.* (2017) which reported that the combined application of compost and urea fertilizer increased grain yield and also improved significantly the chemical properties of the soil. Moreover, the effectiveness of the organic matter is less available during the production period which will occurs for the succeeding harvest. Moreover, nitrogen is essential in the formation of protein, makes up much the tissues of most living things. Nitrogen plays a pivotal role in some soils, environments and plant species (Nasholm *et al.*, 2009; Tegeder & Rentsch, 2010; Bloom, 2015) as cited by Tegeder *et al.,* 2017.

Available Phosphorus

In terms of the availability of Phosphorus, as seen the table it was observed that before the application of the different treatments result shown that the soil contain 136ppm of phosphorus content, which contrast to the result when application were done. In the study it was observed that after application of all the treatments, phosphorus content eventually decreases from ranging from 12.30ppm to 5.8ppm.

Reason to this, phosphorus exhibit on the +3 and +5 oxidation states, but cannot form in pH 5 as seen on the result of the study which pH ranges from 5.6 to 5.77, because of high ΔH–H and slightly negative e.g. H (electron gain enthalpy), dihydrogen acts only as a weak oxidising agent. Thus it can oxidise P to +3 oxidation state but not to its highest oxidation state of +5. Hence P forms pH3 and not pH5, Subhash sahu, (2018). Moreover, some reason on the depletion of the amount of phosphorus is caused by the application of the inorganic fertilizer.

This result of the study complements the results of Gaskell *et al.* (2007) that concentration of nitrogen fertilizer is increasing in soil gradually and migrates towards higher depth of leaching which may contaminate the soil as well as groundwater. The assimilation of excessive amount nitrogen by the plant does not completely assimilated for growth.

Available Potassium

The available potassium in the soil before the experiment is 136.1ppm which marked as advantageous. After 70 days of treatment application, applied 90-0-0Kg N ha^{-1} + 10 bags Vermicast of T3 (153ppm) has the highest total amount of potassium wherein an increase of 16.9 was noted.

This findings was in favored to Rioba *et al.* 2020, stated that the importance of Urea, VC, and Tithonia as potential sources of K for Swiss chard production. However, T4 and T5, decreased slightly into 25. 1 with the application of 68- 0-0Kg N ha^{-1} + 10 bags Vermicompost ha^{-1} of 111 ppm, followed with the application of full Recommended Rated and 10 bags of vermicast ha^{-1} that decreased about 36.1 with 100 ppm and the lowest was observed in the soil applied with full vermicast of T2 with 68 ppm. The depletion of the potassium of T4, T5, and T2 findings might be the source of parent material and the degree of weathering. As the Climatic Data during the conduct of the study.

The data on weather parameters such as rainfall (mm), mean temperature (°C) as well as relative humidity (%) during the conduct of the study were collected from the AgroMet Gaging Station of Cagayan State University, Piat, Cagayan and were presented in Appendices G that Rainfall occurrences were observed on the 5th week, 8th week and 9th with rainfall depths of 19.76, 9.28, 28.78 and 0.25 mm, respectively.

Minimal fluctuations were observed on the temperature which ranged from 24.81°C to 30.23°C. The relative humidity ranged from 65% to 78.43%. Although rainfall occurred during the latter part of the growing period of the tomato crop the relative humidity was lower than those in the early part of the growing period due to the hotter environment as indicated by the higher temperatures.

Table 4. Effect of Vermicast on Soil Analysis Before and After Application.

Soil Parameter	Before Application	After Application				
		T1	T2	T3	T4	T5
pH	6.52	5.06	5.55	5.7	5.77	5.25
Organic Material (N)	0.72	1.03	0.93	0.93	0.93	1.03
Phosphorous, ppm	136.10	7.6	6.10	10.00	5.8	12.30
Potassium, ppm	140	142	68	153	111	100

Cost and Return Analysis

Table 3 shows the marginal cost and return analysis of tomato production as affected by vermicast as soil amendments. The return on investment in every treatment is arranged in descending order: T5 had 54.35 percent, T4 had 54.32 percent, T1 had 53.38, T3 had 46.94 percent, T2 had 22.86 percent. The significant results may be due to application of organic fertilizer combined with inorganic fertilizer this may affect the total cost of production.

Table 3. Marginal Cost and Return Analysis of Tomato Production as Affected by Vermicast.

Treatments	Total Cost of Production	Gross Income (PhP)	Net Income (Php)	ROI (%)
T1 – 90-0-0Kg N ha $^{-1}$	51891.00	111300	594909.00	53.38
T2 – 10 bags Vermicast ha – ^{1}	37723.00	48900	11177.00	22.86
T3 – 45-0-0Kg N ha -1 + 10 bags Vermicast	49789.00	92700	43511.00	49.64
T4 – 68-0-0Kg ha -1 + 10 bags Vermicast	51254.00	112200	60946.00	54.32
T5 – 90-0-0Kg ha -1 + 10 bags Vermicast	62718.00	137400.00	682.00	54.35

Conclusion

Based on the derived conclusion, the researcher recommended the following:

1. Application of combined 90-0-0Kg N ha-1 and 10 bags of vermicast contributes significant impact on the growth and development of the test plant and improved its agronomic characteristics;
2. Improved quality of the physic-chemical properties of tomato in terms of crude fiber, crude protein etc;
3. Application of T5 – 90-0-0Kg N ha^{-1} + 10 bags Vermicast ha^{-1}obtained the highest yield performance and shown highest return of investment;
4. Application of 10 bags of vermicast per hectare is a good benefactor by decreasing the ph level of the soil; and
5. T5 – 90-0-0Kg N ha^{-1} + 10 bags Vermicast ha^{-1} improved soil quality which increase soil biodiversity by the increasing organic matter applied (vermicast).

Recommendation(S)

Based on the generated conclusions, the researcher arrived with the following recommendations:

1. Vermicast have adequate total amount of macronutrient concentration which is highly recommended to use in tomato production.
2. Theapplication of vermicast and 90-0-0Kg N ha^{-1} will be enough to fertilize the tomato under CSU-Piat condition because it obtained the highest ROI with 37.95%.
3. A similar study should be conducted specifically on the highest amount of vermicast added to RR to determine the level of peak of production and income of tomato plants.
4. A similar study should be conducted using different organic fertilizers with different formulations to further determine and compare their effects on fruit quality particularly the sugar content.

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