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YIELD AND QUALITY OF TOMATO FROM ORGANIC FERTILIZATION SYSTEMS IN THE PHILIPPINES

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Abstract — The effects of vermicompost and different organic concoctions on the yield and quality of tomatoes, determining the quality of tomato fruits in terms of ascorbic acid and beta-carotene contents as influenced by different organic fertilization systems was evaluated at Escuala, Casiguran, Sorsogon, Philippines (July- November 2017). The Randomized Complete Block Design (RCBD) was used with 15 treatments replicated thrice. Treatment was as follows: T1 - Farmer's practice (control); and T2 to T15 vermicompost (VC) as basal fertilizer. Results for the yield include the number of fruits, the weight of fruits/ plant, number of marketable fruits/plant, the weight of marketable fruits/plant, and number of non-marketable fruits/plant. Analysis of ascorbic acid and beta-carotene determined the quality of fruits. For each treatment, 100g samples of marketable tomato fruits at the 1st harvest were brought to the College of Agriculture, Food Science Cluster, University of the Philippines for ascorbic acid and beta-carotene content analyses. T1-Farmer's practice (Synthetic fertilizer) was significantly the same as T2-Vermicompost (Organic basal fertilizer) on different parameters of fruit yield. Among the different treatments, T14 (VC+IMO+FAA+CalPhos) yielded the highest number and weight of fruits per plant, number and weight of marketable fruits per plant, and fruits tons/hectare. T14 was similar with T13 (VC+IMO+FAA+FFJ) and T15 (VC+IMO+FFJ+CalPhos) significantly similar with T1 on the numbers of fruits per plant; and significantly different in almost all the other factors in the yield of tomato fruits. Organic fertilizer at T15 had the highest beta-carotene content in tomato fruits (47.80 mg/100g), followed by T2 (24.19 mg/100g), and T14 (19.56 mg/100g).

Keywords **— Ascorbic acid, beta-carotene, fruit yield, organic fertilization, tomato**

INTRODUCTION

Tomato (*Solanum lycopersicum* L.; *Lycopersicon esculentum* Miller*)* locally known as "kamatis" in the Philippines, is an edible, red berry-type fruit of the Nightshade family. It is the second most important vegetable crop next to potato (http://www.growtomatoes.com/tomato-world-production-statistics). In 2020, the top ten countries that processed tomatoes more than 83% of the quantities processed worldwide are California, China, Italy, Spain, Turkey, Iran, Portugal, Brazil, and Algeria (first time), and Tunisia (Branthome, 2020).

In the Philippines, the production of tomatoes for the period of January to March of 2019 reached 95.30 thousand metric tons, up by 3.9 percent from its 2018 level of 91.69 thousand metric tons. Ilocos Region, the major producer of tomatoes had 42.58 thousand metric tons or 44.7 percent of the total production this quarter. The other major producing regions were Central Luzon with 22.8 percent and CALABARZON, 8.9 percent (Bureau of Statistics Authority, 2019).

Tomato is a low-calorie vegetable equivalent to 18 calories per 100 g and it is an excellent source of antioxidants, dietary fiber, minerals, and vitamins. It is a good source of antioxidant vitamin C (providing 21 % of recommended daily levels per 100 g). Consumption of foods rich in Vitamin C helps the body develop resistance against infections agents and scavengers of harmful free radicals. It is also very rich in potassium (100 grams contain 237 mg of potassium and 5 mg of sodium). Potassium is an important component of cell and body fluids that helps control heart rate and blood pressure. It also carries an average level of B-complex vitamins such as folates, thiamin, niacin, riboflavin, and some essential minerals like iron, calcium, manganese, and other trace elements (Rudrappa, 2017). Worldwide, there are 51 million hectares of certified organic agriculture land and 39 million hectares of wild culture land. In the last two decades, organic agriculture has been growing at 11.9% per annum, thereby doubling the size of the sector every six years (Paul, 2017). In the Philippines, organic agriculture has progressed tremendously as seen in the government's proactive initiatives and policies; research activities of state universities, and inclusion of organic agriculture subjects in the curriculum of colleges (Alleje and de Villa, 2014).

Organic farming lessens the use of synthetic fertilizers and restores the fertility of the soil for sustainable agriculture. Microorganisms are found to be useful and potent in eliminating problems associated with the use of chemical fertilizers and pesticides. Effective Microorganism (EM) technology helps farmers develop economically viable farming systems, and environmentally and socially acceptable. It contains mixed microorganism species that are mostly populations of lactic acid bacteria and yeast, photosynthetic bacteria, actinomycetes, and other types of bacteria (Borhan, 2011).

Vermicompost is an excellent soil amendment and bio-control agent which makes it the best organic fertilizer and more eco-friendly as compared to chemical fertilizers (Joshi et al, 2014).

Tomato is one of the high valued crops in the Philippines. Growing tomatoes using organic fertilization systems will lessen the use of synthetic fertilizers and that could improve the quality of tomato fruits, not just quantity. The study was conducted to evaluate the effects of vermicompost and different organic concoctions on the yield and quality of tomatoes.

The study aimed to assess the effect of different organic fertilization systems on the yield of tomatoes; and determine the quality of tomato fruits in

terms of ascorbic acid and beta-carotene contents as influenced by different organic fertilization systems.

This study is significant to researchers, students, and tomato planters. It contributes to the local studies on using organic fertilizers, especially the use of organic concoctions and the use of Indigenous Microorganisms. It also recommends local studies focusing not only on the increase in the yield of tomatoes but also on the fruit content in terms of ascorbic acid and beta-carotene. This would give insights into the production of organic tomato through the application of a different combination of IMO, FAA, FPJ, FFJ, and CalPhos as organic fertilizer. The study focused only on the yield and fruit quality of organically grown tomatoes using different fertilization systems. Vermicompost was used as basal fertilizers. It also used different organic foliar sprays such as IMO, FAA, FFJ, CalPhos, and FPJ.

MATERIALS AND METHODS

Site Description

The research was conducted from July 2017 to November 2017 at Escuala, Casiguran, Sorsogon. Casiguran is a 4th class municipality in Sorsogon Province, Philippines, at the south of Luzon island with coordinates of 12^0 83'N, 124^o 05'E. It belongs to Type 2 climate based on the Climate Map of the Philippines by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA).

Being Type 2, Sorsogon has no pronounced dry season with pronounced rainfall from November to January. July-November average high temperature is 33^0C and the average low temperature is 25 ^{0}C. The average relative humidity is 45% - 90%. Soil Moisture is dry; the probability of rain is 50-90^{0}C. The type of soil present in Casiguran, Sorsogon is loam. The area was previously planted to bittergourd.

Soil Sampling and Analysis

Collection of the soil before planting was done by random sampling of ten soil samples in the entire planting area. The samples were mixed and air-dried. Analysis of soil sample for nitrogen (N), phosphorus (P), potassium (K), organic matter, and pH was done at the Soil Science Laboratory, University of the Philippines Los Baños. Soil analysis was done to characterize the nutrient status of the field. The amount of fertilizer applied was dependent on the result of soil analysis. Based on the result of the analysis, the soil has pH (5.1), a very high amount of OM (6.63%), a low amount of N (0.36 %), a medium amount of P (11 ppm), and a high amount of K (0.93 cmol/kg soil). The fertilizer recommendation on a hectare basis was applied to T1 (Farmer's practice) as follows: Basal fertilizer of three bags 14:14:14 + 1 bag of urea during transplanting; Side dress one month after transplant. One bag 0-0-60 + two bags urea; Top dress two months after transplanting per two bags of 0-0-60.

Test Crop

The variety of tomatoes used was Diamante Max F1. The seeds used in this study were procured from East-West, Philippines. It is a hybrid that is most suitable for cultivation in tropical lowlands. It displays strong vigor and wide adaptability to different growing conditions. It is resistant to bacterial wilt and heat tolerant variety (www.lazada.com.ph/east-west-seed-diamante-max-f1-tomato-kamatis-seed-11443496).

Experimental Design and Treatments

Randomized Complete Block Design (RCBD) was used. The treatments consisted of three replicates of the fifteen treatment plots. T1 was the Farmer's practice (control) and T2 to T15 were treated with vermicompost

(VC) as basal fertilizer. T3 to T15 had additional treatment of different organic concoctions as foliar spray: T2- Vermicompost (VC); T3-VC + Indigenous Microorganisms(IMO); T4- VC + Fermented Plant Juice(FPJ); T5-VC+ Fish Amino Acid (FAA) ; T6- VC + Fermented Fruit Juice (FFJ); T7-VC + Calcium Phosphate (Cal Phos); T8-VC + IMO + FPJ;T9- VC+ IMO+ FAA; T10-VC+ IMO+ FFJ); T11- VC+ IMO+ CalPhos; T12- VC+ IMO + FPJ + FFJ; T13- VC + IMO + FAA + FFJ; T14-VC +IMO+FAA+CalPhoS; T15- VC + IMO + FFJ + CalPhos.

Statistical Analysis

Analysis of Variance was employed to determine the statistical significance of the treatments. LSD test was used to determine the difference between treatment means.

Cultural Management Practices

Preparation of Seedlings. Seeds were sown in previously prepared seedbeds (30 cm high, 1 m wide, and 10 m long). Vermicompost was added to the soil at the rate of 500 grams per square meter. A plastic roof was placed over the seedbed to protect the seedlings from heavy rains. Small furrows were set across the bed, 2-4 cm deep, and 15 cm between furrows. The seeds were sown a distance of about 2.5 cm (1 inch) along the furrows then covered with a thin layer of compost. The seedbed was covered with rice straw mulch. The mulch was removed after 4-5 days upon the emergence of seedlings.

Land Preparation. The soil was plowed and harrowed twice. Furrows were set at a distance of 75 cm.

Laying Out. The total experimental area was 1,377.87 m2 (37.75 m x 36.5 m). Plots were laid out following the treatments. The plot size was 6.75 x 3.5 meters. Distance between plots was 0.5 meters while the distance between replicates was 1 meter.

Transplanting. Healthy and uniform seedlings with 3-5 leaves each were selected. Transplanting was done four weeks after sowing at a distance of 50 cm between hills and 75 cm between rows. After transplanting, the soil was pressed gently around the base of the seedlings. It was watered before and immediately after transplanting. Replanting missing hills was done 5 days after transplanting.

Fertilization. Application of vermicompost and organic concoctions was done based on the treatments. Vermicompost analysis was as follows: N (1.44%), P (5.28 ppm), and K (0.06%). Recommended vermicompost was 5,555.55 ton/ha. For organic treatment from T2 to T15 vermicompost was placed 208 grams/plant as basal fertilizer during transplanting. The different organic concoctions were applied on a weekly interval at the rate of 2.0 tbsp/liter of water.

Pest Control. The experimental area was surrounded by lemongrass to protect from insect pests. Also, Oriental Herbal Nutrient (OHN) was applied at a two weeks interval at the rate of 2.0 tbsp/liter of water.

Weeding and Watering. Both weeding and watering were done as necessary.

Trellising. A-Type bamboo trellis was placed one week before transplanting to support the stems of the plants.

Harvesting. Harvest started after 60 days from transplanting. Fruits were harvested at the breaker stage early in the morning. Harvested fruits were placed in crates lined with banana leaves or used newspapers to prevent mechanical damage to the fruits. Harvesting was done once only due to the limited fruits because of frequent rains and typhoons (PCAARRD Information Bulletin NO. 55/2015).

Data Gathered

Data were obtained from the fifteen sample plants that were used per treatment per replicate.

Yield Parameters

The number of fruits/plant – Total number of fruit per plant was counted manually.

Weight of fruits/plant (kg/plant) - Total weight of fruits per plant was measured using Metler top loading balance.

The number of marketable fruits/plant - Fruits with no damage were considered marketable and were counted.

Weight of marketable fruits/plant (kg/plant) - Fruits considered marketable were weighed.

The number of non-marketable fruits/plants - Defective fruits, which were damaged and considered non-marketable, were counted.

Weight of non-marketable fruits/plant (kg/plant) - All damaged fruits were weighed by using Metler's top-loading balance.

Quality of Fruits

Ascorbic acid - Samples (100 g) and beta-carotene content – Samples (100 g) of marketable tomato fruits and from the 1st harvest were brought to the College of Agriculture, Food Science Cluster, Food Chemistry Laboratory, University of the Philippines, Los Baños.

RESULTS AND DISCUSSION

Yield Parameters

Number and Weight of Fruits/plant (kg). Fruit yield of tomatoes at different fertilization systems had significant differences in the number and weight of fruits per plant (Table 1) per plant. The T1-Farmer's Practice (synthetic fertilizer) significantly had the same number of tomato fruits with T2-Verrmicompost (Organic basal fertilizer) and with almost all of the other treatments with organic concoctions as foliar spray like T13, T5, T7-T15. The least number of fruits that were significantly lower than T1 were obtained from T4, T6, and T12.

The treatment with the highest weight of fruits per plant was at T14 (0.58), significantly the same with T13 (0.52), but statistically different with T1 (041) and other organic treatments from T2-T11 and T15. T1-Farmer's Practice (Synthetic fertilizer), T2 -vermicompost) and other treatments with foliar spray (T5 and T7-T11) were significantly similar in terms of the weight of fruits per plant and other treatments. The weights of fruits that were significantly lower than T1 were from T4, T6, and T12.

The number of fruits per plant in treatments with vermicompost and applied with organic concoctions spray was significantly the same with the farmer's practice using synthetic fertilizers. In terms of the weight of tomatoes per plant, it was observed that treatments with a combination of vermicompost, IMO, FFJ, and FAA and treatments with vermicompost, IMO, FFJ, CalPhos were significantly heavier than the treatment using Farmer's practice (synthetic fertilizer). Organic concoction mixtures of vermicompost + FFJ; vermicompost + FPJ; and vermicompost + IMO + FPJ + FFJ showed a significantly lower number and weight of fruits per plant compared with T1 (Farmer's practice).

Findings of this study are similar to the study of Joshi et al (2014) which said that vermicompost is ideal organic manure for better growth and yield of many plants.

Joshi and Vig (2010) found out that in using cattle dung vermicompost (VC), germination percentage was maximum at VC15 (soil + 15% VC). Almost all growth, yield, and quality

parameters increased significantly as compared to control; though the increase within the treatments was found not significant in number and heaviest weight of marketable fruits.

Average Number and Weight of Marketable fruits/plant. The number of marketable fruits among different fertilization systems had significant differences (Table 1). Specifically, T14 (15) with the highest number of tomato fruits per plant, was significantly different from the following treatments: T1-T4 and T6-T12. T14 was statistically the same with other organic treatments like T5 (14), T13 14) and T15 (13). T1 (Farmer's practice) was significantly the same with the number of marketable fruits in T2 (vermicompost) and other treatments with organic concoctions like T5 and T8-T11. Other organic concoctions like T3 (vermicompost + IMO) and T12 (vermicompost + IMO + FPJ + FFJ) had a significantly had a lower number of marketable fruits compared with T1.

Likewise, the weight of marketable fruits per plant had significant differences at different fertilization systems. T14 (0.54 kg) had the highest weight of fruits per plant. This was significantly the same with T13 (0.49 kg). T1 (.37 kg) compared with other organic fertilizer treatments showed a significant difference and had lower weight compared with T14 (.54 kg) and T13 (.49 kg). T1 also had significant difference but higher weight compared with T4 (.29 kg), T6 (.27 kg), T10 (.29 kg) and T12 (.22 g). Weight of fruits per plant at T1 had no significant difference on the following treatments: T2, T3, T5, T7, T8, T9, and T11.

The lightest tomato fruits per plant were at T12, but significantly the same with T4, T6, and T10. This is statistically different from the other treatments.

The composition of organic fertilizers that have a large number and heavier tomato fruits are the combination of vermicompost, Fish Amino Acid, Fermented Fruit Juice, and CalPhos. According to Alleje and de Villa (2014), vermicomposts are usually used as a soil conditioners. FAA is a source of nitrogen and contains an abundant amount of other secondary nutrients. CalPhos prevents blossom-end rot in tomatoes, prevents premature falling of blossom, improves fruit setting, and increases fruit production.

FFJ helps promote flowering and fruiting. It is a good source of potassium which speeds up the plant's absorption, resulting in sweeter tasting fruits. It helps maintain vigor in plants and resistance against pests. It adds to soil fertility and the advent of good colonies of microorganisms (Agricultural Training Center, 2006).

Average Number and Weight of Non-marketable Fruits/plant. The highest average number (3) of non-marketable fruits was obtained from T1 but not significantly different from T2, T3, T4, T5, T10, and T11 (Table 3). T15 had the lowest number of non-marketable fruits (1). Similarly, the weight of non-marketable fruits per plant showed that T15 had the lowest weight compared with other treatments and had no significant difference with almost all the other treatments except T10.

There was a lower quantity and lesser weight of non-marketable tomato fruits at T15. T15 was composed of vermicompost, fish amino acid, and Calphos. The implication is that these organic fertilizers produce good quality tomato fruits due to CalPhos that prevents blossom-end rot in tomatoes, prevents premature falling of blossom, improves fruit setting, and increases fruit production (Alleje and de Villa (2014).

Total Yield (t/ha). The highest weight of marketable fruits was 14.37ons/ hectare at T14, statistically similar to T13 (13.08 tons/hectare) and T15 (10.45 tons/

hectare). This was significantly different from all the rest of the treatments and higher than the weight of tomatoes from T1 (9.94 tons/hectare).

Organic fertilizer with the combination of vermicompost, indigenous microorganism, fish amino acid, and CalPhos gives higher biomass, increases fruit yield, increases marketable tomatoes, and lowers the number and weight of non-marketable tomatoes. Fish amino acid is a good source of nitrogen and contains an abundant supply of other secondary nutrients (Alleje and de Villa, 2014). Nitrogen is among the essential nutrients required by most crops in great amount. Nitrogen is necessary for chlorophyll production. Chlorophyll is needed to produce food for growth and nutrient uptake. It is also a component of amino acids, a building block of proteins. CalPhos is a good source of calcium and phosphate. Calcium helps induce flowering, prevents blossom-end rot in tomatoes, prevents premature falling of blossom, and improves fruit setting. Phosphorus is essential in root growth, development, and energy.

T14 had the best combination of nutrients that best support the growth and development of tomato plants (Table 1). While T13 organic fertilizer had a mixture of vermicompost, indigenous microorganism, fish amino acid, and fermented fruit juice. Fermented fruit juice is a good source of potassium that strengthens plants tissues, increases the size of fruits, increases crop resistance against diseases, and protects the plants from insects.

This result was comparable with the study of Zucco et al (2015) that compost was used as alternative fertilizer to reduce the need and dependence on synthetic, inorganic fertilizers. VC is a suitable tomato fertilizer for optimal growth at approximately 0.5-0.6 g/g added to the soil. It gives a similar growth rate of tomatoes using the standard inorganic fertilizer. Also, sandy soil with VC amendments generally increases tomato growth parameters compared to clay and loam soils, with loam generally providing the least.

Improvement in the weight of tomato fruits using VC and FAA in this study showed that vermicompost is ideal organic manure for better growth and yield of many plants. Application of vermicompost increases seed germination, stem height, number of leaves, leaf area, leaf weight, root length, root number, total yield, number of fruits/plant, chlorophyll content, pH of juice, micro and macronutrients, carbohydrates (%), and protein (%) content. There was an improvement in the quality of the fruits and seeds (Joshi et al, 2014).

Also, a similar result of this present study was cited by Verma et al (2015) that an increment of 31.83% in tomato yield was observed with the combination of Effective microorganisms (EM) compost and half the recommended dose of chemical fertilizers (N50P30K25 + EM compost at the rate of 5 t/ha).

Quality of Tomato Fruits in terms of Ascorbic Acid and Beta-carotene

The ascorbic acid content of 1.58 mg/100 grams of fresh tomato fruits was observed with the following organic fertilizers treatment: T2, T5, T7, T10, T11, T12, and T14. Generally, those treatments with CalPhos have higher ascorbic acid (Table 2). This was followed by ascorbic acid content of 1.19 mg/100 g of fresh tomatoes at T4, which was higher compared with T1 (0.79 mg/100 g of fresh tomatoes). Also, some of the treatments of organic fertilizer had the same content of ascorbic acid with the T1 of 0.79 mg/100 g. These were T3, T6, T8, T9, T13, and T15.

Table 1. Yield of Tomato Fruits at Different Organic Fertilization Systems, Escuala, Casiguran, Sorsogon, August to November 2017.

Fertilization Systems	No. of Fruits/ Plant	Weight of Fruits/ Plant (Kg)	No. of Marketa-ble Fruits / Plant	Weight of Marketa-ble Fruits/ Plant (Kg)	No. of Non-Marketable Fruits/Plant	Weight of Non-Marketable Fruits/Plant (Kg)	Yield (t/ha)
T1 Farmer's Practice	15 ab	.41 b	13 b	.37 b	3 ab	.06 ab	9.94 b
T2 VC	13 bc	.41 b	11 bc	.38 bc	3 ab	.05 ab	10.13 bc
T3 VC + IMO	12 bc	.35 bc	10 c	.33 bc	3 ab	.04 b	8.84 bc
T4 VC + FPJ	11 c	.35 bc	11 bc	.29 c	3 ab	.08 ab	7.83 c
T5 VC + FAA	15 ab	.42 b	14 ab	.39 b	3 ab	.06 ab	10.41 b
T6 VC + FFJ	15 ab	.30 c	9 c	.27 c	2 b	.06 ab	7.11 c
T7 VC + CalPhos	13 bc	.38 b	12 bc	.35 bc	2 b	.05 b	9.27 bc
T8 VC + IMO + FPJ	12 bc	.39 b	12 bc	.36 bc	2 b	.04 b	9.68 bc
T9 VC + IMO + FAA	11 c	.41 b	12 bc	.38 b	2 b	.05 ab	10.18 b
T10 VC + IMO + FFJ	15 ab	.33 bc	11 bc	.29 c	3 ab	.09 a	7.68 c
T11 VC + IMO + Cal-Phos	13 bc	.37 bc	12 bc	.33 bc	3 ab	.07 ab	8.84 bc
T12 VC + IMO + FPJ + FFJ	11 c	.25 c	9 c	.22 c	2 b	.05 b	5.98 c
T13 VC + IMO + FFJ + FAA	16 ab	.52 a	14 ab	.49 a	2 b	.06 ab	13.08 ab
T14 VC + IMO + FAA + CalPhos	17 a	.58 a	15 a	.54 a	2 b	.05 b	14.37 a
T15 VC + IMO + FFJ + CalPhos	13 bc	.40 b	13 ab	.39 b	1 b	.02 b	10.45 ab

* Means having the same letter in a column are not significantly different using LSD.

Legend : CalPhos - Calcium Phosphate
IMO - Indigenous Microorganisms
FAA - Fish Amino Acid
FPJ - Fermented Plant Juice
FFJ - Fermented Fruit Juice
VC - Vermicompost

The ascorbic acid content in tomatoes in this present study ranged from 0.79 mg to 1.58 mg/ 100 g of fresh weight of tomatoes. This was very much lower compared to the results of other studies. The lower ascorbic acid content of tomato fruits may be due to the low temperature and frequency of rainfall during the whole period of their growth and development. The result in this study was parallel to the study of Liptay et al. (1986) proving that the ascorbic acid content of tomatoes was affected by temperature. The tomato fruit of the "Jumbo" cultivar, grown in the greenhouse was about 14 mg/100 g FW in June 1983 but increased to about 20 mg/100 g by mid-July. Tomatoes harvested in the greenhouse at the end of October had only 7 mg of AA/100 g FW. The temperature of the greenhouse was quite cool and certainly less than 20 ^{0}C during the latter part of October 1983. November, when the greenhouse was heated, the AA content rose to more than 11 mg/100 g FW. Tomatoes had lower quantities of AA when grown at low temperature compared to the quantities at higher temperatures (Liptay *et al*. 1986).

Abduli (2013) cited that vitamin C increased with the combination of 4:1 ratio of vermicompost and soil to 21.35 mg/100g fresh tomato. In this study, it appears that a combination of soil and vermicompost increases the amount of soluble and insoluble solids, total sugar, and vitamin C in tomatoes significantly.

Organic fertilizer at T15 had the highest beta-carotene content in tomato fruits with 47.80 mg/100g, followed by 24.19 mg/100g at T2, and 19.56 mg/100g at T14. Almost all the

Table 2. Ascorbic Acid Content of Tomato at different Fertilization Systems, Escuala, Casiguran, Sorsogon, August to November 2017.

Treatments	Ascorbic Acid (mg/100g)
T1 Farmer's Practice	0.79
T2 VC	1.58
T3 VC + IMO	0.79
T4 VC + FPJ	1.19
T5 VC + FAA	1.58
T6 VC + FFJ	0.79
T7 VC + CalPhos	1.58
T8 VC + IMO + FPJ	0.79
T9 VC + IMO + FAA	0.79
T10 VC + IMO + FFJ	1.58
T11 VC+ IMO + CalPhos	1.58
T12 VC + IMO + FPJ + FFJ	1.58
T13 VC + IMO + FFJ + FAA	0.79
T14 VC + IMO + FAA + CalPhos	1.58
T15 VC + IMO + FFJ + CalPhos	0.79

Legend : CalPhos - Calcium Phosphate
IMO - Indigenous Microorganisms
FAA - Fish Amino Acid
FPJ - Fermented Plant Juice
FFJ - Fermented Fruit Juice
VC - Vermicompost

Table 3. Beta-carotene Content of Tomato at Different Fertilization Systems, Escuala, Casiguran, Sorsogon, August to November 2017.

Treatments	Beta-carotene (mg/100g)
T1 Farmer's Practice	11.06
T2 VC	24.19
T3 VC + IMO	13.78
T4 VC + FPJ	8.75
T5 VC + FAA	9.09
T6 VC + FFJ	17.32
T7 VC + CalPhos	16.71
T8 VC + IMO + FPJ	13.37
T9 VC + IMO + FAA	14.12
T10 VC + IMO + FFJ	18.20
T11 VC+ IMO + CalPhos	13.44
T12 VC + IMO + FPJ + FFJ	17.66
T13 VC + IMO + FFJ + FAA	15.41
T14 VC + IMO + FAA + CalPhos	19.56
T15 VC + IMO + FFJ + CalPhos	47.80

Legend : CalPhos - Calcium Phosphate FPJ - Fermented Plant Juice
IMO - Indigenous Microorganisms FFJ - Fermented Fruit Juice
FAA - Fish Amino Acid VC - Vermicompost

organic treatments were higher than T1, with 11.06 mg/100 g of beta-carotene.

The exception was T5, with 9.09 mg/100 g. The lowest content was 8.75 at T4 (Table 3).

This present study showed high content of beta carotene (8.75 mg to 47.8 mg/100 g) in tomatoes compared to other vegetables and other studies in tomatoes. According to Hignon and Norman (1996) as cited by Ahamad et al. (2007) beta carotene content in carrots was 10.110 mg/100 g, spinach 8.230 mg/100 g, lettuce 3.945 mg/100 g, and tomato 1.930 mg/100 g. There was a trace amount of beta carotene in onion, potato, and mushroom. Also, according to Ahamad et al. (2007), dark green vegetables contained more beta carotene as compared to other vegetables. Spinach contained 9.940 mg/100 g, followed by mint, kulfa, lettuce, and ladyfinger. All of these were all dark green in appearance. Apart from a carrot that contains 11.210 mg/100 g.

Organic fertilizer at T15 had the highest beta-carotene content in tomato fruits with 47.80 mg/100g FW and the lowest content of ascorbic acid with 0.79 mg/100 g fresh weight . Another organic fertilizer at T2 was highest in ascorbic acid content with 1.58 mg/100 g and second highest in beta-carotene with 24.19 mg/100 g fresh weight. The beta carotene content of tomato at different fertilization systems in this present study beta-carotene was very high compared to other studies, while the ascorbic acid content was quite low.

High beta-carotene content can be attributed to the increased nitrogen content of the soil as cited by Cherad et al. (2005). They found out that increasing N in the nutrient solution increased plant biomass, leaf tissue N, phosphorus (P), potassium (K), lutein-zeaxanthin, β-carotene, and chlorophyll. Very low ascorbic acid was due to lower temperature in the month of growing tomatoes, which was from August to October 2017. The planting

period was an off season for tomato growing. During this season typhoons are very common.

Alba et al. (2000) as cited by Othman et al. (2014) found out that temperature, light, mineral uptake, salinity, and irrigation have impact on carotenoid synthesis. An increased rate of potassium and phosphorus was found to enhance lycopene content of 20-30% in hydroponically grown tomatoes.

Also, as cited by Pertuzatti et al. (2015), ascorbic acid for organically grown yellow passion fruit was 2.3 x 102 mg/100g-1, In comparison, the conventional grown had 1.9 x 102. Carotenoid content for organically grown passion fruit was 13.99 mg/100 g while conventionally grown had 25.10 mg/100g.

CONCLUSIONS

This research showed that in terms of fruit yield the synthetic fertilizer used in T1 was comparable with the organic basal fertilizer of T2 (vermicompost). Among the different fertilization systems, it was T14 (VC+IMO+FAA+CalPhos) and T13(VC+IMO+FFJ+FAA) which had more number fruits per plant and with the highest weight of tomato per plant. The highest average number of non-marketable fruits was obtained from T1 (Farmer's Practice). T15 (VC+IMO+FFJ+CalPhos) had the lowest weight of non-marketable.

Tomato fruits' ascorbic acid and beta-carotene contents were influenced by different organic fertilization systems. The highest ascorbic acid content was observed with the following organic fertilizers treatment: T2, T5, T7, T10, T11, T12, and T14. Organic fertilizer at T15 had the highest beta-carotene content in tomato fruits, followed by T2, and T14.

This study recommends the following: use this fertilization system on growing tomato during the dry season and study ascorbic acid and beta-carotene content of tomato fruit; apply this fertilization system using other variety of tomato; study the different growth, yield, tomato fruit ascorbic acid and beta-carotene content; and study the effect of T14 (vermicompost + fish amino acid + CalPhos) on the growth, yield, ascorbic acid and beta-carotene content on other the vegetables.

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