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Growth, yield and quality of bitter gourd (*Momordica charantia* L.) under organic fertilization schemes

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Abstract

Momordica charantia L. is a vegetable crop commonly cultivated under chemical fertilization. Thus, its response to different organic fertilization schemes was investigated. Growth, yield, chemical properties and organoleptic properties were determined, and profitability was also assessed. The experiment was laid out using Randomized Complete Block Design (RCBD) replicated thrice and applied with the following treatments: T1 (farmer's practice-inorganic fertilizer); T2 (vermicompost); T3 (vermicompost and fermented fruit juice); T4 (vermicompost + calcium phosphate); and T5 (vermicompost + fermented fruit juice + calcium phosphate). Early flowering and fruit setting in bitter gourd were not influenced by the treatments while yield components were highest in inorganic fertilized plants. Vermicompost supplemented with calcium phosphate had higher vitamin A (7,354 I.U), while application of inorganic fertilizer contributed to higher vitamin C (69.87 mg/100 g). Total soluble solids (5 °Brix) was highest in plants applied with vermicompost and fermented fruit juice. A higher amount of phosphorus and potassium in the soil was observed after planting. In contrast, lower soil pH, percent organic matter and total nitrogen were manifested as compared to the initial soil analysis. No statistical differences was observed in color, crispness, and aroma, while statistical difference was observed in bitterness. Bitter gourds applied with inorganic fertilizer were the most bitter, while those fertilized with vermicompost and fermented fruit juice had the least bitterness.

Key words: Bitter gourd, calphos, fermented fruit juice, inorganic fertilization, sensory evaluation, vermicompost

Introduction

Momordica charantia L. also known as bitter gourd and bitter melon is a popular plant commonly consumed as vegetable and known for its bitter taste. It is a climbing perennial which is mainly found in Africa, Asia, and Australia (Pullaiah and Naidu, 2003). In the Philippines, it is locally known as ampalaya, amargoso, apalia (Pampango), palia (Ifugao) and paria (Visayan region). It has a long history of human use in traditional medicine throughout the world and has been shown to possess anticancer, antidepressant, antidiabetic, anti-inflammatory, antimicrobial, anti-obesity, antioxidant, and antiulcer properties. It is also known for treating diabetes-related conditions amongst the indigenous populations of Asia, South America, India, the Caribbean and East Africa (Cefalu *et al.*, 2008; Joseph and Jini, 2013). Its common phytochemical components include alkaloids, charantin, flavonoids, glycosides, phenolics, tannins, and terpenoids (Poolperm and Jiraungkoorskul, 2017). In the Philippines, which relies on the abundant use of chemical fertilizers and pesticides the use of compost or any soil organic additives in the large-scale production of bitter gourd is rarely done (Magcale-Macandog, *et al.*, 2016). However, due to the continuous use of chemical fertilizers that led to soil fertility depletion, the interest of using organic fertilizers is increasing day by day (UNCTAD, 2003). Arfan-ul-Haq *et al.* (2015) mentioned that low fertilizer use efficiency (FUE) and synthesis of chemical fertilizers consumes a large amount of energy and money. Thus, possible solution for these situations is the use of organic fertilizers such as vermicompost, fermented fruit juice (FFJ), and calcium phosphate (CalPhos). Vermicompost is a mixture of different organic materials such as leaves, twigs, food leftovers, and vermicast and believed to be a nutrient rich organic fertilizer (www.composting.ces.ncsu.edu/). Fermented fruit juice is a known organic concoction, rich in different vitamins and minerals. It is usually applied to crops to increase yield alongside with other organic fertilizers and also to sweeten the fruits (Hubilla, 2020). CalPhos from eggshell on the other hand, is a nutrient solution that is applied to plants before they enter the flowering stage (www.goodlifepermaculture.com.au/calphos-nutrient-solution/). Since bitter gourd is not well-liked because of its bitterness and its vitamin A and C contents in fruits is not well explored, this research examined its yield, Vitamin A and C content and organoleptic properties.

The effects of five different organic fertilization schemes in bitter gourd were examined with respect to yield; chemical composition such as vitamins A and C; chemical properties of the soil before and after crop establishment; and organoleptic properties through sensory evaluation. This study will benefit the farmers and agripreneurs with respect to the insights of organic production of *M. charantia*.

Materials and methods

Experimental site: The study was conducted at Bellere's Farm, Brgy. Bolo Sur, Sipocot, Camarines, Philippines Sur located at 13°45'46.2240" N and 122°57'43.9056" E. It has a Type IV climate in which rainfall is more or less evenly distributed throughout the year. Temperature in the area varies from 23 °C to

32 °C and is rarely below 22 °C or above 33 °C. The hot season lasts for three months, from April to June with an average daily high temperature above 31°C. The cool season lasts for three months, from December to February, with an average daily high temperature below 28 °C. The wetter season lasts for seven months, from June to January while the drier season lasts for five months. The soil types of the municipality are Faraon clay which occupies 4.47 %, Alimodian clay which occupies 55.67 % and Louisiana clay which covers 39.86 % of the total land area. Generally, the different areas in Sipocot are susceptible to erosion especially during the rainy season which is attributed to its physical characteristic as hilly and mountainous.

Soil sampling and analysis: Before planting, soil samples were collected randomly from 10 different sampling points in the experimental area. Composite soil sample was air dried, pulverized, sieved, and was submitted to the Regional Soils Laboratory at Del Rosario, Naga City, Camarines Sur for the determination of N, P, K and pH. The initial analysis of the soil in the area was: pH - 4.87, % OM - 2.33, N - 0.12%, P_2O_5 - 7.24% and K_2O - 0.07%. The soil pH was classified as very strongly acidic (USDA Soil Quality Indicators, 1988). The fertilizer recommendation was 50-80-60.

Test crop: The variety used in the study was "Galaxy F1" from East-West Seed Company. It is a high-yielding and attractive bitter gourd variety. The fruits are large, glossy, dark green, uniformly cylindrical with blunt blossom end, around 30-35 cm in length and 6 cm in diameter. It yields an average of 5 and 6 fruits per plant and weighs 350 grams per fruit. It is recommended for all-season planting in lowland areas (*www.eastwestseeds.com*).

Organic soil amendments

Vermicompost: The vermicompost used came from Bellere's Farm at Sipocot, Camarines Sur, Philippines. The substrates used for vermicomposting were the mushroom spent from the farm and no other source of N was added in the substrate. The mushroom spent was actually a combination of rice straw, good lumber sawdust and rice bran in a 7:3:1 ratio which was already utilized by mushrooms for its mycelial growth and fructification. It has a guaranteed analysis of 1.05 % N, 0.15 % P_2O_5 and 0.10 % K_2O. It has a pH of 5.88 and EC of 0.30 mS/cm.

Fermented fruit juice: Fermented Fruit Juice (FFJ) was made from bananas harvested from the farm and thoroughly blended with molasses. It has 0.47 % N, 0.02 % P_2O_5, 1.16% K_2O with a pH of 5.32 and EC of 0.40%.

Calcium phosphate: It is a nutrient solution for plants which was made from eggshells and coconut vinegar. It contains 6,151 ± 437 ppm of calcium and 52.54 ± 2.64 ppm of phosphorus.

Experimental design and treatments: The experiment was laid out in Randomized Complete Block Design (RCBD) replicated three times and based on the Statistical Procedure for Agricultural Research (Gomez and Gomez, 1984). The following were the treatments: Treatment 1 – Conventional Method = Farmer's Practice (FP); Treatment 2 – Vermicompost (VC); Treatment 3 – Vermicompost + Fermented Fruit Juice (FFJ); Treatment 4 – Vermicompost + Calcium Phosphate (CalPhos) and; Treatment 5 - Vermicompost + FFJ + Calphos.

Land preparation and laying out of plots: An area measuring 3.5 x 77 m was plowed and harrowed twice to pulverize the soil and eliminate the weeds. Furrows were set at a distance of 1 m and plots were laid out following the treatments. Plot size was 3.5 x 5 m. Distance between hills was 0.5 m whereas distance between plots was 1.0 m. Distance between replicates was 1.0 m.

Crop establishment*:* To break the seed coat lightly, the seeds were soaked in water for 24 hours, then washed. It was incubated for 24-48 hours until the radicles appear. On the first day, the seeds with uniform germination were planted to have a uniform stand of plant in the field. All the slow germinating seeds were discarded. Vermicompost was incorporated into the soil before planting. One germinated seed per hill was planted at a depth of 2 cm and spaced at 50 cm along the row.

Fertilizer application

Farmer's practice: For the farmer's method of *M. charantia* production, the inorganic fertilizers were mixed with the soil in each hole at planting. Moreover, 5 g of ammonium phosphate and 0.6 g of urea were applied when the fruits begin to appear.

Vermicompost application: Three kg of vermicompost was applied basally in each hole before planting.

FFJ and CalPhos application: For FFJ, six tbsp were mixed in one liter of water (Corpuz, 2015), whereas two tbsp of CalPhos was also diluted in the same amount of water. Fifty mL of it was applied during the vegetative stage, 100 mL on the near flowering and flowering stage and 130 mL on the fruiting stage. It was sprayed on the leaves and drenched into the soil in each of the plant weekly and started a week after planting until the end of the experiment.

Cultural management practices

Watering and weeding were done when necessary.

Pest management: Sticky nets were used to control the pests. Bagging the young fruits was also done to avoid fruit fly infestation.

Trellising, training and pruning: Before the vines crept, vertical trellises were established by using bamboo poles with branches to support the stems of the crop. It was trained to grow vertically by tying the vines to the trellis. Lateral shoots/vines were pruned every 4-5 days, leaving only the main stem. Initial pruning was done one month after planting or when lateral vines appeared. All lateral vines from ground level up to the top of the trellis and all ineffective lateral vines above the trellis were pruned at 15 to 20 days interval.

Harvesting: Harvesting was done when the fruits were green, shiny and have attained full size. It was harvested in the morning to maintain their freshness. This is about 60-95 days from planting, and these are approximately 25-30 cm long. Priming was done at 7 days interval.

Data sampling: Data were obtained from fifteen sample plants per treatment per replicate.

Growth and yield parameters: Days to flowering was recorded when 50% of the sample plants started to flower. Days to fruit set was recorded when 50% of the sample plants had already set fruit. Total number of fruits per plant was counted manually.

Total weight of fruits per plant (kg/plant) was measured using a weighing scale. Number and weight of marketable and non-marketable fruits/plant were also obtained, counted, and weighed. Fruit length was measured from pole to pole using tape measure and fruit diameter (cm) was measured using a vernier caliper. Biomass yield (kg/plant) which is the total mass of the crop was also obtained. Leaves, stem, roots and fruits from each treatment were weighed immediately with a spring scale in the field. Economic yield (t/ha) was obtained from the weight of the marketable fruits and was computed on a per hectare basis. Total yield (tons/ha) was obtained from the total weight of the marketable and non-marketable fruits and was computed on a per hectare basis.

Vitamin A and C: One hundred grams of the samples from each treatment were brought to Food Science Analytical Services Laboratory at the University of the Philippines, Los Banos, Laguna for vitamins A and C analysis.

Total Soluble Solids (TSS)*:* TSS (˚Brix) was determined through the use of a refractometer.

Organic fertilizers: Vermicompost and FFJ were analyzed for their N, P and K content. Vermicompost and FFJ was sent to Region I Regional Soils Laboratory at San Fernando, La Union. While, CalPhos was analyzed for its calcium and phosphate contents and was brought to BIOTECH at Los Banos, Laguna.

Final soil analysis: Ten subsamples were collected from each treatment plot. It was mixed, air-dried, and sieved. One kilogram from each treatment was brought to the Regional Soils Laboratory (Region V) for the analysis of its pH, OM, N, P and K content.

Agroclimatic data: Rainfall, relative humidity and temperature were recorded, and data were obtained from PAG-ASA weather station, CBSUA, Pili, Camarines Sur.

Sensory evaluation of the organoleptic properties of *M. Charantia*: The freshly harvested *M. charantia* was evaluated by a 30-member taste panel. They were instructed to rate the taste on a 1-9 scale based on Hedonic scale developed by Peryam and Pilgrims (1957). The sensory attributes included visual (intensity of color), aroma (typical ampalaya aroma), flavor (bitterness) and crispness.

Statistical analysis: The Analysis of Variance for RCBD was used to determine the level of significance among treatments. Further tests using Least Significant Difference Test was used to compare the differences among means through Statistics for Agricultural Research (STAR) software.

Results and discussion

Growth parameters*:* As shown in Table 1, no significant differences were observed in the number of days to flower and days to fruit set of *M. charantia* under different fertilization schemes. Though, it could be noticed that among the treatments, those plants applied with inorganic fertilizers (T1 - Farmer's practice) were the earliest to flower (29 DAP) and to set fruit (39 DAP). This might be because chemical fertilizers released the nutrients faster which promoted vegetative growth & improved vegetation and accelerated flowering. The result of the study is similar to the study of Momin *et al.* (2014) where the minimum (42.65 days) time of first flower was recorded in application of inorganic fertilizer. Moreover, Mondal (2005) reported that inorganic fertilizer (Urea at 150 kg/ha, TSP at 125 kg/ha and MP at 100 kg/ha) and 300 ppm "Ripen-15" gave the maximum number (male-59.47 and female-17.65) of flowers and early flowering and fruiting in cucumber.

Table 1. Growth of *M. charantia* L. under different fertilization schemes

Fertilization schemes	Days to flower	Days to fruit set
T1 (FP)	29	39
T2 (VC)	29	44
T3 (VC + FFJ)	32	44
T4 (VC + CalPhos)	34	49
T5 (VC + FFJ + CalPhos)	31	47
CV (%)	9.96	7.77

*In a column the same letters indicate that the values are not significantly different by LSD (P>0.05). FP – Farmer's Practice; VC – Vermicompost; FFJ – Fermented Fruit Juice

Yield parameters

Yield components: Results presented in Table 2 show a statistically significant variation in the number and weight of fruits/plant and number and weight of marketable fruits/plant. Whereas, fruit length, and width, number and weight of non-marketable fruits showed no significant differences. Fruit length and fruit width under different fertilization schemes have no significant differences. Though, it could be noticed that the longest fruit was obtained from those applied with Vermicompost + Fermented fruit juice + CalPhos (24.21 cm) and the widest girth was obtained from those applied with Vermicompost + CalPhos (3.74 cm). Moreover, bitter gourd applied with inorganic fertilizers (Farmer's Practice) had the most number of fruits (4.40), had the heaviest fruit/plant (0.53 kg), had the most number of marketable fruits (1.79) and had the heaviest marketable fruits/plant (0.34 kg). However, no significant differences were

Table 2. Yield components of *M. charantia* under different fertilization schemes

Fertilization schemes	Fruit length (cm)	Fruit width (cm)	Number of fruits / plant	Weight of fruits/ plant (kg)	Number of marketable fruits/ plant	Weight of marketable fruits/ plant (kg)	Number of non-marketable fruits/ plant	Weight of non-marketable fruits/ plant (kg)
T1 (FP)	22.97	3.59	4.40 a	0.53 a	1.79 a	0.34 a	2.61	0.20
T2 (VC)	23.92	3.72	3.23 b	0.35 b	0.75 b	0.17 bc	2.48	0.18
T3 (VC + FFJ)	22.67	3.56	3.56 b	0.38 b	0.85 b	0.19 b	2.71	0.19
T4 (VC + CalPhos)	22.46	3.76	3.33 b	0.28 c	0.71 b	0.13 bc	2.63	0.14
T5 (VC + FFJ + CalPhos)	24.21	3.74	3.03 b	0.25 c	0.44 c	0.11 c	2.62	0.13
CV (%)	4.12	7.73	9.32	10.92	13.53	18.14	11.29	18.89

*In a column the same letters indicate that the values are not significantly different by LSD Test (P>0.05). FP – Farmer's Practice; VC – Vermicompost; FFJ – Fermented Fruit Juice, CalPhos– calcium phosphate observed on the weight and number of non-marketable fruits/plant among the treatments. It might be due to the reason that all of the treatments were susceptible to fruit flies which were the main reason for the non-marketability of the fruits.

Yield: Bitter gourd under Farmer's Practice had the highest biological yield (12.64 tons/ha) (Table 3). Higher biomass of those applied with inorganic fertilizers might be the result of the higher release of nitrogen and phosphorus from the fertilizers used. The results obtained were directly proportional to the economic yield obtained from all of the treatments. This is similar with earlier reports that organic amended soils possess essential nitrogen twice the level of nitrogen as conventional soils (Delate *et al.*, 2008; Dauda, *et al.*, 2005). The results did not agree with the study of Ayeni *et al.* (2016) where no significant differences on the fresh biomass of *Solanum nigrum* L. applied with inorganic and organic fertilizer were observed. Moreover, it was also reported by Mohil *et al.* (2016), where both organic and NPK fertilizers showed uniform increase in biomass.

Economic yield (tons/ha) was based on the weight of marketable fruits harvested (Table 3). Among the treatments, those applied with inorganic fertilizers had the highest yield (6.79 tons/ha) and significantly different with the rest of the treatments. Furthermore, total yield (marketable + non-marketable yield) obtained under Farmer's Practice was 10.72 tons/ha which was significantly different with the rest of the treatments.

The highest yield observed was obtained from plants applied with inorganic fertilizer because of its high nutrient content and its fast release of nutrients. It could be noted that different types of inorganic fertilizers such as di-ammonium phosphate (18-46-0), ammonium phosphate (16-20-0), urea (46-0-0) and muriate of potash (0-0-60) were applied on T1 based on the result of soil analysis. All of the nutrients needed by the plants were well provided as compared to those applied with vermicompost and foliar fertilizers such as FFJ and CalPhos which showed a low economic yield since organic fertilizers are known to be slow-release fertilizers. Nevertheless, it could also be noted that among the different organic fertilizers used, vermicompost and FFJ had the highest yield, followed by those applied with vermicompost alone, combination of vermicompost and CalPhos and those applied with the combination of vermicompost, FFJ and CalPhos. The reason could be the unavailability of P, K and Ca as soil acidity increases. Phosphorus becomes available when the pH is between 6 and 7.5 while fixation by aluminum, iron, or calcium happens when pH values fall below 5.5 and between 7.5 and 8.5.

Table 3. Yield of *M. charantia* under different fertilization schemes

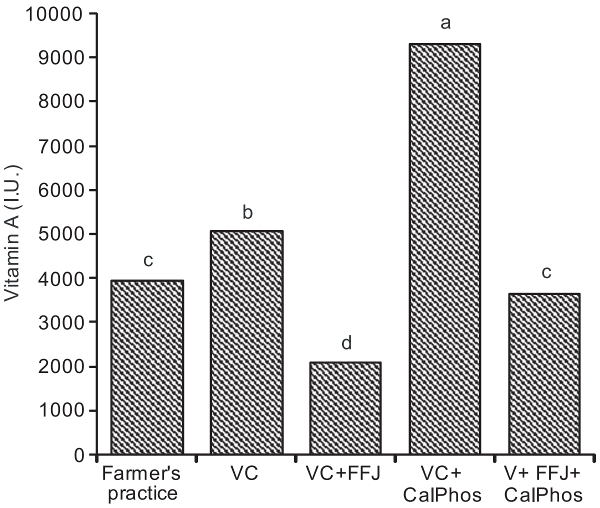
Fertilization schemes	Biomass yield (tons/ha)	Total yield (tons/ha)	Economic yield (tons/ha)
T1 FP	12.64 a	10.72 a	6.79 a
T2 VC	7.91 b	7.07 b	3.38 bc
T3 VC + FFJ	10.69 a	7.67 b	3.76 b
T4 VC + CalPhos	7.24 bc	5.50 c	2.67 bc
T5 VC + FFJ + CalPhos	5.74 c	4.86 c	2.22 c
CV (%)	12.33	10.74	6.72

*In a column the same letters indicate that the values are not significantly different by LSD Test (P>0.05).

It has been said that when adequate K is available, addition of N and/or phosphorus (P) greatly increases K uptake, as yields are increased. The lowest yield was obtained from T5 (VC + FFJ + CalPhos). This could be attributed to nutrient interaction in the soil. Absorption of NH_4-N may result in greatly reduced uptake of Ca and Mg while having lesser effects on K. Large amounts of NH_4-N in the soil would have the same effect on a forage as that of K, causing depressed uptake of Ca and Mg. Sudden rises in temperature tend to be associated with wider K/(Ca+Mg) ratios. Higher temperatures tend to increase the K uptake faster than that of Ca and Mg. Generally, additions of K, Ca or Mg result in a lower concentration of the remaining two cations, regardless of the crop grown (Better Crops, 1998). Furthermore, it could be noted that the experimental area was previously planted with different crops such as tomato, eggplant and corn and never used organic fertilizer for their crops. Thus, the build-up of soil structure which could increase its ability to hold water and nutrients and the presence of microorganisms to break down and release nutrients were not established.

Vitamin A, vitamin C and sugar content: Vitamin A, vitamin C and total soluble solids contents of bitter gourd are shown in Fig. 1 and 2. Among the treatments, bitter gourd applied with VC + CalPhos had the highest vitamin A content (7,354 I.U.). Vitamin A is an important component of bitter gourd which contains various organic compounds such as retinol and retinoic acid. The usual amount of Vitamin A in raw bitter gourd is 471 IU (USDA Nutrient Database). Vitamin A obtained from all of the bitter gourds under different treatments were more than the standard content which could indicate that application of those fertilizers could increase the Vitamin A content of the fruit. Nitrogen fertilizers are also shown to increase the concentrations of carotenes since the use of nitrogen fertilizers increases the concentration of NO_3 in plant foods (Mozafar, 1993). The result is in consonance with the study of Ghosh *et al.* (2016) where the application of organic components and inorganic fertilizers increased the Vitamin A content of bitter gourd. Numerous reports indicate that increased supply of N increased the concentration of carotene in a wide range of fruits and vegetables. Vitamin C on the other hand, was notably higher in bitter gourd applied with inorganic fertilizers (69.87 mg/100g). However, ascorbic acid content of bitter gourd in all of the treatments were below the standard nutrient content of 84 mg/100 g (USDA Nutrient Database). But, generally, the most consistent effects of nitrogen fertilizers on plant vitamins is the decrease in ascorbic acid (Mozafar, 1993). He further stated that increased application of nitrogen fertilizers has been shown to decrease the content of ascorbic acid in many plants. The result is similar with the study of Roberts *et al.* (2007) where they reported that plants grown in 100% vermicompost showed lower concentrations of ascorbic acid than plants growing in other media. They reported that fruit antioxidant concentrations in fruit are dependent upon external factors (*e.g.*, light intensity, temperature) and internal factors (*e.g.* cultivar variety, fruit load and position) (Dumas *et al.*, 2002; Slimestad and Verhuel, 2005).

Highest total soluble solids (TSS) was recorded in bitter gourd applied with VC + FFJ (5 °Brix). Total soluble solids (TSS) increased with the application of inorganic fertilizers such as Vermicompost and FFJ since it provided favorable condition in the plant root zone resulting in higher absorption or uptake of major as well as minor nutrients which might have direct relation with concentration of T.S.S. in fruits. Moreover, fermented



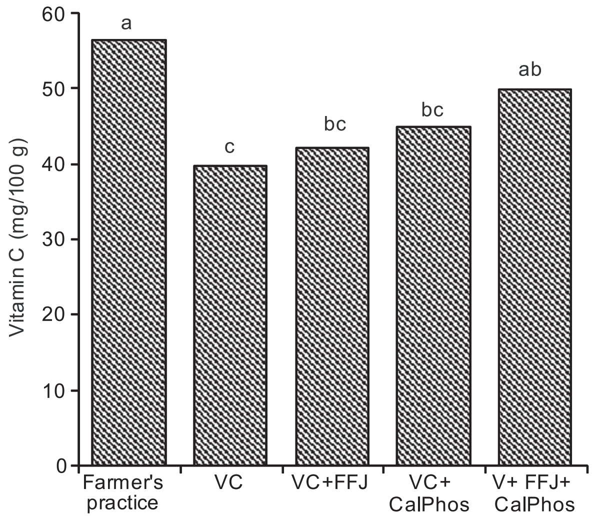


Fig. 1. Vitamin A and C content of *M. charantia* L. under different organic fertilization schemes.

fruit juice contains molasses thus bitter gourd applied with FFJ exhibited a higher TSS content than the rest of the treatments. The result of the study is in consonance with the study of Sakimin *et al.* (2017) where total soluble solids in tomatoes were also observed to increase after 10 weeks of FPJ and FFJ application. The percentage of TSS recorded in all treatments were relatively higher compared to the commercial production using inorganic fertilizer.

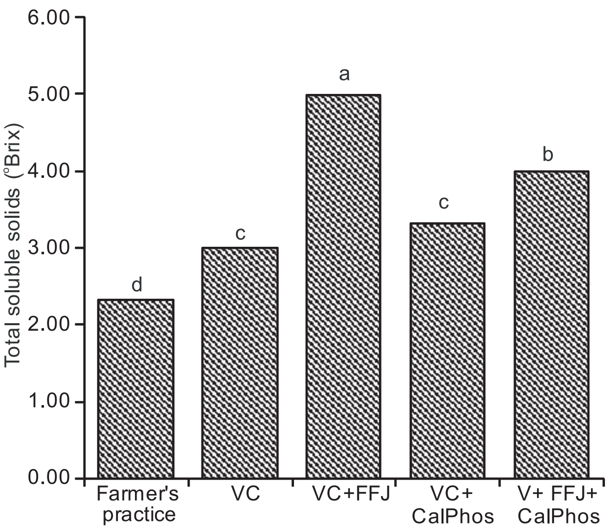


Fig. 2. TSS content of *M. charantia* L. under different organic fertilization schemes

Soil analysis: Generally, the chemical analysis of the soil after planting of bitter gourd under different organic fertilization schemes showed improved phosphorus and potassium content. However, a decrease in soil pH, % OM and nitrogen were observed (Table 4). The soil pH is still classified as very strongly acidic (pH 4.5 - 5.0) based on USDA Soil Quality Indicators (1998). Bitter gourd grows best in soil pH of 6.0 to 6.7 and can tolerate alkalinity up to 8.0 (Behera *et al.*, 2010). Based on the final chemical analysis, T3, T4 and T5 had higher pH as compared to T1 and T2. Furthermore, T5 had higher pH than the other treatments. It could be due to the combined effect of CalPhos and FFJ. It is a known fact that liming materials contain calcium and the major ingredient of CalPhos is calcium carbonate from the eggshells. Thus, the increased pH in soils applied with T4 and T5 could be attributed to its calcium carbonate components. The strong acidity of the area could be attributed to its history of long term inorganic fertilization.

Generally, percent OM was lower than the initial content for all of the treatments. The lower percentage of OM was due to crop removal (plant utilization) and leaching. Moreover, it has been said that cultivated land generally contains lower levels of soil organic matter than comparable lands under natural vegetation since in cultivated areas, only plant material remaining after harvest and not burned makes it back to the soil (McCauley *et al.*, 2017). Though, in general, among the treatments, final OM is slightly higher (except for T4) in treatments with organic fertilizers as compared with the control (inorganic fertilizer). This could be attributed to the organic fertilizers applied. The addition of vermicompost and other organic fertilizers in the soil might have influenced the amount of organic matter present in it. However, based on the cropping history of the experimental area, only inorganic fertilizers were used, thus, there was no buildup of organic matter. The effects of intensive and continuous cultivation might have aggravated OM oxidation and their consequent leaching/erosion.

Nitrogen content also decreased for all of the treatments. The decrease in the amount of total nitrogen in the soil could be attributed to the decrease in its organic matter content. It has been stated by Allison (1957) that cultivation accelerates microbiological activities and the rate of release of ammonia from soil organic matter. A considerable part of this nitrogen may be lost through leaching and erosion and a larger proportion is removed in the crop.

In terms of available phosphorus in the soil, initially, it contained 7.24 ppm which is classified as low (Horneck *et al.*, 2011). But after harvest, soil in T1, T3, T4 and T5 had higher P (10.87, 11.97, 11.15 and 10.03 ppm) than the initial P content and classified as medium. The increase in P content of the soil is due to the mineralization which is the decomposition of the chemical compounds in organic matter, by which the nutrients in those compounds are released in soluble inorganic forms that may become available.

Amount of potassium in the soil before planting was 0.07 meq/100g which is classified as low (Horneck, 2011). However, an increase in potassium content was evident in all of the treatments. It might be due to the fact that the organic fertilizers applied such as vermicompost and FFJ contained 1.16% (11,600 ppm) and 0.10% (1,000 ppm) K content, respectively. Similar results were obtained from the study of Manivannan (2009) where K significantly increased in soils treated with vermicompost and vermicompost plus NPK.

Table 4. Chemical parameters (pH, OM (%), N, P and K) of the soil before and after *M. Charantia* cultivation

Samples	Organic matter (%)	pH	N (%)	P (ppm)	K (meq/ 100g)
Initial soil analysis	2.33	4.87	0.12	7.24	0.07
Final soil analysis					
T1 FP	1.67	4.72	0.09	10.87	0.07
T2 VC	1.74	4.67	0.09	7.71	0.12
T3 VC + FFJ	1.83	4. 84	0.09	11.97	0.09
T4 VC + CalPhos	1.61	4.90	0.08	11.15	0.10
T5 VC + FFJ + CalPhos	1.83	4.93	0.09	10.03	0.10
CV (%)	8.33	3.31	9.47	26.94	21.71

Treatment effects are not significant.

Sensory evaluation of the organoleptic properties of *M. charantia*: Fruit quality of bitter gourd was evaluated based on its color, crispness, aroma and bitterness (Table 5). A total of 30 member taste panel were asked to evaluate the harvested raw bitter gourds from all of the treatments using the 9-point Hedonic scale. For its color, bitter gourds for all of the treatments were rated as moderately dark green. For its crispness, all of the bitter gourds were rated as very much crisp. For its aroma (typical ampalaya smell), bitter gourds under T1 (6.97), T2 (6.88) and T3 (6.35) were rated by the respondents as having a moderately pleasant smell while those under T4 (5.97) and T5 (6.26) were rated as having a slightly pleasant smell. In terms of bitterness, those under T1 had the bitterest taste while those under T3, T4 and T5 were rated as slightly bitter by the respondents. The slight bitterness taste could be attributed to the FFJ and CalPhos fertilizers applied to the bitter gourds. It is known that FFJ from ripe fruits such as papaya and banana could increase the potassium levels in soil. Potassium helps in making the fruit sweeter. Moreover, TSS content of bitter gourd under T3 were higher (5 °Brix) compared to other treatments which could explain the reason for the slightly bitter taste of bitter gourd applied with vermicompost and FFJ.

Table 5. Organoleptic properties of *M. charantia* (color, crispness, aroma and bitterness) under different organic fertilization schemes

Fertilization schemes	Colour	Crispness	Aroma	Bitterness
T1 (FP)	6.61 (MDG)	7.86 (VMC)	6.97 (MP)	7.28 a (VMB)
T2 (VC)	6.62 (MDG)	7.55 (VMC)	6.88 (MP)	6.58 ab (MB)
T3 (VC + FFJ)	6.63 (MDG)	7.52 (VMC)	6.35 (MP)	5.46 c (SB)
T4 (VC + CalPhos)	6.89 (MDG)	7.49 (VMC)	5.97 (SP)	6.24 bc (SB)
T5 (VC + FFJ + CalPhos)	6.35 (MDG)	7.69 (VMC)	6.26 (SP)	5.70 c (SB)
CV (%)	11.18	3.93	5.95	6.74

**same letters in a column indicate that the values are not significantly different by LSD Test (P>0.05). Legend: MDG – Moderately dark green; VMC – Very much crisp; MP – Moderately pleasant; SP – Slightly pleasant; VMB – Very much bitter; MB – Moderately bitter; and SB – Slightly bitter

Early flowering and fruit setting of bitter gourd were not influenced by different fertilization schemes. Likewise, yield and yield components were highest in inorganic fertilized plants. Bitter gourd applied with vermicompost supplemented with CalPhos had higher Vitamin A while those with inorganic fertilizer had the highest Vitamin C content. Total Soluble Solids was highest in plants with vermicompost and fermented fruit juice. Chemical analysis of soil after planting of bitter gourd under different organic fertilization schemes had higher P and K than its initial content. However, lower soil pH, %OM and total nitrogen than the initial content was recorded. In the sensory evaluation of its organoleptic properties, no significant differences were observed in color, crispness and aroma and significant difference was observed in bitterness. Bitter gourds applied with inorganic fertilizer had the bitterest taste while those applied with vermicompost and FFJ were the least bitter.

References

Allison, F.E. 1957. Nitrogen and Soil Fertility. *Yearbook of Agriculture* 85-94.

Arfan-Ul-Haq, M., N. Ahmad, U. Farooq, H. Zafar and M.S. Ali, 2015. Effect of different organic materials and chemical fertilizer on yield and quality of bitter gourd (*Momordica charantia* L.). *Soil Environ*., 34(2): 142-147.

Ayeni, M.J., A.B. Oluwafemi and S.R. Abiodun, 2016. Effect of organic and inorganic fertilizers on the growth performance of *Solanum nigrum* L. *J. Agric. Ecology Res. Int.*, 5(4): 1-6.

Behera, T. K., K.J. John, P.W. Simon and J.E. Staub. 2010. *Bitter Gourd: Botany, Horticulture, Breeding.* Ed. Jules Janick. Wiley-Blackwell, USA.

Better Crops/Vol. 82, 1998, <http://www.ipni.net/publication/bettercrops.nsf>

Calphos Nutrient Solution, 2018, < https://www.agriculture.com.ph/2020/02/08/how-to-make-fermented-fruit-juice-for-fertilizer/>

Cefalu, W.T., J. Ye and Z.Q. Wang, 2008. Efficacy of dietary supplementation with botanicals on carbohydrate metabolism in humans. *Endocr Metab Immune Disord Drug Targets*, 8: 78–81.

Composting, 2018, <https://composting.ces.ncsu.edu/>

Corpuz, O.S. 2015. Bio-organic Fertilizer on Pechay Homegarden in Cota bato. *Turkish Journal of Agriculture and Forestry,* 3(6-1): 6-9

Dauda, S., N.L. Aliyu and U.F. Chiezey, 2005. Effects of variety, seedling age and poultry manure on growth and yield of garden egg (*Solanum gilo* L.). *Aliyu Acad. Forum,* 988-995.

Delate, K., C. Cambardella and A. McKern, 2008. Effects of organic fertilization and cover crops on an organic pepper system. *Hort. Technology*, 18: 215-226.

Dumas, Y., M. Dadomo, G. Di Lucca and P. Grolier, 2002. Effects of environmental factors and agricultural techniques on antioxidant content of tomatoes. *Sci Food Agric.,* 83: 369-382.

Ghosh, C., S. Cheetri, D.K. Rana, B. Mahato, A. Chakraborty, S.K. Bhattacharya and M.K. Bhattacharjya, 2016. Response of organic and inorganic nutrient sources on growth and yield of water melon (*Citrullus lanatus)* in red lateritic soil of Purulia, West Bengal, *International Journal of Bio-Resource, Environment and Agricultural Sciences* (*IJBEAS)*, 2(3): 387-390.

Gomez, K.A. and A.A. Gomez, 1984. *Statistical Procedures for Agricultural Research*. John wiley & sons.

Horneck, D.A., D.M. Sullivan, J.S. Owen, and J.M. Hart, 2011, Soil Test Interpretation Guide. EC 1478. <http://www.usda.gov>.

Hubilla, E.K. 2020. How to Make Fermented Fruit Juice for Fertilizer. <https://www.agriculture.com.ph/2020/02/08/how-to-make-fermented-fruit-juice-for-fertilizer/>

Joseph, B. and D. Jini, 2013. Antidiabetic effects of *Momordica charantia* (bitter melon) and its medicinal potency. *Asia Pac J. Trop Dis*., 3(2): 93-102.

Magcale-Macandog, D.B., P.M.J. Paraiso, A.R. Salvacion, R.V. Estadola, S.G.L. Quinones, I.M.A. Silapan and R.M. Briones, 2016. "An Overview of Agricultural Pollution in the Philippines: The Crops Sector." Prepared for the World Bank. Washington, D.C.

Manivannan, S., M. Balamurugan, K. Parthasarathi, and L. S. Ranganatha, 2009. Effect of vermicompost on soil fertility and crop productivity - Beans (*Phaseolus vulgaris*). *Journal Environmental Biology,* 30(2): 275-81.

Mccauley, A., C. Jones and K. Olson-Rutz, 2017. Soil pH and Organic Matter. Nutrient Management Module No. 8. 4449-8.

Mohil, P., U. Jain and S.R. Abiodun, 2016. Influence of Inorganic and Organic Fertilizers on Biomass Production of *Amaranthus sp. European Journal Experimental Biology*, 6(4): 33-37.

Mondal, K.M., 2005. Effect of Fertilizers and Ripen-15 on the Fruit Set and Yield of Cucumber (*Cucumis Sativus* L.*).* Master's Thesis. Sher-e-Bangla Agricultural University, Dhaka.

Mozafar, A. 1993. Nitrogen fertilizers and the amount of vitamins in plants: A review. *Journal Plant Nutrition,* 16(12): 2479-2506.

Peryam, D.R and F. J. Pilgrim, 1957. Hedonic scale method of measuring food preferences. In: Studies in Food Science and Technology. The methodology of sensory testing. Contribution to the IFT Symposium in Pittsburgh in Food Technology. pp 9-14

Poolperm, S. and W. Jiraungkoorskul, 2017. An update review on the anthelmintic activity of bitter gourd, *Momordica charantia. Pharmacognosy Reviews*, 11(21): 31-34.

Pullaiah, T. and K.C. Naidu, 2003. Antidiabetic Plants in India and Herbal Based Antidiabetic Research. Regency Publications, New Delhi, India, pp: 228-229

Roberts, P., D.L. Jones and G. Edwards-Jones, 2007. Yield and vitamin C content of tomatoes grown in vermicomposted wastes. *Journal of the Science Food Agriculture*, 87(10): 1957 - 1963.

Sakimin S.Z., N.A. Abd. Rahim, A.S. Juraimi, M.A. Alam and F. Aslani, 2017. Effects of fermented plant juice and fruit juice on growth and yield of tomato for sustainable practices. *Bangladesh J. Bot*., 46(1): 405-412

Slimestad, R. and M.J. Verheul, 2005. Seasonal variations in the level of plant constituents in glasshouse production of cherry tomatoes. *J. Agric. Fd. Chem*., 53: 3114 – 3119.

UNCATD, 2003. Organic Fruits and Vegetables from the Tropics. United Nations Conference on Trade & Development. United Nations, New York and Geneva, USA. p 330.

USDA Natural Resources Conservation Service, 1998, Soil Quality Indicators: pH. <www.soils/usda/gov>

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