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Impact of Composting on Growth, Vitamin C and Calcium Content of *Capsicum chinense*

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Abstract

The nutritional quality of the food has become a serious concern in existing agricultural system as the present world aims to enhance only the food production. A field experiment was carried out to study the effect of different fertilizers on growth, vitamin C and calcium content in yield of *Capsicum chinense* at Regional Agricultural Research and Development Center, Makandura consisting four treatments as without fertilizer (control/ T1), only compost (T2), compost + inorganic fertilizer (T3) and only inorganic fertilizer (T4) with a randomized complete block design (RCBD) replicating four times. Vitamin C content was measured by Indophenol dye redox titration method and calcium content was analyzed by atomic absorption spectrophotometer. Data was analyzed using analysis of variance. The highest growth was recorded in T3 and no significant differences between treatments in growth parameters at 50% flowering stage.The Vitamin C content was highest in treatment with only compost (T2) and the lowest in treatment compost + inorganic fertilizer (T3). The results indicated that yield from organically managed crops contain significantly higher amount of vitamin C (9.24±2.27 mg/100g, p= 0.0274). The highest calcium content was found in T1 (control) (1.1±0.05 %) and a significant difference (p= 0.0296) was observed between T1 (control) and T3 (calcium=0.75±0.12 %). Compost alone can be used to produce food with high amount of vitamin C. Use of inorganic fertilizer alone or integration of compost with inorganic fertilizer was less effective in producing high quality nutritious foods.

Keywords: compost, nutritional quality, food quality

1. Introduction

In the near future, the most important challenge has been to produce enough healthy food for the rising population. Therefore, high yielding, improved varieties are being cultivated in large scale by utilizing external inputs such as fertilizers, irrigation water, pesticides. “Green revolution” boosted food productivity. It significantly augmented the “quantity” of the food but decreased its “nutritional quality” and also destroyed the “chemical, physical, and the biological properties of soil” by overuse frequently (Sharma & Agarwal, 2014). A large number of experiments have been conducted to investigate a difference in the nutritional value of organically and conventionally grown food (Bourn & Prescott, 2002).

Worthington (2001) adjudged that organic crops contained significantly more vitamin C, phosphorus, magnesium and iron and lower amounts of heavy metals, less nitrates and significantly less protein but of better quality as compared with conventional crops. Similarly, Lairon (2009) stated that organic based products comprise more minerals such as Fe and Mg, dry matter and more anti-oxidant micronutrients such as salicylic acid and phenols, absence of pesticide residues and less in nitrates. Although the yield of organically managed vegetable cultivation is low, most of their sensory, nutritive and storage quality characters are better than the conventionally grown crops. The higher content of vitamin C concurrently with lower level of nitrates in organic potatoes will be a vital anti-carcinogenic influence on human beings (Rembialkowska, 2003).

Conventionally managed fruits and vegetables usually have higher pesticide residue levels, extreme higher

nitrate concentration and a lower dry matter amount than organically managed fruits and vegetables (Woese et al., 1997). Furthermore, evidence exists that extremely low contents of nitrates in organically grown spinach due to organic manuring and conflicting higher nitrate in the inorganically managed spinach due to nitrogen (N) constituent in inorganic fertilizer and higher contents of minerals such as magnesium and calcium in organically grown savoy, potassium and iron in organically grown potato (Schupan, 1972). Regardless the factors like cultivar, soil type, chemical analysis and harvest conditions, organic crop yields contained significantly higher micronutrient content especially higher amount of vitamins, higher amounts of minerals counting phosphorus compared to conventional crop yields (Hunter et al., 2011).

In contrast, Dangour et al. (2009) argued that there was no evidence about a difference in content of composition including vitamin C, nutrients such as phosphorus, potassium,calcium, copper, iron, manganese, sulphur, total soluble solids, ash, sodium, titratable acidity, specific proteins, plant non digestible carbohydrates, β-carotene and nitrates between organically and conventionally managed crops. Hoefkens et al. (2009) stated that irrespective of gender, education, place of residence (rural or urban) and income level, the conception is stronger when the consumption rate is higher. On average, non consumers also have recognized that organic vegetables have a nutritional and toxicological benefit more than conventional vegetables.

Nutritional quality of food mainly depends on the soil and crop management. Careful management is needed to obtain high yields without harming the environment. Rates of nutrients in the plant is determined by the rates of nutrients in the soil thereby directly affect to the quality of yield. In undeviating agricultural land, the soil is very poor due to unavailability of nutrients; as a result, soil becomes inefficient. Therefore, growers seek alternatives such as artificial and fast acting fertilizers, pesticides to control pests and weeds, irrigation systems and practice agricultural activities to make farming land more efficient. Among these activities, fertilization remains a priority at all times (Savci, 2012). Ogbodo (2013) identified the negative influence of long term application of inorganic fertilizers (without organic amendments and/or complementary liming) which causes acidification and that leads to the multiple nutrient deficiencies especially limitation of available phosphorus (P) in the soil. Moreover, recommended that complementary use of organic manure and lime application with mineral fertilizers to the soil as a measure of rectification the soil fertility constraints and ameliorating land productivity.

Addition of organic amendments confirmed better nutrient uptake and growth than crops under chemical fertilizer management, thus application of organic fertilizers is a soil saturate management technique to boost growth and improve plant nutrient status of cowpea crop (Badar et al.,2015). In contrast, Kandil & Gad, (2009) concluded that combined use of organic manure with inorganic soluble fertilizers afforded a significant positive effect on yield, plant growth, mineral composition and chemical constituents of broccoli. Jaipaul et al. (2011) revealed that the integrated nutrient management (recommended nitrogen, phosphorus and potassium + farmyard manure + biofertilizers) recorded highest yield since it provided a balanced and optimum amount of nutrients during various stages of crop growth.

The type of fertilizer applied significantly affected growth, nutritional quality and yield of lettuce. Different types of organic fertilizers such as chicken manure, cattle manure and bounce back compost demonstrated relatively higher number of leaves, mean leaf dry mass, plant height and marketable yield than the inorganic fertilizers (Masarirambi et al., 2010). In contrast, Oyedeji (2014) discovered that growth parameters (plant height, stem girth, number of branches from one week after transplanting except number of leaves and leaf area) and yield parameters (protein, ash, crude fibre, lipid, carbohydrate, moisture) are higher in inorganic fertilizer application (nitrogen (N) + phosphorus (P) + potassium(K)) than the poultry manure application and the control. Enhanced growth, higher fruit quality and higher yield of tomato was found in any fertilizer application whether inorganic or organic and integrated use of inorganic and organic fertilizers is beneficial than using each fertilizer type alone (Ilupeju et al., 2015).

Compost applied soil have higher carbon, nitrogen, cation exchange capacity, pH and contain extractable levels of calcium, magnesium, phosphorus, zinc, boron and molybdenum compared with the inorganic fertilizer applied soil. Though high level of nutrients in the compost added soil, it does not enhance the edible portion or leaf tissue nutrient amounts in the plant, only levels of phosphorus are significantly higher in the edible portion and phosphorus and potassium are higher in the plant leaf tissueof the plant which added fertilizer. As well the long term use of compost can produce similar amounts of elements and yields of vegetable crops (Warman, 2005).

Regular application of organic based sources especially earthworm digested organic wastes that are rich in macronutrients such as nitrogen (N), phosphorus (P), potassium (K), micronutrients and beneficial soil microbes such as nitrogen fixing bacteria, phosphate solubilizing bacteria and actinomycetes satisfies the plants growth and yield by enriching the soil and persuading as excellent growth promoters and protectors in soil (Sharma &

Agarwal, 2014).

So there is a growing need to conduct research related to the nutritional quality of foods as affected by soil fertilizer management. The main objective of this study is to determine the effect of different fertilizers on growth, vitamin C and calcium (Ca) content of *Capsicum chinense* and also to identify the most suitable management technique that enhances the nutritional quality of harvest of *Capsicum chinense*.

2. Materials and Method

2.1 Experimental Site

The study was conducted under the field conditions in the research field of Regional Agricultural Research and Development Centre (RARDC), Makandura, Gonawila (NWP) in 2016 which is in agro-ecological zone of IL1 (Low country Intermediate zone), Annual Rainfall 1500-2000 millimeters, Annual Average Temperature 27.4^0Celsius, Relative Humidity (RH) 70-80%, Altitude 29meters above mean sea level. The predominant soil type in this region is Alfisol.

2.2 Soil Sampling

Before planting, a representative soil sample consisting approximately ten cores in the field on zigzag pattern at a depth of 30 cm across the soil horizon of the experimental field was taken to determine the available nutrient elements such as phosphorus (P), potassium (K) and calcium (Ca), total organic carbon, pH and electrical conductivity (EC). Soil available phosphorus was determined using Olsen method. Potassium (K) and calcium was analyzed using atomic absorption flame photometric method. Organic carbon was determined using Walkey and Black method. Soil pH value was determined by pH meter, depends on the 1:2.5 soil: water solution and electrical conductivity was checked using suspension method (Dharmakeerthi et al., 2007).

2.3 Design & Procedure

The experiment was laid out in randomized complete block design (RCBD). There were 4 treatments and 4 replicates for each treatment. There were 20 seedlings per one replicate. As the experimental plant, *Capsicum chinense* was cultivated. The chili seeds were sown in a nursery in a propagator of an isolated area. After three weeks the seedlings were transplanted at a spacing of 60*75 cm on raised beds in the field after carrying out conventional tillage operations such as ploughing and harrowing. Irrigation was done daily as there was no precipitation during seedling and growth period of the crop.

Two types of fertilizers were used. They were compost which was produced by crop residues according to the standard procedure by the institute and the inorganic fertilizers which was supplied through the government of Sri Lanka. Inorganic nitrogen (N), phosphorus (P) and potassium (K) are supplied in the forms as urea, triple superphosphate and muriate of potash respectively.

Treatments:

T1 - Without fertilizer (control)

T2 - Only compost (crop residues)

T3 - Compost + Inorganic Fertilizer (NPK)

T4 - Only Inorganic Fertilizer (NPK)

The application rate of the compost was 20 tons per hectare. Half of the amount was applied as basal before transplanting. The inorganic fertilizer was applied according to the recommendations of Department of Agriculture, Sri Lanka (2013).

Compost sample was analyzed to determine the nutrient status and other properties of the compost. Kjeldahal method was used to analyze nitrogen content in the compost. Determination of total phosphorus was done by triacid digest of plant sample by developing vandomolymdo phosphoric yellow color. Potassium (K_2O) was analyzed using flame photometric method. Organic carbon was checked using Walkey and Black. The calcium content was measured using flame atomic absorption spectrophotometry. The pH was determined using 1:3 water solution method and the electrical conductivity was determined using 1:5 water solution method (Dharmakeerthi et al., 2007).

2.4 Data Collection

The average plant height and average canopy width were measured as growth parameters at 50% flowering stage to determine any effect of different fertilizer applications. Matured green pods were harvested in each plot separately according to random sampling technique. Each separate sample was tested for vitamin C

concentrations by indophenol dye redox titration method and calcium content was analyzed using flame photometer.

2.5 Data Analysis

The data were analyzed using Analysis of Variance (ANOVA in SAS version 9.0, 2002). Tukey multiple range test was used to identify significant differences among treatments.Microsoft Excel was used to graphical analysis of data.

3. Results and Discussion

3.1 Initial Soil Nutrient Status

The data in table below shows the chemical properties of soil such as available nutrient elements, total organic carbon, pH and electrical conductivity (EC) in the experimental field.

Table 1. Soil analysis prior to planting

Soil property	Value
Soil available phosphorus (P)	13.3 ppm
Exchangeable potassium (K)	40 ppm
Calcium (Ca)	180 ppm
Organic carbon	1.09%
Soil pH	6.17
Electrical conductivity	0.02 ds/m

The results indicated that the soil where the experiment conducted was fairly low in phosphorus, low in exchangeable potassium and organic content, moderately acidic and low electrical conductivity in accordance with the critical levels of 15 ppm phosphorus, 78 ppm potassium, 2% organic matter, 6.5-7.5 pH and 0.4-0.8 ds/m recommended for crop production (Dharmakeerthi et al., 2007). The soil itself contains high amount of calcium.

3.2 Properties of the Compost Used for the Experiment

The table 2 shows the nutrient composition and other properties of compost used for the experiment.

Table 2. Properties of compost

Property	Value of analyzed compost	Minimum % by total weight
Nitrogen	1.82%	1.0%
Phosphorus (P_2O_5)	0.51%	0.5%
Organic carbon	10.4%	20%
Potassium (K_2O)	0.18%	1.0%
Calcium (Ca)	0.8%	0.7%
Compost pH	6.21	6.5-8.5

Source: Department of Agriculture, Sri Lanka. 2011.

The results indicated that the compost contains the nutrients such as nitrogen, phosphorus, potassium, calcium and organic carbon required for the growth and development of crops. Similarly, Clark et al. (1998) stated that organic manures are rich in carbon, phosphorus, potassium, calcium and magnesium.

3.3 Growth Parameters at 50% Flowering Stage

Tables 3. The mean plant height and mean canopy width at 50% flowering stage

Treatment	**Plant height (cm)**	**Canopy Width (cm)**
T1	24.475 ± 2.058 a	30.45 ±3.032 a
T2	29.05 ± 1.218 a	35.275 ±0.867 a
T3	32.4 ± 0.501 a	41.425 ±0.756 a
T4	25.4 ± 1.594 a	32.4 ±3.211 a

Data represented as mean ± SE. Values in the column superscripted by same letter within a column are not significantly different at $p < 0.05$.

The highest growth was recorded in T3 (Compost + Inorganic fertilizer) and the lowest growth parameters were observed in the control. But there are no significant differences between the treatments. Addition of fertilizers induces higher growth than lacking any application. Similarly, Efthimiadou et al. (2009) revealed that the manure (cow manure, poultry manure and fresh barley) application had greatly affected to increase the growth and lowest height, leaf area index, dry weight and soil organic matter were resulted in the control treatment. Furthermore, Badar et al. (2015) revealed that addition of organic amendments such as coconut coir, farmyard manure and garden clippings showed significantly enhanced root length, increased shoot length and significantly increased plant fresh weight and addition of chemical fertilizer has negative effect on fresh weight and dry weight of cowpea crop. Roussos & Gasparatos (2009) reported that apple trees grown under organic management showed greater branch cross sectional area than the trees grown under conventional management but resulted similar shoot growth.

Seran et al. (2010) proved that inorganic fertilizer applied treatment showed significantly higher growth at early stages of growth but at later stage no significant differences between the organic and inorganic applied treatments and significantly higher bulb numbers in organic onion than convectional grown onion. Application of organic amendment (biosolids) enhances the plant growth and produce comparable or higher yields with less application (than standard) of inorganic fertilizer amounts particularly in sandy soil. Furthermore, organic amended plants recorded higher biomass than plants absence of organic amendments (Ozores-Hampton et al., 2005). In contrast, Kitchen et al., (2003) specified that in both marginal and moderate rainfall areas, organic farming systems produced significantly less biomass at late tillering stage and significantly less grain yield than the conventional farming systems.

3.4 The Vitamin C content

Fruits of *Capsicum* species or peppers have high amount of vitamin C (ascorbic acid) (Teodoro et al., 2013). *Capsicum chinense* (Hot peppers) accumulate phenolic compounds such as ascorbic acid, carotenoids and polyphenols. These compounds have high antioxidant ability and their consumption help in reducing certain types of diseases such as degenerative and chronic diseases in human beings (Campos et al., 2013).

With respect to the analyzed results, the vitamin C content ranged from 0.6 mg/100g to 17.4 mg/100g in *Capsicum chinense.*

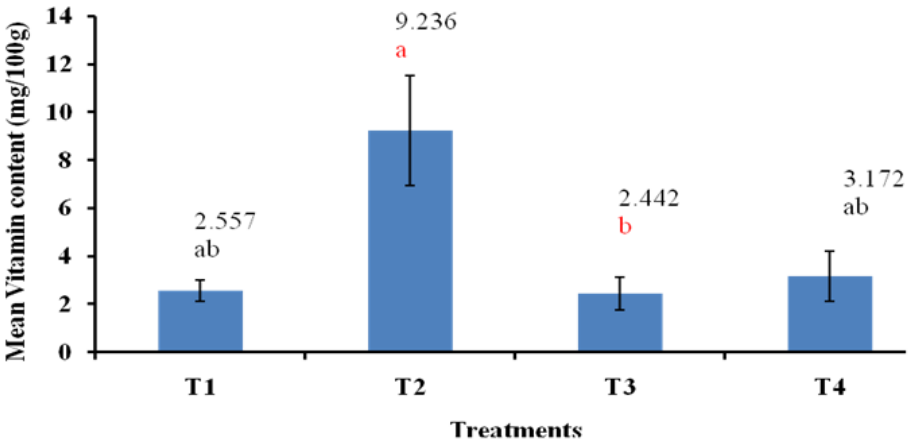

Figure 1. Mean value of vitamin C mg per 100g of capsicum. Vertical T bars indicate standard deviations. Means with the different letters indicate a significant ($P < 0.05$) difference

Results clearly indicate that organic management has contributed to the production of ascorbic acid in capsicum. The results from statistical analysis have shown that compost application (T2) is significant (under alpha level 5%, p value is 0.0274). So, effect of organic management on ascorbic production was clearly observed. Magkos et al.(2003) showed that in organically managed leafy vegetables and potatoes have higher ascorbic acid content, lower protein content with higher quality in cereal crops and some vegetables.

The lowest value for vitamin C was observed in T3 (organic fertilizer + inorganic fertilizer). Hamouz et al. (2009) concluded that higher levels of nitrogen fertilization affect negatively, higher levels of potassium and magnesium fertilization had no effecton the production of vitamin C in potatoes.

Production of vitamin C mainly depends on plant metabolism, nutrient and water supply by the soil. However, influence of soil microbes on assisting the plants to produce compounds like ascorbic acid cannot be underestimated. Therefore, the addition of synthetic fertilizers and lack of nutrient supply may have resulted unsatisfactory production of vitamin C in the control, T3 (Organic fertilizer + Inorganic fertilizer) and T4 (Only Inorganic fertilizer). Seran et al. (2010) stated that addition of organic fertilizer enhances organic matter content in soil and with the addition of inorganic fertilizers, activities of soil macro and micro organisms are reduced when compared to organic fertilizers. Lin et al., (2004) discovered a minor effect of nitrogen fertilization on the ascorbic acid content, only high quantities of nitrogen fertilizer application leads to significant reduction of ascorbic acid content and the yield reduction in tuber crop yields.

Organically cultivated strawberries had significantly higher ascorbic acid (9.7% more), total antioxidant activity (8.5% more), total phenolics (10.5% more), better appearance and taste and high dry matter content than conventionally cultivated strawberries (Reganold et al., 2010). Similarly Chauhan et al., (2006) reported that soil microorganisms positively effect on plants: recycle organic matter and nutrients, make availability of nutrients to plants, excrete enzymes and other nutritious substances that stimulate plant feeding.

3.5 The Calcium Content

Calcium is very essential in building strong bones and teeth, muscle contraction, nerve impulse,oocyte activation, blood clotting, fluid balance within cells, transmission and regulating heartbeat. Long duration of calcium deficiency able to cause osteoporosis and then increased risk of fractures (Pravina et al., 2013).

The results revealed that calcium content in the mature pods ranges from 0.6% to 1.2%.

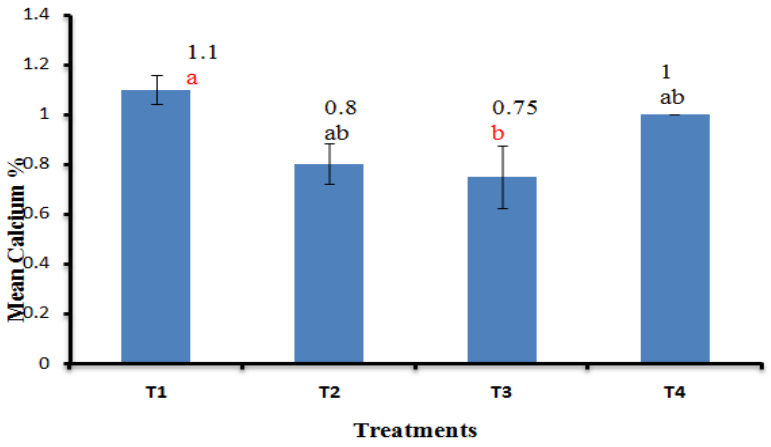

Figure 2. Mean value of calcium content in different treatments (%).Vertical T bars indicate standard deviations. Means with the different letters indicate a significant ($P < 0.05$) difference

Results show that a significant difference (under alpha level 5%, p value is 0.0296) between the T1 (control) and T3 (Organic fertilizer+inorganic fertilizer). Soil itself is rich with calcium to reach 1.1% in T1 (control). So, when organic matter is added part of free available calcium may have been adsorbed in to colloidal sites of humic substances present in organic matter. As a result, entry of calcium into the plants under the condition of treated organic matter may have been lowered. In accordance to Hecjman et al. (2013) a significant positive difference was observed in fertilizer treatments on nitrogen, phosphorus and potassium concentrations in the grain and quantity of grain yield when compared with the control, but no significant difference on calcium and magnesium concentrations in the grain yield. Warman (2001) stated that the Mehlich-3 extractable calcium (Ca), lead (Pb), manganese (Mn) content and cation exchange capacity (CEC) were higher of compost added soils.

4. Conclusion

Compost is an efficient soil amendment rich in essential nutrients and beneficial elements. Thus improve the nutritional quality of the yield, improved by organic conditions. Growth of the crop has not affected by the type of fertilizer used whether compost or inorganic fertilizer. The nutrient content in the soil significantly influences to enhance the nutrient content in the harvest. Use of inorganic fertilizer alone or integration of compost with inorganic fertilizer was less effective in producing high quality nutritious foods. The results clearly indicate that compost alone can be used to produce food with high amount of vitamin C.

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