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Full Length Research Paper

The effects of mineral and liquid organic fertilizers on some nutritional characteristics of bell pepper

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The economical effect of liquid organic fertilizer on agriculture may be a factor in the extension of its practice in larger areas. The rates of compost required to supply sufficient N requirements might be economically challenging for farmers. Therefore, the organic liquid fertilizers might help in reducing the need of high rates of compost to maintain proper N amount and in reducing the expenses. The objective of this study was to investigate the effects of mineral and liquid organic fertilizers on some nutritional characteristics of bell pepper. Results show that the main effects and interaction between cultivars and fertilizers were not statistically singificant on the subject parameters in this experiment. However, the application of mineral fertilizer resulted in the highest ascorbic acid content in fresh fruits (110.07 mg 100 g^{-1}). In comparison with liquid organic fertilizers, mineral fertilizer had higher levels in other parameters such as lipids (8.16 g 100 g^{-1}), fruit dry matter (13.39 g 100 g^{-1}), K (18.5 g kg^{-1}), Ca (0.83 g kg^{-1}), Mg (0.98 g kg^{-1}), Mn (7.9 mg kg^{-1}) and S (0.21 mg kg^{-1}). Ascorbic acid, protein and dry matter content were affected by the colour of fruit. Also, a higher ascorbic acid and Ca, acorbic acid and Mg, lipid and Ca contents suggest a positive correlation between these parameters. However mineral fertilizers had more favorable effects on quality of bell pepper, our results indicated that liquid organic fertilizers might be considered sufficient as a source of nutrients in organic growing.

Key words: Bell pepper, liquid organic fertilizer, quality, mineral fertilizer, ascorbic acid, mineral content.

INTRODUCTION

Over the last few years, consumer awareness of food-safety issues and environmental concerns has increased the interest in organic farming (Bavec and Bavec, 2007). Almost from the beginning, arguments were gradually raised about organic growing practices. Numerous re-searchers have compared organic and conventional growing techniques and have revealed reasonable contradictory findings on organically grown products (their quality and yield). Foods and vegetables are the main topic of this controversy due to their significance as being source of antioxidants (Mitchell and Chassy, 2004). There has also been a concern for hygiene of composts. Most findings from comparative studies show that compost does not improve the yield (Flores et al., 2009; del Amor, 2007; Evanylo et al., 2008; Gül et al., 2007, Toor et al., 2006), on the other hand however, some findings indicate that organic fertilizers sufficient to produce vigorous, healty and high yielding plants at levels comparable to plants treated with synthetic N fertilizers (Olaniyi and Akanbi, 2007), and also that yield is higher when compost combined with bio N and mineral N (Ghoname and Shafeek, 2005).Nonetheless, both conventional and organic agricultural practices consist of dynamics that represent variations, depending upon the regions, soil quality, pests, growing season, grower, farm, sampling time, climate and genotype. Therefore making comparisons between these systems is very difficult (Mitchell and Chassy, 2004; Barrett et al., 2007; Mitchell et al., 2006).

Fertilization is one of the most important dynamic to consider, when making comparisons between organic and conventional agriculture practises. There is a wide range of organic wastes and by-products that are available for plant nutrition in organic growing such as

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Table 1. Average climate data (months) at the time when the experiment was conducted*.

Month	Average temperature (°C)	Average insolation (h)	Average number of days with precipitation	Average amount of precipitation (kg m^{-2})
May	16.7	7.8	8.1	38.7
June	21.3	9.2	7.1	36.1
July	23.7	9.9	3.8	25.6
August	23.6	9.0	3.1	15.7

*Data obtained from Turkish State Meteorological Service (TSMS).

poultry manure, cattle manure, plant residues, etc. Nevertheless, because of their complex composition, it is very challenging to apply sufficient amount that will provide plant requirements (Mitchell and Chassy, 2004).
Although, it has proven to be valuable to improve the organic matter content, fertility, porosity, water holding capacity and bulk density of soil through the addition of organic composts (Zaccheo et. al., 2002, Evanylo et al., 2008; Mitchell et al., 2006), more quickly with the higher rates (Evanylo et al., 2008), some practices show that organic composts do not provide nitrogen in a form that is as readily accessible to plants as conventional fertilizers because of their high resistance to degradation (Zaccheo et al., 2002), and of a slower rate of availability and mineralization of nutrients from the organic composts (Toor et al., 2006; del Amor, 2007).

Consequently, the yield of the crops is declined. Or it is difficult to say that improvements in soil physical properties benefit yield unless higher rates of compost is applied to soil (Evanylo et al., 2008). On the other hand, some results indicate that the slower release of nitrogen, as occurs when manure is substituted for synthetic fertilizers, results in higher polyphenol concentration in food (Rosen, 2008), thus organic food compared to conventional ones has more health-promoting substances. It appears that the most strong influence or differences between organic and conventional systems is the quantity and behavior of N (Mitchell et al., 2006).

The economics of organic agriculture may be a factor in the extension of its practice to larger areas since the rates of compost required to supply sufficient N requirements might be economically challenging for farmers (Evanylo et al., 2008). Therefore organic liquid fertilization products can help in reducing the need for high rates of compost to maintain proper amount of nutrients and hence in reducing the expenses.

Sweet pepper fruits are a rich source of vitamin C, polyphenols, chlorophylls, carotenoids, sugars (Flores et al., 2009), magnesium, calcium, potassium, phosphorus and iron (Jadczak et al., 2010). Peppers, with 1 796 180 mt (Anonymous, 2011), are some of the most commonly produced vegetable in Turkey. Bell pepper production, especially for trade markets, is also on the increase in Turkey. Although, due to its relatively long-term vegetation period, pepper has high nutrient demands, yield in sweet pepper does not necessarily increase with a higher dosage of nitrogen (Amor, 2006). In addition, the ascorbic acid content has been found to decrease in sweet pepper, and no differences in antioxidant concentrations are observed with increasing fertilizer application (Flores et al., 2009). Therefore it was concluded that nitrogen dosage should be limited to 120 ppm, and fertilizer requirements were calculated by this limitation.

The aim of this research was to investigate the effects of mineral and liquid organic fertilizers on some nutritional characteristics of bell pepper, and to understand better, the response of pepper plant fed with organic nutrient solution to provide more nutrient to plants.

MATERIALS AND METHODS

The experiment was carried out in the experimental field of the Horticulture Department, Faculty of Agriculture, Namik Kemal University, in Tekirdag, Turkey (40° 59' N, 27° 29' E) during late spring-summer growing season in 2009.

The cultivars used 'California Wonder types', were Red Wonder F_1 (MayAgro Seed Co.) and Yellow Bell (United Genetics Seeds Co.). Seeds were sown in trays containing peat, and incubated at 20°C until germinated. Seedlings were transferred to multicelled trays (200 ml each cell) at the cotyledonary leaf stage; soil transplantation was carried out at the 4 to 5 true leaf stage.

In the experiment, one inorganic and two organic liquid fertilizers were used; the two organic fertilizers used were commercially available products (Biofarm). The first organic fertilizer (OF1; 120 ppm N, 48 ppm P_2O_5, and 40 ppm K_2O) was originated from vegetale sources and contained 7.5% N, 3% P_2O_5, 2.5% K_2O, 35% organic matter, and 20% amino acid and the second originated from animal and vegetale sources, and contained 4% N, 2% P_2O_5, 3.5% K_2O, 35% organic matter, 5% humic acid and 19% fulvic acid (OF2; 120 ppm N, 60 ppm P_2O_5, and 105 ppm K_2O) while the mineral fertilizer (MF; 120 ppm N, 60 ppm P_2O_5, 105 ppm K_2O) contained KNO_3, NH_4NO_3 and $(NH_4)_2HPO_4$. Suspensions of all fertilizers were applied into the soil, from transplanting onwards, once every third watering.

The soil was silty-clay loam containing 0.078% N, 0.86% Ca, 35 ppm P, 270 ppm K, 470 ppm Mg, 7.8 ppm Fe, 0.8 ppm Cu, 0.5 ppm Zn, 8.9 ppm Mn with a pH of 7.66. The organic matter was 1.56 and electrical conductivity (EC) was 0.088%. Climatic data during the experiment are presented in Table 1.

Data collection and analytical methods

At the conclusion of the experiment, the following characteristics of fruits were studied: ascorbic acid in dry and fresh samples (mg 100 g $^{-1}$), crude protein (g 100 g^{-1}), lipids in fresh samples (g 100 g^{-1}),

Table 2. Effects of mineral and liquid organic fertilizers on ascorbic acid content in dry and fresh fruit of bell pepper.

Cultivar/ fertilizer	Ascorbic acid content in dry fruit (mg 100 g^{-1})			Ascorbic acid content in fresh fruit (mg 100 g^{-1})		
	Red Wonder F_1	Yellow Bell	Mean	Red Wonder F_1	Yellow Bell	Mean
OF1	17.41	10.15	13.78	23.52	28.23	25.88
OF2	18.35	11.16	14.75	112.04	23.06	67.55
MF	17.58	11.20	14.39	69.20	150.94	110.07
Mean value	17.78	10.83	-	68.25	67.41	-
LSD *(p = 0.05)*	ns	ns	ns	ns	ns	-

OF1, Organic fertilizer 1 (120 ppm N, 48 ppm P_2O_5, 40 ppm K_2O); OF2, organic fertilizer 2 (120 ppm N, 60 ppmP_2O_5, 105 ppm K_2O); MF, mineral fertilizers (120 ppm N, 60 ppm P_2O_5, 105 ppm K_2O

dry matter (g 100 g^{-1}) and mineral content (%, ppm).

Fruits used for analysis were collected from plants cultivated in the central of each parcel. Collected samples were washed and dried in a ventilated oven at 65°C for mineral content and at 105°C for dry matter. Ascorbic acid content of fresh and dry samples were estimated with titrimetric method and calculated by the following equation (Anonymous, 1983):

Ascorbic acid (mg 100 g^{-1}) = $V_2 * 0.2 * 100 / (V_1 – V_0)* m$

Where, V_2 is the volume of colour solution used (ml), V_1 is the volume of colour solution used for the titration of standard ascorbic acid solution (ml), V_0 is the volume of colour solution used for blank (ml), and m is the sample weight of filtrate used in titration (g).

The fruit samples were analyzed for crude protein contents based on nitrogen analysis, utilizing the Kjeldahl method according to the Association of Official Analytical Chemists International (AOAC) and crude protein content was also estimated, using a nitrogen conversion factor of 6.25 (AOAC, 1990). Lipid extraction from the samples was carried out by hexane extraction under the operating conditions specified by International Union of Pure and Applied Chemistry (IUPAC), standard methods for the analysis of oils, fats and derivaties no. 1.121 and expressed as a percentage by dry matter of the product.

Nitrogen content of the fruits was determined by Kjeldahl method and P, K, Ca, Mg, Cu, Zn, Mn, Fe and S contents were determined by Inductively Coupled Plazma Atomic Emission Spectrometer (Varian-Vista Model Axial Simultaneous).

Cultivation and irrigation practices

Seedlings of bell pepper cultivars were planted in soil on May 11 within and between row distances of 0.4 and 0.6 m respectively. Weeding was carried out when the need arose during the growing periods. Number of main stem-shoot on each plant was limited to three and no fruit thinning was performed on each shoot. Furrow irrigation was used regularly to maintain a constant water level for steady plants.

Statistical analysis

A randomized complete block design with six replicates was set up. Statistical analysis was performed with the aid of the SPSS statistical package (17.0 for Windows) and least significant differences between the means were calculated for 5%.

RESULTS AND DISCUSSION

Results show that the main effects and interaction between cultivars and fertilizers were not statistically significant on subjected parameters in the experiment. Ascorbic acid (AA) content of dry fruit varied from 10.15 to 18.35 mg 100 g^{-1}, while that of fresh fruit varied from 23.00 to 150.94 mg 100 g^{-1} (Table 2). In the dry samples, the main difference resulted from cultivars. Regarding cultivars, cv. Red Wonder F_1 gave the highest AA content both in dry and fresh samples, though differences were slight in fresh samples.

Regarding fertizers and cultivars interaction in dry samples, all fertilizer applications resulted in higher AA content with cv. Red Wonder $F_{1,}$ than with cv. Yellow Bell, though in fresh samples, cultivars' response to fertilizer applications differed. In fresh samples, the highest AA content was obtained from MF treated Yellow Bell plants with 150.94 mg 100 g^{-1}, and the lowest AA content was obtained from OF2 treated Yellow Bell plants with 23.06 mg 100 g^{-1} and OF1 treated Red Wonder F_1 plants with 23.52 mg 100 g^{-1} indicating that both fertilizer and cultivars effected the ascorbic acid content (Szafirowska and Elkner, 2008; Simonne et al., 1997; Chassy et al., 2006).

In contrast with the work of Szafirowska and Elkner (2008), in this study, application of mineral fertilizer resulted in the highest AA content of fresh samples. On the other hand, our result is in line with that of the study of Barrett et al. (2007) in which they reported that the AA content of raw tomato was lower with organic fertilizers. However, in contrast with the results of this study, it should be mentioned that Barrett et al. (2007) pointed out that AA content of microwaved tomato was also lower with organic fertilizers.

In support of this study, Rosen (2008) reported that the analysis of 46 valid matched pairs for AA or vitamin C content favored organic produce by a score of 29 to 17. In agreement with the work of Premuzic et al. (1998), a positive correletion between AA and Ca ($P \leq 0.043$) and AA and Mg ($P \leq 0.036$) content was found (data not presented).

It is known that processing can cause a reduction in AA content (Lee and Kader, 2000; Eleyinmi et al., 2002), hence it is not unlikely that AA content of fresh samples were higher than AA content of dry samples. However, the highest AA reduction was observed with different

Table 3. Effects of mineral and liquid organic fertilizers on crude protein, dry matter of fruit, N and lipid content of bell pepper fruit.

Fertilizer	Cultivar	Crude protein (mg 100 g^{-1})	Dry matter of fruit (g 100 g^{-1})	N (g 100 g^{-1})	Lipid (g 100 g^{-1})
OF1	Red Wonder F_1	5.50	12.96	1.37	10.03
	Yellow Bell	4.54	13.21	1.42	5.82
	Mean	5.02	13.08	1.39	7.92
OF2	Red Wonder F_1	8.85	10.52	1.54	6.13
	Yellow Bell	4.96	13.51	1.48	5.60
	Mean	6.90	12.01	1.51	5.86
MF	Red Wonder F_1	5.00	11.19	1.14	6.28
	Yellow Bell	6.22	15.59	1.68	12.05
	Mean	5.61	13.39	1.41	8.16
	LSD (p=0.05)	ns	ns	ns	ns
Cultivar main effect	Red Wonder F_1	6.45	11.55	1.35	7.48
	Yellow Bell	5.24	14.10	1.52	7.82
	LSD (p=0.05)	ns	ns	ns	ns

OF1, Organic fertilizer 1 (120 ppm N, 48 ppm P_2O_5, 40 ppm K_2O); OF2, organic fertilizer 2 (120 ppm N, 60 ppmP_2O_5, 105 ppm K_2O); MF, mineral fertilizers (120 ppm N, 60 ppm P_2O_5, 105 ppm K_2O); ns, not significant.

fertilizer applications and different cultivars. The highest AA reduction was observed with MF applied Yellow bell plants (93%) and OF2 applied cv. Red Wonder F_1 plants (84%).

It has been reported that N dosages and antioxidant activity are negatively correlated (Flores et al., 2009; del Amor, 2007). While yield increases with the increase in N, vitamin C and mineral content decrease with the increase in N due to the dilution effect (Flores et al., 2009) or stress condition (del Amor, 2007). Due to the fact that applied nitrogen was limited to 120 ppm in our work, a decrease in AA content could not be explained by high rates of N. The major differences between organic and mineral fertilizers used in this research was that organic fertilizers contained 35% of organic matter and other additional sources (amino acid, humic and fulvic acids), and N, P_2O_5 and K_2O contents of OF2 and MF were the same. From this view point, we can speculate that organic matter supply did not improve ascorbic acid content in bell pepper either.

For the cases in which MF fertilizer resulted in higher AA content related to organic liquid fertilizers in fesh fruits and cv. Red Wonder F_1 which had a higher AA content than Yellow Bell in both fresh and dry fruits, it might be argued that both cultivar and fertilizer affected the AA content of bell pepper.

Regarding the main effect of fertilizers on the lipids and dry matter of fruit, the highest and the lowest percentages were obtained from MF and OF2 treated plants respectively. In respect to the effect of fertilizers on crude protein and N content, the highest and the lowest values were obtained from OF2 and OF1 respectively (Table 3). With respect to the interaction, the highest dry matter of fruit (15.59 g 100 g^{-1}) was from MF treeated cv. Yellow Bell plants, and the lowest (10.52 g 100 g^{-1}) was from the OF2 treated cv. Red Wonder F_1 plants. Considering N content of fruit, the highest (1.68 g 100 g^{-1}) and the lowest (1.14 g 100 g^{-1}) levels were obtained from MF treated cv. Yellow Bell and MF treated cv. and Red Wonder F_1 plants respectively. The lipid content was highest with MF treated cv. Yellow Bell (12.05 g 100 g^{-1}) and lowest with the OF2 treated cv. Yellow Bell (5.60 g 100 g^{-1}). The crude protein was highest with the OF2 treated cv. Red Wonder F_1 (8.85 mg 100 g^{-1}) and lowest with the OF1 treated cv. Yellow Bell (4.54 mg 100 g^{-1}) (Table 3).

It has been reported that ascorbic acid, protein and mineral content of bell pepper were affected by the colour of fruit (Simonne et al., 1997). In our experiment, with regards to the cultivar main effect, it should be emphasized that while cv. Yellow Bell plants had higher lipids and N content and dry matter of fruit, it had lower crude protein content related to cv. Red Wonder F_1 plants (Table 3). A higher concentration of Ca, as in AA content of fruit, and lipids suggest a positive correletion of lipids and Ca content ($P \leq 0.028$).

Higher crude protein content of cv. Red Wonder F_1 with organic liquid fertilizers and of cv. Yellow Bell with mineral fertilizer together with the fertilizer main effect mentioned before indicate that protein content of bell pepper was effected by fertilizer and cultivar as well as the colour of fruit. Also, as the OF2 and MF had more

Table 4. Effects of mineral and liquid organic fertilizers on fruit mineral content of bell pepper fruit (dry matter basis).

Fertilizer	Cultivar	P (g kg^{-1})	K (g kg^{-1})	Ca (g kg^{-1})	Mg (g kg^{-1})	Cu (mg kg^{-1})	Zn (mg kg^{-1})	Mn (mg kg^{-1})	Fe (mg kg^{-1})	S (mg kg^{-1})
OF1	Red Wonder F_1	2.2	16.7	0.75	0.80	8.80	10.7	7.6	57.0	0.13
	Yellow Bell	2.2	18.7	0.50	0.97	8.30	11.8	7.7	43.2	0.17
	Mean	2.2	17.7	0.62	0.88	8.55	11.3	7.6	50.1	0.15
OF2	Red Wonder F_1	2.5	18.8	0.75	1.00	8.50	11.0	8.0	46.0	0.13
	Yellow Bell	2.2	17.6	0.56	0.80	7.19	10.2	6.5	36.7	0.14
	Mean	2.3	18.2	0.65	0.90	7.84	10.6	7.2	41.3	0.13
MF	Red Wonder F_1	2.0	16.8	0.67	0.87	7.60	9.5	6.9	41.8	0.14
	Yellow Bell	2.7	20.3	1.00	1.10	8.30	11.5	8.9	38.7	0.18
	Mean	2.3	18.5	0.83	0.98	7.95	10.5	7.9	40.2	0.21
	LSD (p=0.05)	ns	ns	ns	Ns	ns	ns	ns	ns	ns
Cultivar main effect	Red Wonder F_1	2.2	17.4	0.72	0.89	8.30	10.4	7.5	48.2	0.13
	Yellow Bell	2.3	18.8	0.68	0.95	7.93	11.1	7.7	39.5	0.16
	LSD (p=0.05)	ns	ns	ns	Ns	ns	ns	ns	ns	ns

OF1, Organic fertilizer 1 (120 ppm N, 48 ppm P_2O_5, 40 ppm K_2O); OF2, organic fertilizer 2 (120 ppm N, 60 ppmP_2O_5, 105 ppm K_2O); MF, mineral fertilizers (120 ppm N, 60 ppm P_2O_5, 105 ppm K_2O); ns, not significant.

phosphorus and potassium rates than OF1, it can be suggested that, a higher rates of P and K have a positive effect on protein content of bell pepper. In agreement with the work by Kaya et al. (2008), fruit dry matter of pepper was lower by the organic fertilizer treatments compared to the mineral fertilizer. On the other hand however, fertilizer effect was slight. In our study, responses of cultivars to fertilizers indicate a more strong influence of cultivar on dry matter of fruit as was in the work of Jadczak et al. (2010).

Regarding the main effect of fertilizer, it was observed that, though there were slight differences between treatments and even for some parameters values were at par, Fe, Zn ve Cu content of fruits were higher with OF1 and K, Ca, Mg, Mn, and S content were higher with MF than those with other fertilizers (Table 4).

With regard to the cultivars, Ca, Cu and Fe contents of fruits were higher with cv. Red Wonder F_1, while K, Mg, Zn, Mn and S content of fruits were higher with cv. Yellow Bell. With regard to fertilizers and cultivars' interaction, while P, K, Ca, Mg, Mn and S content of fruits were higher with MF treated cv. Yellow Bell plants, Cu and Fe content of fruits were higher with OF1 treated cv. Red Wonder F_1. (Table 4).

It could be emphasised that values higher with cv. Yellow Bell are also higher with MF. In line with the report of Suarez et al., (2008), the findings indicated that the influence of the cultivation method on mineral and trace element contents might be depended on the cultivar and the cultivation method affected the minerals more than the trace element content. As it is seen in Table 4, the highest P, K, Ca, Mg, Mn and S content of fruit was obtained from MF treated Yellow Bell plants.

There are many factors influencing mineral element content of fruit and these factors might act at the same time (Toor et al., 2006). But it may be said that regarding the mineral content of pepper, although effects were not significant, mineral fertilizers generally gave the highest values.

Conclusion

From the view point of this work, it seems pepper differs from the other vegetables for its response to mineral fertilization (Flores et al., 2009; Chassy et al., 2006). In agreement with the work of Chassy et al. (2006), in which the authors stated that no significant differences was found for bell pepper in nutrient related compounds, while tomato was found to be responsive when the organic and conventional systems were compared by a three-year cropping, our results show that fertilizers were not statistically significant on the subjected parameters in the experiment. Also, the main effect and interaction between the cultivars and fertilizers were not statistically significant.

Even so, ascorbic acid content was higher with the use of mineral fertilizer compared to the use of organic liquid fertilizers in this study.

The higher ascorbic acid, protein and dry matter content of cv. Red Wonder F_1 indicate that those parameters were affected by the colour of the fruit. The higher ascorbic acid and Ca, ascorbic acid and Mg, and lipid and Ca contents indicate a positive correlation between these patameters.

Even though fertilizers had no significant effect on the nutritional content of fruit, for the most of the parameters such as ascorbic acid, lipids, fruit dry matter and K, Ca, Mg, Mn and S mineral fertilizer produced higher levels compared to liquid organic fertilizers. However, this study is limited to the selected cultivars, type of soil, growing season, time of sampling and environment of research facility but it can be speculated that liquid organic fertilizers might be considered sufficient as a source of nutrient in organic growing practices.

REFERENCES

Anonymous (1983). Gida maddeleri muayene ve analiz metodları. Tarım Orman ve Köyişleri Bakanlığı Koruma ve Kontrol Genel Müdürlüğü (Kod No: 2.01-248.01Titrimetrik Yöntem ile Askorbik Asit Tayini (74-76), Ankara, Türkiye.

Anonymous (2011). http://faostat.fao.org/site/339/default.aspx (06.08.2011).

AOAC (1990). Official methods of analysis, Association of Official Analytical Chemists International, Arlington, VA, edn. 16.

Barrett DM, Weakley C, Diaz JV, Watnik M (2007). Qualitive and nutritional differences in processing tomatoes grown under commercial organic and conventional production systems. J. Food Sci. 72(9): 441-451.

Bavec F, Bavec M (2007). Organic production and use of alternative crops. Taylor & Francis Group, LLC, USA, p. 230.

Chassy AW, Bui L, Renaud ENC, Van Horn M, Mitchell AE (2006). Three-year comparison of the content of antioxidant microconstitutents and several quality characteristics in organic and conventionally managed tomatoes and bell peppers. J. Agric. Food Chem. 54(21): 8244-8552.

Amor FM (2007). Yield and fruit quality response of sweet pepper to organic and mineral fertilization. Renewable Agric. Food Syst. 22(3): 233-238.

Eleyinmi AF, Ilelaboye NOA, Aiyeleye FB, Akoja SS (2002). Effect of different pre-drying operations on some nutritionally valuable minerals, ascorbic acid and rehydration index of *Capsicum* species. Trop. Agric. Res. Extension, 5(1 & 2): 57-61.

Evanylo G, Sherony C, Spargo J, Starner D, Brosius M, Haering K (2008). Soil and water environmental effects of fertilizer-, manure-, and compost-based fertility practices in an organic vegetable cropping system. Agric. Ecosyst. Environ. 127: 50-58.

Flores P, Hellin P, Fenoll J (2009). Effect of manure and mineral fertilization on pepper nutritional quality. J. Sci. Food. Agric. 89(9): 1581-1586.

Ghoname A, Shafeek MR (2005). Growth and fertility of sweet pepper (*Capsicum annum* L.) grown in plastic house as affected by organic, mineral and bio-N-fertilizers. J. Agro. 4(4): 369-372.

Gül A, Kıdoğlu F, Anaç D (2007). Effect of nutrient sources on cucumber production in different substrates. Scientia Horticulturae, 1132: 216-220.

Jadczak D, Grzeszczuk M, Kosecka D (2010). Quality characteristics and content of mineral compounds in fruit of some cultivars of sweet pepper (*Capsicum annuum* L.). J. Elementol. 15(3): 509-515.

Kaya S, Caturano E, Tuzel Y, Okur N, Leonardi C (2008). Response of tomato plants to organic nutrition in soilless culture. J. Food Agric. Environ. 6(2): 303-305.

Lee SK, Kader AA (2000). Preharvest and postharvest factors influencing vitamin C content of horticultural crops. Postharvest Biol. Technol. 20(3): 207-220.

Mitchell AE, Chassy AW (2004). Nutritional quality and organic agriculture. The Soy Connection 12(4): 3-5

Mitchell AE, Hong Y, Koh E, Barrett DM, Bryant DE, Denison F, Kaffka S (2006). Ten-year comparison of the influence of organic and conventional crop management practices on the content of flavonoids in tomatoes. J. Agric. Food. Chem. 54(21): 8244-8252.

Olaniyi JO, Akanbi WB (2007). Effect of organo mineral and inorganic fertilizers on the yield quality of fluted pumpkin (*Telfaria occidentalis* hook. F.). Afr. Crop Sci. Confr. Proc. 8: 347-350.

Premuzic Z, Bargiela M, Garcia A, Rendina A, Iorio A (1998). Calcium, iron, potassium, phosphorus and vitamin C content of organic and hydroponic tomatoes. Hort. Sci. 33(2): 255-257.

Rosen JD (2008). Claims of organic food's nutritional superiority: A critical review. American Council on Science and Health, USA, p. 15.

Simonne AH, Simonne EH, Eitenmiller RR, Mills A, Green NR (1997) Ascorbic acid and Provitamin A contents in unusually colored bell peppers (*Capsicum annuum* L.) J. Food Comp. Anal. 10: 299-311.

Suarez MH, Rodriguez RE, Romero CD (2008). Analysis of organic acid content in cultivars of tomato harvested in Tenerriffe. Eur. Food Res. Technol. 226: 423-435.

Szafirowska A, Elkner K (2008). Yielding and fruit quality of three sweet pepper cultivars from organic and conventional cultivation. Vegetable Crops Res. Bull. 69: 135-143.

Toor RK, Savage GP, Heeb A (2006). Influence of different types of fertilizers on the major antioxidant components of tomatoes. J. Food Composit. Anal. 19: 20-27.

Zaccheo P, Cabassi G, Ricca G, Crippa L (2002). Decomposition of organic residues in soil: Experimental technique and spectroscopic approach, Organic Geochem. 33: 327-345.