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Influence of Agricultural Practices on Fruit Quality of Bell Pepper

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Abstract: An experiment was carried out under plastic house conditions to compare the effect of four fermented organic matter sources (cattle, poultry and sheep manure in addition to 1:1:1 mixture of the three organic matter sources) in which 4 kg organic matter m^{-2} were used, with that of the conventional agriculture (chemical fertilizers) treatments on Marvello red pepper fruit quality, by using a Randomized Complete Block Design (RCBD) with four replicates. Pepper fruits characteristics cultivated in soil supplemented with manure were generally better than those from plants grown in soil only. Addition of animal manure increased bell pepper fruit content of soluble solids, ascorbic acid, total phenols, crude fibre and intensity of red color as compare with conventional agriculture that produced fruits with higher titratable acidity, water content, lycopene and bigger fruit size. In most cases of animal manure treatments, best results were obtained by the sheep manure treatment that produced the highest TSS, while the worst results were obtained by the poultry manure treatment that produced the smallest fruit and lowest fruit lycopene content.

Key words: *Capsicum annum*, phenols, ascorbic acid, lycopene, manure

INTRODUCTION

Bell pepper (*Capsicum annum* L.) which belongs to the Solanacea family, is one of the most varied and widely used foods in the world; it was originated in the Mexico and Central America regions and Christopher Columbus encountered it in 1493 (Kelley *et al*., 2009). A phenolic compound called capsaicin is responsible for the pungency in peppers. Pepper is grown as an annual crop due to its sensitivity to frost; pepper is actually a herbaceous perennial and will survive and yield for several years in tropical climates (Kelley *et al*., 2009; Peet, 1995). One medium green bell pepper can provide up to 8%of the Recommended Daily Allowance of Vitamin A, 180% of Vitamin C, 2% of calcium and 2% of iron (Kelley *et al*., 2009).

Consumer awareness of the relationship between foods and health, together with environmental concerns, has led to an increased demand for organically produced foods. In general the public perceives organic foods as being healthier and safer than those produced through conventional agricultural practices (Jolly, 1989). Consumers demand organic products because they believe they are more flavorful and respectful to the environment and human health (Perez-Lopez *et al*., 2007b). Organic foods have a nutritional and sensory advantage when compared to their conventionally produced counterparts. Advocates for organic produce claim it contains fewer harmful chemicals, is better for the environment and may be more nutritious (Mitchell and Chassy, 2005). Sweet pepper fruits are an excellent source of health promoting substances, particularly antioxidants, ascorbic acid (vitamin C), polyphenols, carotenoids and sugars (Leja *et al*., 2008; Howard *et al*., 2000; Jadczak *et al*., 2010).

A carotene (lycopene) which provides protection against cancer is also present in red bell peppers (Perez-Lopez *et al*., 2007a); lycopene ranged from 0.18-0.36 mg/100 g f. wt.-depending upon cultivars and was found to be higher in conventional agriculture than organically produced pepper (Hallmann and Rembialkowska, 2008).

The accessibility of nitrogen has the potential to influence the synthesis of phenolic antioxidants and soluble solids and there is a decrease in the concentration of phenolic antioxidants in plants with increasing nutrient availability (Doll *et al*., 1994). Organic red peppers could be considered as those having the highest antioxidant activity of all studied peppers compared to conventional one (Hallmann and Rembialkowska, 2008; Perez-Lopez *et al*., 2007b).

Addition of sheep manure increased bell pepper fruit soluble solids content and decreased titratable acidity values compared to the unamended soil, while their pH was significantly lower. It was found that amounts and characteristics of pepper fruits from plants cultivated in soil supplemented with manure were generally better than those from plants grown in soil only (Liaven *et al*., 2008).

Ascorbic acid, known as vitamin C, needs to be consumed via food or medicine, as it is not produced in the human body; it participates in nearly all chemical reactions that occur in human organism (AntonialiI *et al.*, 2007). The levels of vitamin C, carotenoids and phenolic compounds in peppers depend on several factors, including cultivar, agricultural practices and maturity stage (Perez-Lopez *et al.*, 2007a). In a study conducted by Mitchell *et al.* (2007) stated that vitamin C content was higher in organically produced vegetables as compare to conventionally produce, also Hallmann and Rembialkowska (2008) found that; organically produced bell peppers contained significantly more vitamin C than conventionally grown fruits.

Environmental stresses are known to activate the bio-synthesis of phenolic compounds (Mitchell *et al.*, 2007). Differences between the content of phenolic metabolites in organically and conventionally produced fruits allow for the possibility that organically grown produce may benefit human health more than corresponding conventionally grown produce. Reviews of existing literature demonstrate inconsistent differences in the nutritional quality of conventionally and organically produced vegetables with the exception of potentially higher levels of certain minerals, ascorbic acid and less nitrates in organic foods (Woese *et al.*, 1997; Bourn and Prescott, 2002).

Organic farming provides peppers with the highest intensities of red and yellow colors, while conventional fruits were those with the lowest values of color intensity (Perez-Lopez *et al.*, 2007a, b). Fertilization with K increased fruit acidity and decreased maturity index, so adequate management of fertilization with Ca and K could improve the yield and fruit quality of pepper; and the fruit quality measurements of pH (5.26-5.45), TSS (8.6-9.1%) and TTA (0.21-0.24%) were affected by the chemical fertilizers (Rubio *et al.*, 2010).

Pepper producers often use large amounts of agrochemicals in an attempt to improve and protect fruit quality and plant vigor. Also vegetable growers in Jordan routinely apply manure to their soil either alone or in combination with mineral fertilizers. However, there is limited research on the effects of these organic amendments on fruit quality. The objectives of the study were to develop scientific data on bell pepper (*Capsicum annum* L.) fruit quality in response to the application of different agricultural practices; conventional and organic.

MATERIALS AND METHODS

This study was conducted during the 2010/2011 season, under a plastichouse conditions at Station of Princess Tasneem Bent Ghazi for Technological Research in Humrat Al-Sahen; about 15 km from As Salt-Jordan. The climate in this region is rather hot and dry during summer, warm and rainy in winter.

Organic matter preparation and soil solarization: Three months prior to transplanting, three different organic matter sources (cattle, poultry and sheep manure) were fermented according to Preusch *et al.* (2004) recommendations. On the other hand during hot summer months (from August to October), soil solarization was done according to procedures outlined by Ames and Kuepper (2000).

Treatments applications: A plastichouse was installed over the solarized area, the conventional planting was done according to the system applied in the farm where the experiment was conducted and that included the use of fertilizers (50 kg ha^{-1} $week^{-1}$ of 20 N-20 P-20 K as fertigation and 118 kg ha^{-1} of ammonium nitrate as side dressing) according to recommendations of Russo and Perkins-Veazie (2010) and Mitchell *et al.* (2007) and chemicals for pest control. For organic culture planting; four fermented organic matter sources were used (cattle, poultry, sheep manure in addition to 1:1:1 mixture of the three organic matter sources), with amount of 4 kg m^{-2}. Marvello pepper cultivar was transplanted on 26th of October 2010 and experiment was finished by the 29th of May 2011.

Experimental design and statistical analysis: Five treatments were conducted in a randomized complete block design with four replicates. All data obtained were statistically analyzed according to the design used in this experiment as outlined by Steel and Torrie (1980) and differences between treatment means were compared by using Least Significant Difference at 5% significant level.

Parameters measured: For measurements or analysis, the fruits were harvested at three time intervals during the experiment period; they were collected when green and fully grown, except for lycopene and anthocyanin determination, its left until red color was completed, then at the end of the experiment average readings were considered.

Total soluble solids (TSS): A small sample of blender pulp was filtered and then TSS in juice was determined by an Antago N1 bench refractometer, results were expressed in percentage (Rubio *et al.*, 2010).

Total titratable acidity (TTA): Determined by means of 10 g of pulp ground in a blender and homogenized with 90 mL distilled water. NaOH (0.11 mol L^{-1}) was used as a standardized titration solution of malic acid per 100 g of sample and results were expressed in percentage (Antonialil *et al.*, 2007).

Moisture content: Five fruits were taken from each replication, cut into pieces, dried in a forced air circulation oven at 70°C, until constant weight, results were expressed in percentage (Rubio *et al*., 2010).

Fruit size: It was determined by water displacement method, average readings were expressed in cm^3 (Leskinen *et al*., 2002).

pH: The fruits were liquefied and filtered for pH determinations; a digital pH-meter were used with the application of electrode directly in the blender pulp (Rubio *et al*., 2010).

Lycopene content: Five fruit sample were blended with acetone and then absorption spectra were measured by Spectrophotometer, results expressed as mg of lycopene per 100 g of fruit fresh weight, according to procedure outlined by Caller and Mackinney (1965).

Ascorbic acid (Vitamin C): Determined by the titratability of 3 g of the blended pulp homogenized with 50 mL of oxalic acid at concentration of 12%. The titratable solution consisted of 2.6 sodium indophenols dichlorophenol. Results were expressed in mg of ascorbic acid per 100 g of pulp (Antonialil *et al*., 2007).

Total phenolics: Detected by the photometric method with Folin's reagent according to Leja *et al*. (2008) and Abu-Zahra *et al*. (2007), results were expressed in mg total phenols per 100 g of fruit fresh weight.

Crude fibre: Estimated by methods outlined by Abu-Zahra *et al*. (2007) and expressed as percentage.

Anthocyanin: Estimated by methods outlined by Abu-Zahra *et al*. (2007) and expressed as mg anthocyanin per 100 g of fruit fresh weight.

RESULTS AND DISCUSSION

Total Soluble Solids (TSS): Addition of animal manure improved bell pepper fruit taste by increasing the fruit soluble solids content in compare to the conventional produced fruit (Table 1), the TSS percentage found in fruit of all treatments was relatively low and ranged from 5.21 to 6.66% in compare to that obtained by Rubio *et al*. (2010) which could be due to differences between the used cultivars. The lowest TSS% was obtained by the conventional treatment, while the highest was obtained by the sheep manure treatment. These results are in agreement with those obtained by Cayuela *et al*. (1997), whom found that; organically grown fruits had significantly higher TSS content than the conventionally grown ones.

Total titratable acidity (TTA): The TTA percentages found in all treatments were relatively low and ranged from 0.131 to 0.192% (Table 1) which is lower than that obtained by Rubio *et al*. (2010) due to differences in the used cultivars. Addition of animal manures decreased bell pepper fruit titratable acidity values compared to the unamended soil; the lowest titratable acidity was obtained by the sheep manure treated pepper fruits, while the highest was obtained by the conventional treatment which does not show a significant difference with the mixture manure treatment. These results showed an opposite trend to fruit soluble solids content and in agreement with Liaven *et al*. (2008) results.

Moisture content: Fruit moisture content ranged from 87.60-92.05% (Table 1), the use of animal manure was found to decrease the water content of the fruits which reflected in increasing fruit dry weight but this decrease is only significant with the cattle manure which produced the lowest fruit water content in compare to the conventional treatment which produced the highest water content.

Fruit size: Fruit size ranged from 152.5-172.34 cm^{-3} (Table 1). The conventional treatment resulted in the significantly biggest fruit, compared to all other treatments which may be due to the good availability of soil nutrients that produced healthy plants with large vegetative growth that reflected in the yield and fruit size. While the large fruit size in the sheep manure treatment may be due to the good improvement of soil physical and chemical conditions. On the other hand the smallest fruit were obtained by the poultry manure treatment, without being significantly different from the cattle manure treatment which could be due to the low availability of soil nutrients and unproven soil physical conditions as explained by Abu-Zahra and Tahboub (2009).

Table 1: Bell pepper fruit contents of TSS, TTA, moisture, fruit size and fruit pH as influenced by organic matter source treatments*

Treatments	TSS (%)	TTA (%)	Moisture content (%)	Size (cm^{-3})	Fruit pH
Conventional	5.21^{c}**	0.192^{a}	92.05^{a}	172.34^{a}	4.74^{a}
Cattle manure	5.67^{bc}	0.155^{b}	87.60^{b}	159.17^{bc}	4.82^{a}
Poultry manure	6.08^{b}	0.157^{b}	88.80^{ab}	152.50^{c}	4.76^{a}
Sheep manure	6.66^{a}	0.131^{c}	90.53^{ab}	167.09^{ab}	4.82^{a}
Mixture manure	5.91^{b}	0.172^{ab}	90.85^{ab}	162.50^{b}	4.63^{a}
$LSD_{0.05}$	0.49	0.024	03.57	009.08	0.19

* Values are the mean of four replicates. ** Means within each column having different letters are significantly different according to LSD at 5% level

Table 2: Bell pepper fruit contents of lycopene, ascorbic acid, total phenols, crude fibre and anthocyanin as influenced by organic matter source treatments*

Treatments	Lycopene (mg/100 g)	Ascorbic acid (mg/100 g)	Total phenols (mg/100 g)	Crude fibre (%)	Anthocyanin (mg/100 g)
Conventional	0.450^{a}**	137.25^{c}	00.1240^{c}	2.18^{b}	29.90^{b}
Cattle manure	0.408^{ab}	144.60^{c}	00.1365^{b}	2.96^{a}	35.30^{ab}
Poultry manure	0.271^{c}	157.28^{b}	00.1363^{b}	2.31^{b}	36.23^{a}
Sheep manure	0.358^{b}	168.75^{a}	00.1458^{a}	2.42^{b}	34.94^{ab}
Mixture manure	0.388^{ab}	157.04^{b}	00.1343^{b}	2.26^{b}	38.54^{a}
$LSD_{0.05}$	0.083	010.86	69.3400	0.30	06.13

*: Values are the mean of four replicates. **: Means within each column having different letters are significantly different according to LSD at 5% level

pH: Results of Marvello pepper cultivar fruit pH (Table 1) do not show any significant differences between all the used treatments. Fruit pH was ranged from 4.63 to 4.82 which do not locate within ranges obtained by Rubio *et al.* (2010). Also our results do not coincide with Liaven *et al.*, (2008) who found that the addition of sheep manure significantly lowered the fruit pH.

Lycopene content: Results of lycopene (Table 2) was ranged from 0.271-0.450 mg 100 g^{-1}, the highest lycopene amount was obtained by the conventional agriculture, without being significantly different from the cattle and or mixture organic matter treatments. On the other hand the lowest fruit lycopene was obtained by the poultry manure treated pepper fruits, with a significant difference from all of the used treatments. These results are in agreement with that obtained by Hallmann and Rembialkowska (2008) and within the obtained lycopene ranges. Therefore, organic treatments do not improve fruit lycopene content in compare to conventional agriculture that hastened fruit lycopene content.

Ascorbic acid content (vitamin C): Sweet pepper fruits are an excellent source of vitamin C, since high amounts were obtained from all of the used treatments that ranged from 137.25-168.75 mg100 g^{-1} (Table 2) and in agreement with results obtained by Jadczak *et al.* (2010). The highest amount of vitamin C, was obtained from the sheep manure, while the lowest amount was obtained by the conventional agriculture, although without being significantly different from the cattle manure treatment. These results are, to some extent, in agreement with those reported by Cayuela *et al.* (1997).

Total phenolics: Organic matter treatments had significantly more total phenols than the conventional system (Table 2); the highest (1458 mg 100 g^{-1}) content was obtained by the sheep organic treatment, on the other hand same level of significance were observed from sheep, poultry and mixture organic matter treatments. These results are in agreement with those reported by Leja *et al.* (2008). The low content of phenolic compounds in the conventional agriculture is due to increase availability of plant nutrients mainly nitrogen (Doll *et al.*, 1994). Otherwise the restricted uses of chemicals were reported to accelerate synthesis of phenolic compounds in organic production (Hakkinen and Torronen, 2000).

Crude fibre: Results of table 2, shows that crude fibre was improved only by the use of the cattle manure which produced the highest (2.96%) crude fibre content. No statistically differences were observed between all other treatments, eventhough the lowest (2.18%) crude fibre content was obtained by the conventional treatment, same results were obtained by Abu-Zahra and Tahboub (2009).

Anthocyanin content: The highest anthocyanin (38.54 mg 100 g^{-1}) amount was obtained by the mixture organic matter treatment (Table 2), without being significantly different from all other organic matter treatments. The least anthocyanin content was obtained by the conventional treatment which was significantly lower than mixture and poultry organic matter treatments. These results are in agreement with results obtained by Cayuela *et al.* (1997) and Perez-Lopez *et al.* (2007a, b) in which organic farming provides peppers with the highest intensities of red and yellow colors, while conventional fruits were those with the lowest values of color intensity.

CONCLUSIONS

It was found that characteristics of pepper fruits from plants cultivated in soil supplemented with manure were generally better than those from plants grown in soil only. Addition of animal manure increased bell pepper fruit content of soluble solids, ascorbic acid, total phenols, crude fibre and intensity of red color in compare to conventional agriculture that produced fruits with higher titratable acidity, water content, lycopene and bigger fruit size. Fruit pH do not affected by the organic matter treatments or conventional agriculture. In most cases of animal manure treatments; best results were obtained by the sheep manure treatment that produced the highest TSS, while the worst results were obtained by the poultry manure treatment that produced the smallest fruit and lowest fruit lycopene content.

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REFERENCES

Abu-Zahra, T.R. and A.A. Tahboub, 2009. Strawberry (*Fragaria* X *Ananassa* Duch.) fruit quality grown under different organic matter sources in a plastichouse at Humrat Al-Sahen. Acta Hortic., 807: 353-358.

Abu-Zahra, T.R., K. Al-Ismail and F. Shatat, 2007. Effect of organic and conventional systems on fruit quality of strawberry (*Fragaria* X *Ananassa* Duch) grown under plastichouse conditions in the Jordan Valley. Acta Hortic., 741: 159-172.

Ames, G.K. and G. Kuepper, 2000. Overview of organic fruit production. NCAT agriculture specialists, ATTRA. URL: http://attra.ncat.org/attra-pub/PDF/fruitover.pdf

Antonialil, S., P.A.M. Leal, A.M. de Magalhaes, R.T. Fuziki and J. Sanches, 2007. Physico-chemical characterization of Zarco HS yellow bell pepper for different ripeness stages. Sci. Agric., 64: 19-22.

Bourn, D. and J. Prescott, 2002. A comparison of the nutritional value, sensory qualities and food safety of organically and conventionally produced foods. Crit. Rev. Food Sci. Nutr., 42: 1-34.

Caller, M. and G. Mackinney, 1965. The carotenoids of certain fruits (apple, pear, cherry, strawberry). J. Food Sci., 30: 393-395.

Cayuela, J.A., J.M., Vidueira, M.A. Albi and F. Gutierrez, 1997. Influence of the ecological cultivation of strawberries (*Fragaria* X *Ananassa* cv. chandler) on the quality of the fruit and on their capacity for conservation. J. Agric. Food Chem., 45: 1736-1740.

Doll, H., U. Holm, B. Sogaard and H. Bay, 1994. Phenolic compounds in barley varieties with different degree of partial resistance against powdery mildew. Acta Hortic., 381: 576-582.

Hakkinen, S.H. and A.R. Torronen, 2000. Content of flavonols and selected phenolic acids in strawberries and *Vaccinium* species: Influence of cultivar, cultivation site and technique. Food Res. Int., 33: 517-524.

Hallmann, E. and E. Rembialkowska, 2008. The content of selected antioxidant compounds in bell pepper varieties from organic and conventional cultivation before and after process. Proceedings of the 2nd Conference of the International Society of Organic Agriculture Research ISOFAR, June 18-20, 2008, Modena, Italy.

Howard, L.R., S.T. Talcott, C.H. Brenes and B. Villalon, 2000. Changes in phytochemical and antioxidant activity of selected pepper cultivars (*Capsicum* species) as influenced by maturity. J. Agric. Food Chem., 48: 1713-1720.

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

Jolly, D.A., 1989. Organic foods-consumer attitudes and use. Food Technol., 43: 60-66.

Kelley, W.T., G.E. Boyhan, K.A. Harrison, D.M. Granberry and D.B. Langston *et al*., 2009. Commercial Pepper Production Handbook. The University of Georgia, Georgia.

Leja, M., G. Wyzgolik and I. Kaminska, 2008. Changes of some biochemical parameters during the development of sweet pepper fruits. Mokslo Darbai J., 27: 277-283.

Leskinen, M., H.M. Vaisanen and J. Vestergaard, 2002. Chemical and sensory quality of strawberry cultivars used in organic cultivation. Acta Hortic., 567: 523-526.

Liaven, M.A., J.L. Jimenez, B.I. Coro, R.R. Rosales, J.M. Molina, L. Dendooven and F.A. Miceli, 2008. Fruit characteristics of bell pepper cultivated in sheep manure vermicompost substituted soil. J. Plant Nutr., 31: 1585-1589.

Mitchell, A.E. and A.W. Chassy, 2005. Antioxidants and the nutritional quality of organic agriculture. http://mitchell.ucdavis.edu/Is%20Organic%20Better.pdf

Mitchell, A.E., Y.J. Hong, E. Koh, D.M. Barrett, D.E. Bryant, R.F. Denison and S. Kaffka, 2007. Ten-year comparison of the influence of organic and conventional crop management practices on the content of flavonoids in tomatoes. J. Agric. Food Chem., 55: 6154-6159.

Peet, M., 1995. Sustainable Practices for Vegetable Production in the South. Focus Publication, Newburyport, MA., ISBN: 9780941051552, Pages: 174.

Perez-Lopez, A.J., F.M. del Amor, A. Serrano-Martinez, M.I. Fortea and E. Nunez-Delicado, 2007a. Influence of agricultural practices on the quality of sweet pepper fruits as affected by the maturity stage. J. Sci. Food Agric., 87: 2075-2080.

Perez-Lopez, A.J., J.M. Lopez-Nicolas, E. Nunez-Delicado, F.M. del Amor and A.A. Carbonell-Barrachina, 2007b. Effects of agricultural practices on color, carotenoids composition and minerals contents of sweet peppers, cv. almuden. J. Agric. Food Chem., 55: 8158-8164.

Preusch, P.L., F. Takeda and T.J. Tworkoski, 2004. N and P uptake by strawberry plants grown with composted poultry litter. Scientia Hortic., 102: 91-103.

Rubio, J.S., F.G. Sanchez and P. Flores, 2010. Yield and fruit quality of sweet pepper in response to fertilization with Ca and K. Spanish J. Agric. Res., 8: 170-177.

Russo, V.M. and P. Perkins-Veazie, 2010. Yield and nutrient content of bell pepper pods from plants developed from seedlings inoculated, or not, with microorganisms. Hortscience, 45: 352-358.

Steel, R.G.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics. 2nd Edn., McGraw-Hill, New York, pp: 326-347.

Woese, K., D. Lange, C. Boess and K.W. Bogl, 1997. A comparison of organically and conventionally grown foods-Results of a review of the relevant literature. J. Sci. Food Agric., 74: 281-293.