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RESEARCH PAPER

## Quality, bioactive compounds, and antioxidant activity of serrano chili peppers cultivated in volcanic rock-vermicompost and nutrient solutions

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### Abstract

**E. Cruz-Crespo, M.T. Sumaya-Martínez, Á. Can-Chulim, J. Pineda-Pineda, R. Bugarín-Montoya and G. Aguilar-Benítez. 2015. Quality, bioactive compounds, and antioxidant activity of serrano chili peppers cultivated in volcanic rock-vermicompost and nutrient solutions. Cien. Inv. Agr. 42(3): 375-384.** The concentration of antioxidant compounds, the antioxidant activity, physical quality characteristics, and the yield of serrano chilies (*Capsicum annuum* L.) are affected by agricultural practices, such as the use of vermicompost in containers combined with chemical fertilizers, the investigations of which have focused on yield. A study was performed to determine whether vermicompost mixed with volcanic rock and the ionic composition of the nutrient solution affect the variables mentioned above. Serrano chilies were planted in volcanic rock:vermicompost in the following proportions 100:0, 80:20 and 60:40 and were watered with Steiner nutrient solution at 25, 50, and 75%. Interaction of the factors was determined for the fresh weight of the fruits. Fruit length, diameter, number, weight, yield, firmness, hue, and chroma increased with the nutrient solutions at 50 and 75%. Ascorbic acid levels fell with the solutions at 50 and 75%, and total phenols and antioxidant activity increased with the solutions at 25 and 50%. The 80:20 and 60:40 volcanic rock:vermicompost substrates similarly increased the length, diameter, number, weight, total phenols and antioxidant activity of the fruit. Yield increased with a greater proportion of the vermicompost. The solution at 50% and the volcanic rock:vermicompost mixture 80:20 were the best conditions for the content of phenolic compounds, antioxidant activity, as well as diverse quality variables, although the 60:40 proportion was more favorable for yield.

**Key words:** Ascorbic acid, *Capsicum annuum*, phenols, yields

## Introduction

The *Capsicum annuum* L. fruits are the most consumed worldwide and are a source of bioactive compounds, such as polyphenols and ascorbic acid, which have antioxidant properties related to the prevention of degenerative diseases (Tundis *et al.*, 2013). On the other hand, the commercial price of chili peppers is determined by quality attributes, such as the characteristics of color, firmness, and size (Abbot, 1999).

Currently, given the problems with production in the field, the production of vegetables in greenhouses through the use of organic or mineral media has increased. In this regard, the use of the compost and vermicompost in containers has increased over the past several years, slowly replacing the use of soil (Ali *et al.*, 2007), which is attributed to the current tendency of using environmentally friendly materials. However, their use is reported in mixtures with other materials, with or without the use of nutrient solutions in different concentrations (De Grazia *et al.*, 2007; Cruz-Crespo *et al.*, 2014) to improve the physical properties of the growing medium and to reduce the use of chemical fertilizers, focusing on the study of the variables related to nutrition and yield. Therefore, information is scarce regarding the effects on the physical quality characteristics and the content of antioxidant compounds (ascorbic acid, phenolic compounds) and antioxidant activity. In this respect, Patthamakanokporn *et al.* (2008) and Erba *et al.* (2013) noted that these characteristics and the levels of antioxidant compounds are affected by several factors, such as pre- and post-harvest management, and the pattern of the effect can vary among species.

Regarding pre-harvest management, there are few reports on the use of organic manures on some vegetables in soil, where increases were found in the contents of ascorbic acid, phenolic compounds, and the antioxidant activity of tomatoes (*Solanum lycopersicum* L.) (Toor *et al.*, 2006), cucumber (*Cucumis sativus* L.), and cab-

bage (*Brassica oleracea* L.) (Pavla and Pokluda, 2008). In regard to the use of chemical fertilizers, there is only information on the effect of the form and dose of nitrogen on the compounds mentioned (Smolen and Sady, 2009). Therefore, the aim of this investigation was to contrast the proportions of vermicompost and volcanic rock in combination with different levels of Steiner nutrient solution on the physical characteristics of the serrano chili, its yield, ascorbic acid, total phenols, and antioxidant activity.

## Materials and methods

### *Experimental site*

The experiment was performed between July 15, 2012 and January 30, 2013 in a greenhouse located at 21° 25' 40'' N, 104° 53' 30'' W and 974 m.a.s.l. The high and low temperatures were 38 and 23 °C, respectively, the average relative humidity was 83%, and the light intensity was 463  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ .

### *Substrates and crop management*

The substrates were composed of mixtures of volcanic rock (VR) and vermicompost (VC) in different proportions (VR/VC, 100:0, 80:20 and 60:40 v/v) (Table 1). The sizes of the volcanic rock particles were 0.3 to 10 mm, and the vermicompost particle size was 0.5 to 3.3 mm. The latter was made using mango stone–sugar cane bagasse–bovine manure (1:1:1). ‘Tampiqueño’ serrano chili seeds were sown into 200-cell plug trays, using a mixture of perlite plus coconut fiber 50:50 (v/v). Then, seeds were irrigated with Steiner nutrient solution at 25% (Steiner, 1984) until the time of the transplant.

Forty-five days after planting, one ‘Tampiqueño’ serrano chili seedling was placed in a pot made of black 35 x 35 cm polyethylene. The pots were distributed randomly in rows with a separation of one meter and 45 cm between pots.

**Table 1.** Chemical and nutritional properties of the substrates used (VC: vermicompost; VR: volcanic rock).

Materials or substrates	pH 1:2	EC 1:2	OM	CEC	N	P	K	Ca	Mg
		dSm <sup>-1</sup>	%	Cmol <sub>(c)</sub> kg <sup>-1</sup>			%		
VC	8.1 <sup>1</sup>	4.72	30	44.3	1.24	1.84	2.02	2.56	0.63
VR/VC, 80:20	6.0	0.33	3.8	6.88	0.20	0.30	0.38	0.54	0.11
VR/VC, 60:40	6.2	0.72	10.5	15.3	0.38	0.62	0.83	1.31	0.22

<sup>1</sup>Average of three determinations; pH = potential of hydrogen; EC = electrical conductivity; OM= organic matter; CEC = cation exchange capacity.

Drip irrigation was initiated using the Steiner nutrient solution at concentrations of 25, 50, or 75%, which was prepared using the fertilizers Ca(NO<sub>3</sub>)<sub>2</sub>·4H<sub>2</sub>O, KNO<sub>3</sub>, MgSO<sub>4</sub>·7H<sub>2</sub>O, KH<sub>2</sub>PO<sub>4</sub>, K<sub>2</sub>SO<sub>4</sub>, and HNO<sub>3</sub>. For micronutrients, a stock solution was prepared with 2.8 g·L<sup>-1</sup> of H<sub>3</sub>BO<sub>3</sub>, 2.2 g·L<sup>-1</sup> of MnSO<sub>4</sub>·H<sub>2</sub>O, 0.4 g·L<sup>-1</sup> of ZnSO<sub>4</sub>, 0.08 g·L<sup>-1</sup> of CuSO<sub>4</sub>, 0.1 g·L<sup>-1</sup> of Na<sub>2</sub>MoO<sub>4</sub>, and 3 mg·L<sup>-1</sup> of Fe-EDTA. Of this solution, 1 mL was used for every liter of Steiner nutrient solution. The pH of the solutions was adjusted to 6.0. Water use was 200 mL for each irrigation trial, which took place 2 – 6 times a day, depending on the water requirements (leaching fraction was 25%).

#### Experimental design and treatments

Treatments formed a factorial arrangement 3 × 3 corresponding to three nutrient solution concentrations (Steiner nutrient solution at 25, 50, and 75%) and three substrates (VR/VC, 100:0; 80:20 and 60:40 v/v), in a randomized experimental design with eight replications. For fruit yield, the experimental unit was a plant in a pot. For the fruit quality variables, the experimental unit consisted of 20 fruits per plant. For bioactive compounds and antioxidant activity, the experimental unit was one fruit per plant.

#### Fruit quality and yield variables

Fruits that did not present corkiness or curvature were evaluated, as well as those that reached a length of ≥5 cm. Fruit length and fruit equatorial diameter (cm) were measured with a Truper<sup>®</sup> digital vernier caliper. The number of fruits per harvest

was counted. The weight of each fruit and fruit yield per plant (g) were obtained using an OHAUS Explorer<sup>®</sup> electronic balance. Fruit size was classified according to the specifications of the Official Mexican Standard NMX-FF-025-SCFI-2013 (SE, 2014). Evaluations were conducted on October 24, 2012 (first harvest), November 15, 2012 (second harvest), December 13, 2012 (third harvest), and January 19, 2013 (fourth harvest).

Additionally, during the third harvest, the firmness (N·cm<sup>-2</sup>) was determined using the Force Gauge model Gy-4 texturometer with a 0.5 cm diameter concave tip. Readings were taken on opposite sides of the fruit, and the average was calculated. For hue and chroma, a Konica Minolta Optics, Inc. 1865945 colorimeter was used to obtain the readings of parameters a and b of the opposite sides of the fruit. Then, the hue angle = tan<sup>-1</sup> b/a and chroma = (a<sup>2</sup>+b<sup>2</sup>)<sup>1/2</sup> were calculated.

#### Bioactive compounds and antioxidant activity

To prepare the sample, 6 g of the pericarp of the chili was weighed and blended with 30 mL of oxalic acid at 3%. Later, the sample was filtered using Whatman filter paper and was stored at -20°C. The sample was extracted from 5 g of the pericarp of the chili and was blended with 25 mL of oxalic acid at 3%, centrifuged at 5,000 rpm for 10 min, filtered through a 0.45 μm Millipore hydrophilic PVDF syringe filter and frozen at -20°C.

Acid ascorbic content was determined according to Dürüst *et al.* (1997). Briefly, 100 μL of the sample (a different dilution factor in oxalic acid

at 0.4% was used for each sample) was added to 100  $\mu\text{L}$  of acetate buffer, and then 800  $\mu\text{L}$  of DCPI (2,6-dichloroindophenol sodium) was added. The absorbance of the mixture was measured immediately at 520 nm in a microplate reader (PowerWave XS, Biotek instruments, USA). Ascorbic acid (ASC A) was used as a reference standard, and the results were expressed as mg ascorbic acid $\cdot 100\text{ g}^{-1}$  of fruit.

Total phenol content (TPC) was determined according to Georgé *et al.* (2005). Briefly, 100  $\mu\text{L}$  of the methanolic extract was added to 500  $\mu\text{L}$  of 1:10 diluted Folin-Ciocalteu reagent, and 400  $\mu\text{L}$  of sodium carbonate solution (at 7.5%) was added. After incubation at room temperature for 30 min, the absorbance of the mixture was measured at 765 nm in a microplate reader (PowerWave XS, Biotek Instruments). Gallic acid was used as a reference standard, and the results were expressed as the equivalent of milligrams of gallic acid (mg GAE $\cdot 100\text{ g}^{-1}$  of fruit).

Antioxidant activity was measured using DPPH (1,1-Diphenyl-2-picrylhydrazyl radical), as described by Morales and Jimenez-Pérez (2001). A 7.4 mg $\cdot 100\text{ mL}^{-1}$  ethanolic solution of the stable DPPH radical was prepared. Next 100  $\mu\text{L}$  of the samples were taken into vials, and 500  $\mu\text{L}$  of DPPH solution was added. The solution was stirred in a vortex and centrifuged at 10,000 rpm for 5 min after standing for one hour at room temperature. Finally, absorbance was measured at 520 nm in a microplate reader, and  $\mu\text{mol}$  equivalents of Trolox $\cdot\text{g}^{-1}$  of fruit was obtained.

### Statistical analyses

Data were analyzed by analysis of variance and the Tukey comparison of means at 5% probability. Correlations were determined between variables. Polynomial regression models were also obtained. SAS version 8 software was used for the statistical analysis (SAS Institute, Cary, North Carolina, USA).

## Results and discussion

### Fruit quality and yield

*Substrate-nutrient solution interaction.* The interaction of the factors displayed a significant increase in fruit weight ( $P\leq 0.0095$ ) on the four harvest dates (Table 2). The interaction effect of nutrient solution and substrate contributed to the sum of squares of treatments from 10.7 to 14%, considering the four harvest dates. Meanwhile, the solution factor contributed 31.4 to 46.9%, and the substrate contributed 39 to 57.9%. For fruit diameter, the interaction was significant ( $P\leq 0.0424$ ), although the tendency was not clear (Table 2).

*Nutrient solution factor.* On the four harvest dates, comparison of means expressed differences due to the effects of the nutrient solution, in which the S50 and S75 treatments contrasted with that of S25 by approximately 10% for fruit length and fruit diameter and between 15 and 19% for fruit weight, without differences between S50 and S75 (Table 3).

Fruit numbers increased significantly in response to the proportional increase of the ionic concentration in the nutrient solution. On the other hand, the fruits of the first and second harvests were classified as small, whereas for the third and fourth harvests, fruits with S25 were classified as small, and those obtained with S50 and S75 were classified as medium.

The yield behavior over time in the different nutrient solutions is shown in Figure 1, which indicates a significant difference of 124 to 203 g between S50 and S25 and of 174 to 252 g between S75 and S25, with no differences between S50 and S75. A positive relation was also obtained for fruit yield with the variables related to fruit size and number fruits ( $R = 0.46$  to 0.01% between the variables fruit yield and diameter,  $R = 0.5$  to 0.01% between yield and fruit length,  $R = 0.84$  to 0.01% between variables fruit yield and number).

**Table 2.** Fruit weight and diameter for ‘Tampiqueño’ serrano chili by substrate-nutrient solution interaction of three harvests from 2012-2013.

Substrate	Second harvest			Third harvest			Fourth harvest		
	S25	S50	S75	S25	S50	S75	S25	S50	S75
Fruit weight (g)									
VR/VC, 100:0	5.34 b <sup>1</sup>	5.50 b	6.00 b	5.20 c	5.33 b	6.00 b	5.20 c	5.37 b	6.00 b
VR/VC, 80:20	5.54 a	6.83 a	6.86 a	5.73 a	7.51 a	7.36 a	5.89 a	7.36 a	7.38 a
VR/VC, 60:40	5.43 b	6.83 a	6.84 a	5.52 b	7.61 a	7.38 a	5.70 b	7.47 a	7.41 a
Fruit diameter (cm)									
VR/VC, 100:0	1.13 c	1.41 b	1.43 b	1.29 b	1.41 b	1.47 a	1.41 a	1.44 b	1.54 b
VR/VC, 80:20	1.44 b	1.50 a	1.51 a	1.51 a	1.54 a	1.55 a	1.46 a	1.64 a	1.64 a
VR/VC, 60:40	1.50 a	1.59 a	1.44 b	1.51 a	1.54 a	1.49 a	1.46 a	1.61 a	1.59 ab

<sup>1</sup>Values followed by the same letter in the same column do not differ significantly (Tukey,  $P \leq 0.05$ ). S25 = nutrient solution at 25%; S50 = nutrient solution at 50%; S75 = nutrient solution at 75%. VC = vermicompost; VR = volcanic rock.

**Table 3.** Fruit length (FL), fruit diameter (FD), fruit number (FN), and fruit weight (FW) of ‘Tampiqueño’ serrano chili in four harvests during 2012-2013.

Solution	FL (cm)	FD (cm)	FN	FW (g)	FL (cm)	FD (cm)	FN	FW (g)
	First harvest				Second harvest			
S25	6.45 a <sup>1</sup>	1.27 b	45.00 c	5.27 c	6.45 b	1.36 b	32.44 c	5.43 b
S50	6.42 a	1.45 a	52.16 b	5.37 b	7.12 a	1.47 a	46.39 b	6.39 a
S75	6.68 a	1.45 a	62.05 a	5.44 a	7.17 a	1.46 a	55.05 a	6.44 a
Substrate								
VR/VC, 100:0	6.28 b	1.25 b	52.44 a	5.22 b	6.67 b	1.32 b	38.44 b	5.49 b
VR/VC, 80:20	6.47 ab	1.45 a	55.05 a	5.42 a	7.00 ab	1.48 a	42.44 b	6.41 a
VR/VC, 60:40	6.91 a	1.47 a	51.72 a	5.44 a	7.09 a	1.48 a	53.00 a	6.36 a
CV (%)	8.76	5.85	7.98	1.4	6.54	3.18	22.38	2.5
Solution	Third harvest				Fourth harvest			
S25	6.65 b	1.43 b	49.77 b	5.48 b	6.64 b	1.44 b	30.66 c	5.60 b
S50	7.53 a	1.49 ab	66.44 a	6.81 a	7.40 a	1.56 a	50.77 b	6.73 a
S75	7.46 a	1.50 a	70.77 a	6.75 a	7.46 a	1.58 a	63.55 a	6.78 a
Substrate								
VR/VC, 100:0	6.54 b	1.39 b	52.94 b	5.34 b	6.40 b	1.46 b	32.11 b	5.37 b
VR/VC, 80:20	7.65 a	1.53 a	63.28ab	6.86 a	7.56 a	1.57 a	53.33 a	6.87 a
VR/VC, 60:40	7.45 a	1.51 a	70.78 a	6.84 a	7.54 a	1.55 a	59.55 a	6.86 a
CV (%)	12.62	5.25	22.96	3.05	8.96	3.56	19.17	3.67

<sup>1</sup>Values followed by the same letter in the same column do not differ significantly (Tukey,  $P \leq 0.05$ ). S25 = nutrient solution at 25%; S50 = nutrient solution at 50%; S75 = nutrient solution at 75%. VC = vermicompost; VR = volcanic rock.

Information is scarce in relation to the variables fruit length, diameter and weight due to the use of nutritive solutions. There are some reports regarding fruit yield. Godoy-Hernández *et al.* (2009) noted that using a nutritive solution in concentrations of 50 and 75% caused no differ-

ences in the yield of tomato fruits. Therefore, the results depend on the species.

According to results obtained by the effect of the nutrient solution in this investigation, a study is recommended on serrano chilies in substrates

and in the greenhouse with solutions at a concentration of >75%. With solutions S50 and S75, the fruits became approximately 6 N·cm<sup>-2</sup> firmer compared to S25 (Table 4). Additionally, hue and chroma had higher values with the S50 and S75 solutions, in which the chroma coincided with reports by Vázquez-García *et al.* (2010), whereas hue remained near the reported value.

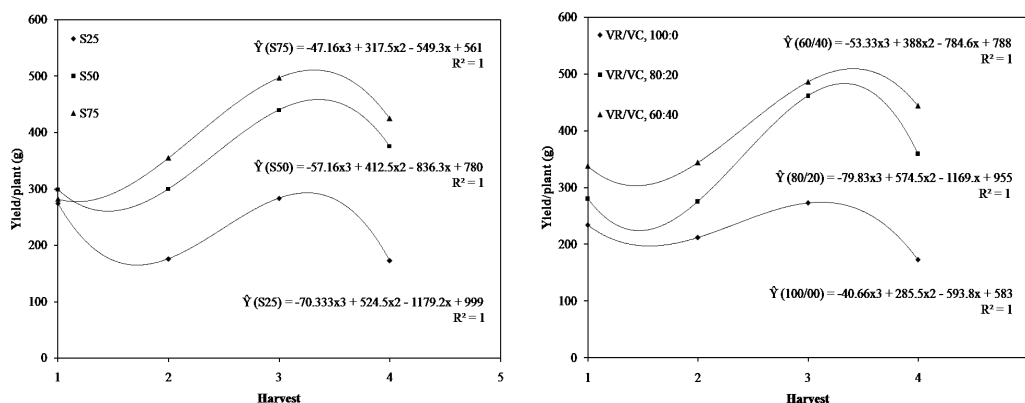
These fruits acquired a more intense color (emerald green, characteristic of the ‘Tampiqueño’ variety) in comparison with the solution at 25%, in which the color was much less intense (light green). Cruz-Crespo and Sandoval-Villa (2012) indicated that tomato fruits became firmer and had a higher hue value with the solution at 50% compared with non-application or greater ionic concentration in solution.

**Substrate factor.** In Table 3, the contrast of means shows substrates VR/VC,80:20 and VR/VC,60:40 as displaying the greatest length, diameter, weight and number of fruits in comparison to VR/VC,100:0, although for the first and second harvests in all substrates, all fruits reached a small size. In the third and fourth harvest, only substrates VR/VC, 80:20 and VR/VC, 60:40 reached a medium size. This shows that vermicompost in the growth medium increase the fruit size.

Figure 1 shows the fruit yield over time. During the first and second harvests, a significant dif-

ference of 46 to 63 g was obtained between VR/VC, 100:0 and VR/VC, 80:20 and 104 to 132 g between VR/VC, 100:0 and VR/VC, 60:40. The difference between the third and fourth harvests was 188 g between VR/VC, 100:0 and VR/VC, 80:20 and 213 to 271 g between VR/VC, 100:0 and VR/VC, 60:40. Vermicomposted materials are rich in nutrients, retain water and contain growth-regulating substances (Hernández *et al.*, 2010), all of which contribute to greater fruit size and higher yields. There is scarce literature illustrating the effect of composts and vermicomposts on the variables studied here. In this respect, Silva *et al.* (2010) indicated that the combination of compost with soil in proportions of 25 to 75% increased the number of fruits in relation to the treatment without vermicompost. López-Espinosa *et al.* (2013) applied compost mixed with sand (1:1) plus a vermicompost tea for jalapeño chili (*C. annuum*) and obtained the same yield, length, diameter and number of fruits as with chemical fertilization. Therefore, a prior definition is recommended of the most adequate proportions when mixing materials.

Table 4 shows greater fruit firmness at 3.6 N·m<sup>-2</sup> for the substrate VR/VC, 80:20 compared to VR/VC, 60:40 and 6.68 N·m<sup>-2</sup> compared to VR/VC, 100:0. For hue and chroma, the values are approximately 118° and 22, respectively, without differences among substrates, which



**Figure 1.** Fruit yield of ‘Tampiqueño’ serrano chili planted with different nutrient solutions (left) and different substrates (right) from 2012-2013. S25 = nutrient solution at 25%; S50 = nutrient solution at 50%; S75 = nutrient solution at 75%. VC = vermicompost; VR = volcanic rock.



**Table 4.** Firmness (FIR), hue (HUE), chroma (CHR), bioactive compounds (ASC A= ascorbic acid; TPC = total phenolic content) and antioxidant activity (AA) of third-harvest fruits of ‘Tampiqueño’ serrano chili.

	FIR (N cm <sup>2</sup> )	HUE (°)	CHR	ASC A mg 100 g <sup>-1</sup> of fruit	TPC GAE mg 100 g <sup>-1</sup> of fruit	AA μmoltrolox g <sup>-1</sup> of fruit
Solution						
S25	123.42 b <sup>1</sup>	108.34 b	19.31 b	41.19 a	64.73 a	2.49 a
S50	128.77 a	124.21 a	23.51 a	32.69 b	62.95 a	2.23 a
S75	129.35 a	122.34 a	23.59 a	31.00 b	55.07 b	1.62 b
Substrate						
VR/VC, 100:0	123.93 b	117.79 a	21.75 a	30.71 a	57.68 b	1.83 b
VR/VC, 80:20	130.61 a	119.08 a	22.71 a	36.57 a	65.48 a	2.25 ab
VR/VC, 60:40	127.01 ab	118.50 a	21.95 a	37.63 a	59.58ab	2.26 a
CV (%)	4.09	8.0	9.62	15.81	9.56	14.97

<sup>1</sup>Values followed by the same letter in the same column do not differ significantly (Tukey,  $P \leq 0.05$ ). GAE =Gallic acid equivalents. S25 = nutrient solution at 25%; S50 = nutrient solution at 50%; S75 = nutrient solution at 75%. VC = vermicompost; VR = volcanic rock.

indicates that fruits were light green. The positive effect of vermicompost on firmness was also observed by Zaller (2007) on tomato fruits, although the results varied between the genotypes evaluated.

#### *Bioactive compounds and antioxidant activity*

**Nutrient solution factor.** The amount of ascorbic acid was 23% higher with the solution at 25% than in concentrations of 50 and 75%, with no significant difference. For total content of phenols (Table 4), a 14% higher concentration was found with the solution S25 and S50 than with S100. Antioxidant activity maintained a similar tendency to that of the total phenolic content, in which S25 and S50 were greater by approximately 31%. Additionally, a positive correlation was found between antioxidant activity and total phenolic content ( $R = 0.61$ ,  $P \leq 0.01$ ) and between antioxidant activity and ascorbic acid ( $R = 0.55$ ,  $P \leq 0.01$ ). This result was congruent with the results found in basil (*Ocimum basilicum* L.) plantations (Nguyen *et al.*, 2010) and in the medicinal plant known as “King of bitters” (*Andrographis paniculata* B.) (Upadhyaya *et al.*, 2011). There are few investigations on nutrient solutions or on the application of chemical fertilizers on the content of ascorbic acid, phenols, and

antioxidant activity, and these investigations mainly report the effect of N or K levels, with conflicting reports. Hernández-Fuentes *et al.* (2010) evaluated two levels of fertilization with N-P-K on chili peppers (*C. annuum*) and found no difference in the amounts of ascorbic acid. Likewise, Chiesa *et al.* (2009) showed that low N levels increased the levels of ascorbic acid in lettuce (*Lactuca sativa* L.). Zhu *et al.* (2009) found a higher amount of total phenols in cabbage plants with low doses of nitrogen. Nguyen *et al.* (2010) reported an increase in the amount of total phenols and antioxidant activity in basil leaves when increasing the concentration of K in the nutrient solution.

**Substrate factor.** No differences were found for the amount of ascorbic acid, due to the effect of the substrate (Table 4). In contrast, the total amount of phenols and antioxidant activity increased with substrates VR/VC, 80:20 and VR/VC, 60:40, although the values were lower than those reported by Medina-Juárez *et al.* (2012). References are minimal in relation to the results of organic and inorganic growth media, or those amended with vermicompost in secondary metabolites. Picchi *et al.* (2012) showed that the total contents of phenols and ascorbic acids increase in the cauliflower (*B. oleracea*) Magnifico hybrid with the use of organic fertilizers in

comparison with inorganic fertilizer, but this was contrary to the findings in the Emerald hybrid. Faedah-Omar *et al.* (2012) reported, for cassava (*Manihot esculenta* C.) tubers, a higher amount of total phenols and antioxidant activity when treated with vermicompost than when chemical fertilizer was applied to the soil.

This study yielded several conclusions. The interaction of the nutrient solution and substrate exerted a positive effect on the fruit's fresh weight. Nutrient solutions at 50 and 75% increased, on

the same scale, fruit length, diameter, weight, number, and yield, as well as firmness, hue, and chroma on the different harvest dates. However, the ascorbic acid content, total phenol content, and antioxidant activity decreased with the 75% solution; thus, the 50% solution was considered the most suitable. The volcanic rock substrate in combination with vermicompost in proportions of 80:20 and 60:40 similarly increased the fruit's length and firmness, phenolic content, and antioxidant activity, and fruit yield increased with the 60:40 proportion of volcanic rock:vermicompost.

### Resumen

**E. Cruz-Crespo, M.T. Sumaya-Martínez, Á. Can-Chulim, J. Pineda-Pineda, R. Bugarín-Montoya y G. Aguilar-Benítez. 2015. Calidad, compuestos bioactivos, y actividad antioxidante de chile serrano, cultivado en tezontle-lombricomposta y soluciones nutritivas. Cien. Inv. Agr. 42(3): 375-384.** La concentración de los compuestos antioxidantes, la actividad antioxidante, las características físicas de calidad y rendimiento del chile serrano *Capsicum annum* L. pueden ser afectados por las prácticas agrícolas tal como el uso de la lombricomposta en contenedor en combinación con fertilizantes químicos, cuyas investigaciones se han enfocado al rendimiento. Se llevó a cabo el estudio para conocer si la lombricomposta en mezcla con tezontle y la concentración iónica de la solución nutritiva afectan las variables arriba mencionadas. Se cultivó chile serrano en tezontle:lombricomposta en las proporciones 100:0, 80:20 60:40, y regado con las soluciones nutritivas a 25, 50 y 75%. Se encontró interacción de los factores para peso fresco. La longitud, diámetro, número, peso y rendimiento de frutos así como firmeza, hue y croma incrementaron con las soluciones nutritivas a 50 y 75%. El ácido ascórbico disminuyó con la solución a 50 y 75%, y los fenoles totales y actividad antioxidante incrementaron con la solución a 25 y 50%. El sustrato tezontle:lombricomposta 80:20 y 60:40 incrementaron de manera similar la longitud, diámetro, número, peso, fenoles totales y actividad antioxidante del fruto. El rendimiento incrementó a mayor proporción de lombricomposta. Se concluyó que la solución a 50% y la mezcla tezontle-lombricomposta en la proporción 80:20 fueron las más convenientes por favorecer el contenido de compuestos fenólicos, actividad antioxidante y diversas variables de calidad, aunque para mayor rendimiento fue más favorable la proporción 60:40.

**Palabras clave:** Ácido ascórbico, *Capsicum annum*, fenoles, rendimiento.

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