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Yield and quality of tomato produced on substrates and with application of humic acids

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ABSTRACT

The aim of this work was to evaluate the yield and quality of tomato fruits, hybrid "Vênus", produced on substrates and with application of nutrient solution and humic acids (AH). Four doses of AH were evaluated (0, 20, 40 and 80 L ha^{-1}) and 4 substrates: S1 (coconut fiber (CF)), S2 (FC + carbonized coffee husk (CC) in the ratio 1:3), S3 (CF + CC in the ratio 2:3) and S4 (CC), were evaluated following the randomized blocks design in factorial 4x4 scheme with four replications. The 35-day old seedlings were transplanted into plastic bags of 7 L. The humic acids were applied four times in eight-day intervals, and the first application was carried out eight days after transplanting. There was no significant effect of AH on the yield and quality of fruit, except in relation to soluble solids (SS)/titratable acidity (AT). Doses of up to 36 L ha^{-1}, increase the AT, above that amount favored increase of SS. The carbonized coffee husk in treatments S2, S3 and S4, did not alter the production of small fruits, medium, non-commercial, moisture, pH, SS, AT and SS/AT, however, significantly reduced the total production, commercial and large size fruit. The production of fruits in S1 was significantly higher compared to the other treatments, with an average of 142.6 t ha^{-1}, showing average increase in yield of 24.4%, 29.3% and 36.1% compared to plant of treatments S2, S3 and S4, respectively.

Keywords: *Lycopersicon esculentum*, production, fruit quality, soluble solids.

RESUMO

Produtividade e qualidade de tomate produzido em substratos e com aplicação de ácidos húmicos

Este trabalho foi realizado com o objetivo de avaliar a produtividade e qualidade de frutos de tomateiro, híbrido Vênus, produzidos em substratos, com aplicação de solução nutritiva e de ácidos húmicos (AH). Foram avaliadas 4 doses de AH (0, 20, 40 e 80 L ha^{-1}) e 4 substratos: S1 (fibra de coco (FC)), S2 (FC + casca de café carbonizada (CC) na proporção 1:3), S3 (FC + CC na proporção 2:3) e S4 (CC). O delineamento experimental foi em blocos casualizados distribuídos em esquema fatorial 4x4. As mudas foram transplantadas com 35 dias para sacolas plásticas com capacidade de 7 L. Os AH foram aplicados quatro vezes em um intervalo de oito dias, sendo a primeira aplicação oito dias após o transplantio. Não houve efeito significativo dos AH sobre a produtividade e a qualidade de frutos, exceto na relação sólidos solúveis (SS)/acidez titulável (AT). Doses de até 36 L ha^{-1} aumentaram AT, porém, acima desse valor, favoreceram o incremento de SS. A casca de café carbonizada, nos tratamentos S2, S3 e S4, não alterou a produção de frutos pequenos, médios, não-comerciais, umidade, pH, SS, AT e SS/AT, porém, diminuiu significativamente a produção total, comercial e de frutos grandes. A produção de frutos comerciais em S1 foi significativamente superior à das plantas dos demais tratamentos, com média de 142,6 t ha^{-1}, apresentando aumento médio de produtividade de 24,4%, 29,3% e 36,1%, em relação às plantas dos tratamentos S2, S3 e S4, respectivamente.

Palavras-chave: *Lycopersicon esculentum*, produção, qualidade de fruto, sólidos solúveis.

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Plasticulture has been used for olericulture since the 1970s. Protected cultivation enabled the environment to be adjusted to plants and consequently the production period could be extended to seasons of the year, even in regions before unsuitable for agriculture (Andriolo, 1999). However, when cultivating in a protected environment, directly in the soil and without substrates, Moraes & Furlani (1999) reported that various problems occur of contamination by bacteria, phytopathogenic fungi and nematodes and salinity.

The choice of substrate is important because it allows increase in tomato growth and yield. Therefore its physical and chemical properties should be considered, such as particle distribution by size, density, good water retention and nutrients, oxygen availability, high-capacity for cation exchange and low C/N ratio (Martinez, 2002). Several types of organic substrates are used in cultivation without soil, such as coconut fiber, turf, wood residues, pine bark and partially carbonized, or not, rice husks or inorganic materials such as sand, volcanic rocks, perlite, fiberglass and phenolic foam, used alone or in combinations (Carrijo *et al.*, 2004; Fontes *et al*., 2004).

Inert material substrates should be selected that are long lasting, cheap, easy to use and have low electric conductivity. In this sense coconut fiber has been used with excellent results in tomato production but the statistical difference has not been ascertained regarding sawdust and carbonized rice husks (Carrijo *et al.*, 2004). Transporting coconut fiber, however, increases production costs, so that substrates should be developed from cheap materials that are available in every region of Brazil.

The effect of humic substances (HS) on plants depends on the material of origin, fulvic and humic acid concentration, the dose used, the plant species and variety. The main effects of HS on the plant metabolism include induction of plasmatic membrane H^+-ATPases, root development and increased ion transportation (Façanha *et al.*, 2002); stimulus to plant growth from the release of bioactive molecules with action similar to that of auxin (Canellas *et al.*, 2002) and the effect of enzymes on various metabolic pathways (Vaughan & Malcolm, 1985), on sugars and organic acids that improve tomato quality.

The objective of the present study was to assess the effects of humic acid and organic substrates on Italian-type tomato yield and quality when cultivated in a protected environment.

MATERIAL AND METHODS

The experiment was carried out in the Horticulture Sector, Department of Agriculture at the Federal University of Lavras, in Lavras, Minas Gerais State, Brazil, from August 2007 to January 2008. Venus hybrid seeds, of the Saladete or Italian group, with determined growth habit and oblong fruits, were sown on extruded polystyrene 28-well trays. They were irrigated daily by misting from 8 a.m. to 7 p.m. with a functioning time of three minutes every two hours, 15 mca functioning pressure and an average 6.19 L $hour^{-1}$ flow.

The seedlings were transplanted 35 days after sowing to 7 L plastic bags and distributed in 1.0 x 0.8 x 0.4 m spacing (between double rows, single rows and plants in the same row, respectively) with a 2.78 plant/m^2 population density. The experiment was carried out in a chapel model protected environment, 30 m long, 10 m wide and 1.8 m tall, covered with low density 150 micras polyethylene.

A randomized block design was used in a 4x4 factorial scheme consisting of four humic acid doses (0; 20; 40 and 80 L ha^{-1}) and four substrates: S_1 = coconut fiber (CF); S_2 (CF + carbonized coffee husks (CC) at a 1:3 ratio, based on volume); S_3 (CF + CC, at a 2:3 ratio, based on volume); and S4 (CC) (Table 1). Codahumus 20 was used as HA source, applied every eight days in four installments, that is, one quarter of the doses established (0, 20, 40 and 80 L ha^{-1}), starting on the eighth day after transplant (Table 1). The plots consisted of nine plants and the samples were removed from five central plants in each plot.

The nutrients were supplied by daily fertirrigation, according to the development stage of the crop and the doses were based on recommendations by Castellane & Araújo (1995). In the initial growth phase: 12.5 N; 1.5 P; 7.0 K; 4.0 Ca; 2.0 Mg; 2.0 S (mmol L^{-1}); and further, 20 Fe; 15 Mn; 5 Zn; 30 B; 0.8 Cu; 0.5 Mo (µmol L^{-1}). In the growth and fructification phase: 14.0 N; 2.0 P; 11.2 K; 5.2 Ca; 1.6 Mg; 5.7 S (mmol L^{-1}); and 25 Fe; 15 Mn; 5 Zn; 30 B; 0.8 Cu; 0.5 Mo (µmol L^{-1}).

To tutor the tomato plant, a secondary stem was selected from a vigorous branch just below the first florescence cluster and the other branches were removed, 15 days after transplant. From then onwards there was no further pruning so that the plants developed with four to six stems. Spray irrigation was applied using multiple exit sprays and a mean 1.0 L h^{-1} flow. Irrigation time was determined by measuring the interval between the start of applying the water and the beginning of drainage from the plastic bags and the frequency was adjusted daily, according to the crop development stage and the climatic conditions.

Ripe tomatoes or tomatoes at the maximum physiological development stage were harvested every five days in a total of 11 harvests. The tomatoes were weighed and classified according to the equatorial diameter (caliber) as small (40<50 mm), medium (50<60 mm) and large (>60 mm) and those that presented blossom end rot were also separated. With the results obtained, the production was determined of small, medium, large, noncommercial tomatoes (tomatoes with blossom end rot and insect attack were included in this class), total (consisting of the sum of the commercial and noncommercial tomatoes) and commercial tomatoes. The commercial tomatoes production was obtained from the sum of the large, medium and small classes (caliber).

At the second harvest, five fruits were selected per plot with orangey-red coloring to determine the fresh fruit matter (FFM), dry fruit matter (DFM), moisture, pH, soluble solids and titratable acidity (AT). The FFM was determined in tomatoes with caliber ≥50 mm. The fresh tomatoes were weighed, cut and dried in a forced air circulation chamber at 70°C for 72 hours and then weighed to determine the DFM and moisture. The SS, pH and AT contents were determined according to the norms described by the Adolfo Lutz Institute (1985). The SS/AT ratio was also determined that expresses the tomato flavor.

The data were submitted to analysis of variance and the substrate means were compared by the Tukey test at 5% probability and the humic acid dose by regression using the Sisvar software (Ferreira, 2000).

RESULTS AND DISCUSSION

There was no significant effect of the humic acid (HA) applied to the substrates, except in the SS/AT ratio (Figure 1). This probably occurred due to lixiviation of the humic substances (SH) produced by the high irrigation frequencies (10 to 14 times per day) and the capacity of the substrates to gradually make HS available from 3.0 to 6.2 g kg^{-1} (Table 1). However, the substrates presented significant effect on large, total and commercial fruit production (Table 2) and on the mean fresh fruit and dry fruit matter contents (Table 3).

The plants cultivated in the substrates containing coconut fiber (S1) presented the following tomato distribution by size class, among small, medium, large and

Table 1. Physico-chemical properties of substrates (características físico-químicas dos substratos). Lavras. UFLA. 2008.

Characteristics	S_1	S_2	S_3	S_4	AH*
pH in H_2O	5.8	7.2	7.3	7.8	-
N-total (g kg^{-1})	9.2	8.7	9.7	8.2	4.0
P (g kg^{-1})	2.0	2.4	2.5	2.5	33.4
K (g kg^{-1})	8.2	17.7	22.0	30.5	37.1
Ca (g kg^{-1})	4.2	10.2	8.2	9.1	1.7
Mg (g kg^{-1})	1.5	2.8	2.5	2.3	0.3
S (g kg^{-1})	2.3	2.5	2.7	2.4	7.5
B (mg kg^{-1})	29.5	19.6	21.4	21.2	-
Cu (mg kg^{-1})	85.2	57.7	61.8	45.0	-
Mn (mg kg^{-1})	77.8	182.0	157.1	164.2	7.1
Zn (mg kg^{-1})	84.2	52.9	55.0	29.7	16.2
Fe (mg kg^{-1})	716.3	1256.1	1265.1	1188.9	102.1
Umidity (%)	78.8	77.3	76.4	71.9	-
Density (g dm^{-3})	89.0	100.0	240.0	210.0	1230.0
CE (mS cm^{-1})	3.8	3.8	4.8	5.6	-
C total (dag kg^{-1})	40.6	40.6	36.9	41.0	9.9
C/N	44.1	46.7	38.0	50.0	24.9
Humic acid (g kg^{-1})	2.0	2.5	1.4	2.5	100.0
Fulvic acid (g kg^{-1})	3.2	2.4	1.6	3.7	102.0

S1: coconut fiber (FC); S2: FC + carbonized coffee husk (CC) in the ratio 1:3; S3: FC + CC in the ratio 2:3; S4: CC); C.E.: electrical conductivity; *Coda 20: Codahumus 20. humic acid (S1: fibra de coco (FC); S2: FC + casca de café carbonizada (CC) na proporção 1:3; S3: FC + CC na proporção 2:3; S4: CC; C.E.: condutividade elétrica; *Coda 20: Codahumus 20. ácido húmico).

Table 2. Average yield of Italian tomato fruits, hybrid Venus, small (FP), medium (FM), large (FG), non-commercial (FNC), total (PT), commercial (PC) (produção média de frutos de tomate italiano, híbrido Vênus, pequenos (FP), médios (FM), grandes (FG), não-comerciais (FNC), total (PT), comercial (PC)). Lavras, UFLA, 2008.

Treatments	FP	FM	FG	FNC	PT	PC
	(t ha^{-1})					
S1	13.7 a	55.6 a	73.2 a	4.2 a	146.8 a	142.6 a
S2	15.0 a	51.4 a	41.4 b	4.3 a	111.8 b	107.5 b
S3	16.0 a	52.3 a	32.5 b	4.0 a	105.7 b	101.6 bc
S4	17.2 a	53.9 a	20.1 c	4.8 a	95.1 c	90.4 c
Average	15.5	53.3	41.8	4.3	114.8	110.5
CV (%)	25.3	16.6	24.3	35.2	9.4	10.7

Means followed by the same letter in the column do not differs according to Tukey's test at the 5% level of probability (na coluna, médias seguidas pela mesma letra não diferem entre si pelo teste de Tukey, ao nível de 5% de probabilidade). S1: coconut fiber (FC); S2: FC + carbonized coffee husk (CC) in the ratio 1:3; S3: FC + CC in the ratio 2:3; S4: CC (S1: fibra de coco (FC); S2: FC + casca de café carbonizada (CC) na proporção 1:3; S3: FC + CC na proporção 2:3; S4: CC).

noncommercial tomatoes: 9.4%, 37.9%, 49.9% and 2.9%, respectively. However, in the substrate with carbonized coffee husks (S4) small tomatoes increased to 18.1%, medium tomatoes to 56.6% and there was a 21.1% decrease in large tomato size.

The average tomato production in the different substrates was not significantly different for small (15.5 t ha^{-1}) and medium (53.3 t ha^{-1}) fruits (Table 2). However, S1 presented a large tomato production mean of greater than the other substrates, with increases of 43.5%, 55.6% and 72.6% for S2, S3 and S4, respectively. It was observed that as the carbonized coffee husks (CC) content increased in the substrates, there was a significant reduction in large, total and commercial tomato production due to variation in electric conductivity (3.8 to 5.6 mS cm^{-1}) and the pH (5.8 to 7.8) resulting in fewer nutrients available to the plant (Table 1).

According to Alvarenga *et al.* (2004), 2.5 mS cm^{-1} is the maximum salinity limit expressed by the electric conductivity of the soil for the tomato and there is a 10% yield decrease for every 1.0 mS cm^{-1} increase above the tolerance limit. Carrijo *et al.* (2004) observed greater mean fruit matter in the crops with green coconut fiber and carbonized rice husks that may have been related to the greater capacity of these substrates to make water and nutrients available.

The mean noncommercial tomato (NCF) production was not affected by the different treatments (Table 2). The NCF production of 4.3 t ha^{-1}, due mainly to calcium deficiency, was within the average values, from 3.8 to 5.8 t ha^{-1} observed by Sampaio *et al.* (1999). Blossom end rot probably occurs due to factors such as irrigation management, high relative air humidity in the harvest season and decrease in the transpiratory flow of water and nutrients to the canopy that affected the Ca^{+2} redistribution for the fruits. In nutritive solution, Paiva *et al.* (1998) verified greater calcium accumulation in tomatoes under low relative humidity conditions (40%) because it increased the transpiratory flow of water and nutrients to the canopy and consequently for the fruits.

Substrate S1 was significantly different compared to the other treatments in total tomato production (TP), 146.8 t ha^{-1} (Table 2) while treatments S2 and S3 presented mean TP values significantly higher than S4. The mean commercial tomato production (CP) in S1 (142.6 t ha^{-1}) was greater than

Table 3. Physico-chemical evaluation of Italian tomato fruits, hybrid Venus, average mass of fresh fruit (MFF), moisture, dry mass of fruits (MSF), soluble solids (SS), titratable acidity (AT) and pH (AT) (avaliação físico-química de frutos em tomate italiano, híbrido Vênus, massa média de frutos frescos (MFF), umidade, massa seca de frutos (MSF), sólidos solúveis (SS), acidez titulável (AT) e pH). Lavras, UFLA, 2008.

Treatments	MFF (g)	Umidity (%)	MSF (%)	SS (ºBrix)	AT (% citric acid)	pH
S1	169.9 a	94.4 a	5.7 a	4.3 a	0.53 a	4.3 a
S2	165.2 ab	94.1 a	6.0 ab	4.3 a	0.56 a	4.3 a
S3	164.8 ab	93.7 a	6.2 ab	4.3 a	0.55 a	4.3 a
S4	159.2 b	94.0 a	6.0 b	4.1 a	0.55 a	4.3 a
Average	164.8	94.0	6.0	4.3	0.55	4.3
CV (%)	5.4	0.8	6.1	5.5	5.26	0.8

Means followed by the same letter in the column do not differ according to Tukey's test at the 5% level of probability (na coluna, médias seguidas pela mesma letra não diferem entre si pelo teste de Tukey, ao nível de 5% de probabilidade). S1: coconut fiber (FC); S2: FC + carbonized coffee husk (CC) in the ratio 1:3; S3: FC + CC in the ratio 2:3; S4: CC (S1: fibra de coco (FC); S2: FC + casca de café carbonizada (CC) na proporção 1:3; S3: FC + CC na proporção 2:3; S4: CC).

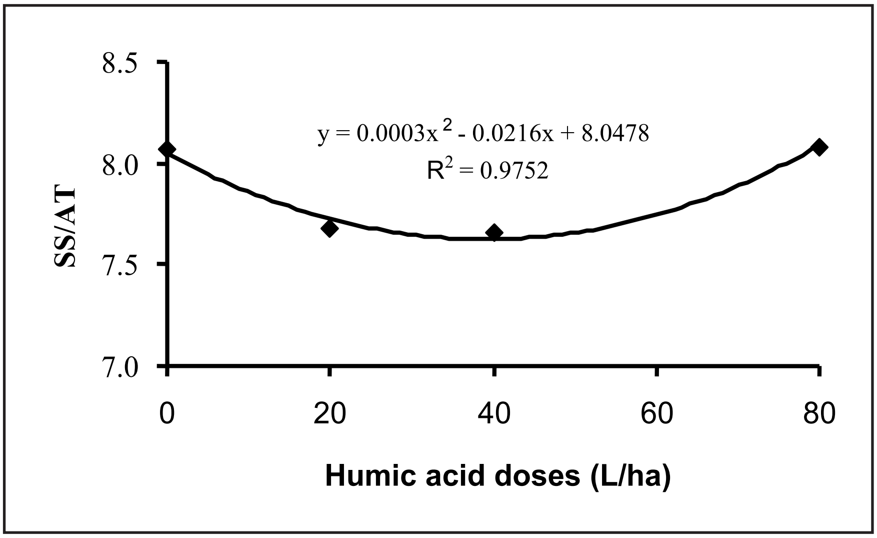

Figure 1. SS/AT relation in tomato fruits of the Italian group, hybrid Venus, according to doses of humic acids applied to organic substrates (relação SS/AT em frutos de tomateiro do grupo italiano, híbrido Vênus, em função de doses de ácidos húmicos, aplicados em substratos orgânicos). Lavras, UFLA, 2008.

the plants in the other treatments but S2 only surpassed significantly substrate S4 (Table 2). The plants in the S1 treatment presented a greater increase in commercial tomatoes (CP) of 24.4%, 29.3% and 36.1% compared to the plants in substrates S2, S3 and S4, respectively. It should be emphasized that the mean CP estimate in the different substrates, of 110.5 t ha^{-1}, was greater than those obtained in NFT hydroponic culture with the UC-82 and Saladinha cultivars, with means of 85.5 to 101.3 t ha^{-1} (Genúncio *et al*., 2006) and using coconut fiber and fertirrigation in the TX and Larissa cultivars, means of 104 t ha^{-1} (Carrijo *et al*., 2004).

The fresh fruit matter (FFM) with diameter (≥50 mm) in substrate S1 was significantly superior only to S4, with respective means of 169.9 and 159.2 g (Table 3). Carrijo *et al.* (2004) reported that coconut fiber increased FFM in the TX and Larissa cultivars, mean 128.2 g m^{-2}, greater than the rock wool (107.4 g m^{-2}) and rice husk (110.7 g m^{-2}) substrates. It is important to emphasize that in hydroponic culture with substrate, the Carmen cultivar presented FFM very close to those reported in the present experiment, 143.1 to 160.7 g (Fernandes *et al.*, 2002).

The mean fruit moisture was around 94.1% and was not affected by the treatments (Table 3). Fernandes *et al.* (2002) reported similar values for the Carmen cultivar, conducted in NFT of about 94.3% moisture and Davies & Hobson (1981) reported that tomatoes have 92.5% to 95.0% water and 5.0% to 7.5% dry matter in their composition. The substrates used presented statistically significant differences for tomato dry matter (DFM) with a mean of 6.0% (Table 3). This result was very close to the DFM contents reported by Fernandes *et al.* (2002) in long life tomatoes, with means of 5.6% and 5.8%.

The soluble solids (SS) are the main components that give flavor to the tomato (sugars and acids) and influence the industrial yield (Giordano *et al.*, 2000). The SS contents did not vary significantly in the treatments and presented a mean average of 4.3ºBrix (Table 3). Values from 4 to 6ºBrix for SS are considered normal in tomatoes (George *et al.*, 2004). Souza *et al.* (2001) found significant differences for SS content among tomato genotypes ranging from 4.21º to 5.30ºBrix indicating the importance of the factor of genetic control.

The environment has an important influence on the tomato SS contents. Caliman *et al*. (2008) observed lower and significant SS values in a protected environment than in the field, 3.60º to 3.68ºBrix and 5.20º to 5.95ºBrix, respectively. The higher ºBrix values for the genotypes produced in the field were related to the sugar synthesis and accumulation in the tomatoes due to the greater luminosity compared to cultivation in a protected environment. Under the conditions of the present experiment, a decrease was observed in luminosity intensity, associated to mistiness and rainfall during the harvest season. In this case, Cintra *et al.* (2000) reported mean the SS values below 4.0ºBrix, probably related to the rainy season.

Titratable acidity (AT) influences flavor because it measures the quantity of organic acids and indicates tomato adstringency. Citric and malic acids are the main organic acids found in tomatoes, representing 9% and 4% of the dry fruit matter. AT was not influenced by the substrate type and presented a mean of 0.55% (Table 3). The mean AT values were a little above the range considered normal for tomatoes, from 0.3% to 0.4% (George *et al*., 2004). However, in hydroponic cropping, Fernandes *et al.* (2002) reported 0.5% to 0.6% AT in the pulp of Carmen hybrid tomatoes. However, using highly saline irrigation water (CE 9.5 dS m^{-1}) the AT values (from 0.91% to 1.01%) were above the levels considered normal in tomatoes (Blanco & Folegatti, 2008). The factors that contributed to increased acidity were probably related to the ionic concentration of the nutritive solution and decrease in solar radiation, common in protected environments that affected the photoassimilate metabolism.

The treatments did not affect the tomato pH and the mean was 4.3 (Table 3). The values found were below the maximum limit established of 4.5 and it was important to prevent microorganism proliferation in the pulp. The pH is a genetic characteristic. Feltrin *et al.* (2005) reported means ranging from 3.96 to 4.17 in the Sweet Million, Rocio and Densus cultivars.

There was significant effect only among the organic acid factors and the SS/AT variable ($p<0.05$) (Figure 1). The regression presented a decreasing quadratic response to the 36 L ha^{-1} humic acid (HA) dose corresponding to the minimum point of the SS/AT ratio, or 7.6. However, starting at this value, the SS/AT ratio increased to 8.1 at the 80 L ha^{-1} HA dose. The data indicated that there was a small increase in AT up to the 36 L ha^{-1} dose but above this value the SS content increased, with little reduction in organic acids.

At higher doses, the humic acids increased the SS/AT ratio, probably favoring the process of organic acid conversion to sugars. Abdel-Mawgoud *et al.* (2007) reported greater SS contents in tomatoes with HA leaf application at the 75 g 100 L^{-1} dose, indicating a positive relation with the photoassimilate content produced by the plant. This occurred because the humic acid stimulated photosynthesis and there was a greater rate of assimilates in the leaves and exportation to the tomato, that increased the SS content.

High quality tomatoes are characterized by containing more than 0.32% AT, 3% SS and an SS/AT ratio greater than 10 (Mencarelli & Saltveit Junior, 1988). The AT and SS contents reported in the present study were within the limits established by the referred authors, because they presented average values of 0.55% and 4.3%, respectively. However, the maximum values reported for the SS/AT ratio were below 10. Nevertheless, it was observed that in field cropping the tomatoes were more flavorful, with greater °Brix than the tomatoes produced in the protected environment, with means of 12.1 and 16.8 SS/AT (Caliman *et al.*, 2008). This occurred because there was greater solar radiation in the field than in the protected environment. In the present experiment the harvest season coincided with the season of heavier rainfall, low luminosity and high relative humidity that would explain the lower photosynthesis activity and the dilution factor, that is, water accumulation in the tomatoes.

Coconut fiber presented significantly greater results than the other substrates for large, total and commercial tomato production. On the other hand, carbonized coffee husks altered the electric conductivity and pH of the substrate solution that significantly decreased the large, total and commercial tomato size although it did not affect the quality characteristics.

REFERENCES

ABDEL-MAWGOUD AMR; EL-GREADLY NHM; HELMY YI; SINGER SM. 2007. Responses of tomato plants to different rates of humic-based fertilizer and NPK fertilization. *Journal of Applied Sciences Research* 3: 169-174.

ALVARENGA MAR; LIMA LA; FAQUIN V. 2004. Fertirrigação. In: ALVARENGA MAR (ed). *Tomate: produção em campo, em casa-de-vegetação e em hidroponia*. Lavras: Editora UFLA. p. 123-158.

ANDRIOLO JL. 1999. *Fisiologia das culturas protegidas*. Santa Maria: UFSM. 142p.

BLANCO FF; FOLEGATTI MV. 2008. Doses de N e K no tomateiro sob estresse salino: III. Produção e qualidade de frutos. *Revista Brasileira de Engenharia Agrícola e Ambiental* 12: 122–127.

CALIMAN FRB; SILVA DJH; MARTINS CJL; MOREIRA GR; STRINGHETA PC; MARIN BG. 2008. *Acidez, ºbrix e sabor de frutos de diferentes genótipos de tomateiro produzidos em ambiente protegido e no campo*. UFV-Depto. Fitotecnia. Disponível em: <http://200.210.234.180/HORTA/Download/Biblioteca/olfg4152c.pdf>. Acessado em: 18 de março de 2008.

CANELLAS LP; OLIVARES FL; FAÇANHA ALO; FAÇANHA AR. 2002. Humic acids isolated from earthworm compost enhance root elongation, lateral root emergence, and plasma membrane H^+-ATPase activity in maize roots. *Plant Physiology* 130: 1951-1957.

CARRIJO OA; VIDAL MC; REIS NVB; SOUZA RB; MAKISHIMA N. 2004. Produtividade do tomateiro em diferentes substratos e modelos de casas de vegetação. *Horticultura Brasileira* 22: 05-09.

CASTELLANE PD; ARAÚJO JAC. 1995. *Cultivo sem solo-hidroponia*. Jaboticabal: FUNEP. 43p.

CINTRA AAD; GRILLI GVG; BRAZ LT; SANTOS GM; BRAZ BA. 2000. Caracterização de frutos de cultivares de tomateiro para processamento. *Horticultura Brasileira* 18: 723-725.

DAVIES JN; HOBSON GE. 1981. The constituents of tomato fruit – the influence of environment, nutrition and genotype. *CRC Critical Review of Food Science Nutrition* 15: 205-280.

FAÇANHA AR; FAÇANHA ALO; OLIVARES FL; GURIDI FGA; VELLOSO ACX; RUMJANEK VMR; BRASIL F; SCHRIPSEMA J; BRAZ-FILHO R; OLIVEIRA MA; CANELLAS LPC. 2002. Bioatividade de ácidos húmicos: efeitos sobre o desenvolvimento radicular e sobre a bomba de prótons da membrana plasmática. *Pesquisa Agropecuária Brasileira* 37: 1301-1310.

FELTRIN DM; POTT CA; FURLANI PR; CARVALHO CRL. 2005. Produtividade e qualidade de frutos de cultivares de tomateiro fertirrigado com cloreto e sulfato de potássio. *Revista de Ciências Agroveterinárias* 4: 17-24.

FERNANDES AA; MARTINEZ HEP; FONTES PCR. 2002. Produtividade, qualidade dos frutos e estado nutricional do tomateiro tipo longa vida conduzido com um cacho, em cultivo hidropônico, em função das fontes de nutrientes. *Horticultura Brasileira* 20: 564-570.

FERREIRA DF. 2000. *Sistemas de análises estatísticas*, 3.1. Lavras: UFLA.

FONTES PCR; LOURES JL; GALVÃO JC; CARDOSO AA; MANTOVANI EC. 2004. Produção e qualidade do tomate produzido em substrato, no campo e em ambiente protegido. *Horticultura Brasileira* 22: 614-619.

GENÚNCIO GC; MAJEROWICZ N; ZONTA E; SANTOS AM; GRACIA D; AHMED

CRM; SILVA MG. 2006. Crescimento e produtividade do tomateiro em cultivo hidropônico NFT em função da concentração iônica da solução nutritiva. *Horticultura Brasileira* 24: 175-179.

GEORGE B; KAUR C; KHURDIYA DS; KAPOOR HC. 2004. Antioxidants in tomato (*Lycopersium esculentum*) as a function of genotype. *Food Chemistry* 84: 45-51.

GIORDANO LB; SILVA JBC; BARBOSA V. 2000. Escolha de cultivares e plantio. In: SILVA JBC; GIORDANO LB. (org). *Tomate para processamento industrial*. Brasília: Embrapa Comunicação para Transferência de Tecnologia/EMBRAPA Hortaliças. 168p.

INSTITUTO ADOLFO LUTZ. 1985. *Normas Analíticas do Instituto Adolfo Lutz*. 3.ed. São Paulo: Instituto Adolfo Lutz. 533p.

MARTINEZ PF. 2002. Manejo de substratos para horticultura. In: ENCONTRO NACIONAL DE SUBSTRATOS PARA PLANTAS, 3, 2002. Campinas: *Caracterização, manejo e qualidade de substratos para produção de plantas*. Campinas: IAC. p. 53-76.

MENCARELLI F; SALTVEIT JUNIOR ME. 1988. Ripening of mature-green tomato fruit slices. *Journal of American Society for Horticultural Science* 113: 742-745.

MORAES CAG; FURLANI PR. 1999. Cultivo de hortaliças de frutos em hidroponia e em ambiente protegido. *Informe Agropecuário* 20: 106-113.

PAIVA EAS; MARTINEZ HEP; CASALI VWD; PADILHA L. 1998. Occurrence of blossom end rot in tomato as a function of calcium dose in the nutrient solution and air relative humidity. *Journal of Plant Nutrition* 21: 2663-2670.

SAMPAIO RA; FONTES PCR; SEDIYAMA CS. 1999. Resposta do tomateiro à fertirrigação potássica e cobertura plástica do solo. *Pesquisa Agropecuária Brasileira* 34: 21-30.

SOUZA JC; MALUF WR; SOBRINHO FS; GOMES LAA; MORETTO P; LICURSI V. 2001. Características de produção e conservação pós-colheita de frutos de tomateiros híbridos portadores do alelo “alcobaça”. *Ciência e Agrotecnologia* 25: 503-509.

VAUGHAN D; MALCOLM RE; ORD BG. 1985. Influence of humic substances on biochemical processes in plants. In: VAUGHAN D; MALCOLM RE. (eds). *Soil organic matter and biological activity*. Dordrecht: Kluwer Academic. p. 77-108.