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Seedlings production of two tomato (*Solanum licopersicum* L.) cultivars under different environments and substrates

Produção de mudas de duas cultivares de tomate (*Solanum licopersicum* L.) em diferentes ambientes e substratos

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Abstract

The type of environment and substrates quality in seedlings production are essential for the production of productive plants under field conditions. In order to determine the best environment and substrate for seedlings production of two tomato cultivars (IPA 06 and Santamélia), two experiments, completely randomized and arranged in subdivided plots with five replicates, were conducted under the environmental conditions of Boa Vista, Roraima, Brazil. Treatments consisted of the association among five environments (A1 - greenhouse, A2 - Chromatinet ® 35% red, A3 - Chromatinet ® 50% red, A4 - Chromatinet ® 35% Silver and A5 - Chromatinet ® 50% Silver) and four substrates S1 - OrganoAmazon®; S2 - OrganoAmazon® + PuroHumus®; S3 - OrganoAmazon® + PuroHumus® + soil + bovine manure, and S4- OrganoAmazon® + PuroHumus® + soil + bovine manure + carbonized rice husk (CRH) on the following variables: number of leaves, plant height, stem diameter, dry shoot and root biomass, plant height/stem diameter ratio accordingly to colon & Dickson quality index of seedlings. Substrates made with the addition of PuroHumus®, without presenting CRH (S2 and S3), which favored the increasing of all analyzed variables. In addition, greenhouse, especially when is associated to S2 substrate, had achieved the best environment for seedlings production of the two evaluated tomato cultivars. Photoconverter shading nets we are not efficient in tomato seedlings production under climatic conditions of Boa Vista, Roraima, Brazil.

Key words: Horticulture; photoconverter shading nets; plant propagation; plant establishment; protected environment; transplanting.

Resumo

O tipo de ambiente e a qualidade de substratos na produção de mudas de espécies olerícolas são essenciais à obtenção de plantas produtivas em campo. Assim, objetivando determinar o melhor ambiente e substrato visando a produção de mudas de duas cultivares de tomate (IPA 06 e Santamélia), dois experimentos delineados inteiramente ao acaso e arranjados em parcelas subdivididas, com cinco repetições, foram conduzidos sob as condições ambientais de Boa Vista, Roraima, Brasil. Os tratamentos consistiram da associação entre cinco ambientes (A1 – estufa agrícola; A2 – Chromatinet® 35% vermelha; A3 – Chromatinet® 50% vermelha; A4 – Chromatinet® 35% Silver e A5 – Chromatinet® 50% Silver) e quatro substratos (S1 – OrganoAmazon®; S2 - OrganoAmazon® + PuroHumus®; S3 - OrganoAmazon® + PuroHumus® + soil + esterco bovino, e S4 - OrganoAmazon® + PuroHumus® + soil + esterco bovino + casca de arroz carbonizada (CAC)) sobre as variáveis: número de folhas, altura de planta, diâmetro do colo, biomassa seca da parte aérea e raiz, relação altura/diâmetro do colo e índice de qualidade de Dickson das mudas. Substratos confeccionados com a adição de PuroHumus®, sem apresentar CAC (S2 e S3), favoreceram o incremento de todas as variáveis analisadas. Além disso, a estufa agrícola, principalmente quando associada ao substrato S2, foi o melhor ambiente para a produção de mudas das duas cultivares de tomate. Os telados com telas fotoconversoras não foram eficientes na produção de mudas de tomate sob as condições climáticas de Boa Vista, Roraima, Brasil.

Palavras-chave: Ambiente protegido; estabelecimento de plantas; horticultura; propagação de plantas; telas fotoconversoras; transplante.

Introduction

Tomato (*Solanum licopersicum* L.) is one of the vegetables of great interest for rural producers of all regions of Brazil, being one of major responsible for high national horticultural production (Onoyama, Reifschneider, Moita & Souza, 2010). In order to obtain high yields, it is necessary to produce quality seedlings, a final plant performance under field conditions, which depends on both the nutritional and phytosanitary aspects (Costa *et al.*, 2011a).

In this stage of cultivation, adoption of protected environments aims to provide microclimatic conditions favorable to crop due to control of meteorological variables that affect the crop, such as: temperature, humidity and solar radiation (Beckmann *et al.*, 2006). Currently, most of the protected environments for plant production are covered by low density polyethylene films (agricultural greenhouses), however, photoconverter shading nets of different colors and shading percentages (Aluminet® and Chromatinet®) and monofilament (Sombrite®) also are being used (Costa *et al.*, 2011a; Costa *et al.*, 2010a).

Photoconverter shading nets are able to modify the quantity and quality of the transmitted solar radiation, determining optical modifications of the dispersion and reflectance of the light in environment, which can cause anatomical and morphological modifications affecting the plant productive characteristics (Costa *et al.*, 2010a; Costa *et al.*, 2010b).

Besides the environment, another essential attribute to vegetable seedlings production is the use of substrates. According to Frade Junior *et al.*(2011), this should ensure an adequate root system growth through its solid phase, ensure the optimal water and nutrient supplying through its liquid phase and ensure the oxygen supplying and CO_2 transport between roots and external environment through its gas phase.

In the State of Roraima, northern Brazil, two commercial compounds are widely used in seedling production: OrganoAmazon® and PuroHumus® (Monteiro Neto *et al.*, 2016). However, is necessary to formulate alternative substrates using materials accessible to each region.

Given these concerns, the aim of this study was to evaluate the influence of environments and substrates on seedlings production of two tomato cultivars in Boa Vista, Roraima, Brazil.

Material and methods

The study was carried out in the experimental area of the Agricultural Sciences Center of the Federal University of Roraima - CCA / UFRR, in Boa Vista-RR, Brazil, from July to September 2015, whose geographic coordinates were recorded at 2°49'11 "N, 60°40'24" W and altitude of 90 m.a.s.l., the climate of the region being characterized as Aw, tropical rainy, with annual averages of rainfall, relative humidity and temperature of 1678 mm, 70% and 27.4°C, respectively (Araújo *et al.*, 2001).

Two independent experiments were carried out, one for cv. IPA 06 and another for cv. Santamélia, both conducted in a completely randomized design, in a subdivided plots scheme, with five environments (plots) and four substrates (subplots). Each treatment was submitted to five replicates, the experimental unit consisting of five tomato plants.

The five environments used were as follows: an arc-type greenhouse covered with low-density polyethylene (LDPE) [control environment (A1)] and four roofs covered with different ChromatiNet® photoconverters: A2 [screened with 35% red photoconverter shading nets (ChromatiNet® Red)]; A3 [screened with red color photoconverter shading nets with 50% shading (ChromatiNet® Red)]; A4 [screened with 35% shading silver (ChromatiNet® Silver) photoconverter and A5 [screened with 50% shading silver (ChromatiNet® Silver) photoconverter shading nets].

Greenhouse had dimensions of 6 m in length, 3.40 m in width and 2.4 m at right foot, surrounded by Sombrite® with 50% shading. Subsequently, photoconverter shading nets had structure in wood with dimensions of 17 m of length, 4 m of width and 2.5 m at right foot.

The substrates prepared and evaluated were as follows: S1 [OrganoAmazon®], S2 [OrganoAmazon® + PuroHumus® (1:1 v/v)]; S3 [OrganoAmazon® + PuroHumus® + soil + bovine manure (1:1:1:1 v/v)] and S4 [OrganoAmazon® + PuroHumus® + soil + bovine manure + carbonized rice husk (CRH) (1:1:1:1:1 v/v)]. These were manually homogenized and transferred into containers for later seedling. Substrate samples were then sent to laboratory for chemical characterization according to the proposed methodology by Raij & Quaggio (1983), the results are presented in Table 1.

Table 1. Chemical characterization of the substrates used for seedlings production of two tomato cultivars. Boa Vista, Roraima, Brazil, 2015.

Substrate*	pH (H_2O)	N	P	K	Ca	Mg	S	B[1]	Cu[1]	Mn[1]	Zn[1]	Fe[1]
							---- $cmol_c$ dm^{-3} ----					
S1	7.7	48.6	0.6	1.0	0.8	0.3	1.0	5.4	0.1	0.5	0.2	0.1
S2	7.1	81.1	1.0	2.0	1.1	0.7	1.2	7.9	0.1	1.1	0.2	0.3
S3	7.2	41.6	0.7	1.2	1.1	0.7	1.1	6.3	0.1	0.9	0.3	0.7
S4	7.2	43.1	0.7	1.5	1.2	0.5	1.2	6.8	0.1	1.0	0.1	0.1

*S1 (OrganoAmazon®), S2 (OrganoAmazon® + PuroHumus®), S3 (OrganoAmazon® + PuroHumus® + soil + bovine manure), S4 (OrganoAmazon® + PuroHumus® + soil + bovine manure + CRH).

Compost and organic fertilizers were purchased in local shops of Boa Vista. A typical Latosol (LAdx), collected at soil depth of 0-20 cm, was sieved using a 6 mm photoconverter shading net. pH was corrected with an addition of 0.196 kg m^{-2} of limestone dolomite. After limestone application was wetted daily for 20 days for limestone reaction. Subsequently, carbonization of rice husk was carried out considering the complete carbonization of rice husk. Bovine manure, purchased from extensively raised animals, was sieved and watered daily until curing.

The characterization of luminous incidence in the environments was defined by accumulated average of daily records of global solar radiation (GR) and photosynthetic active radiation (PAR), as well as PAR/GR ratio, performed in three established schedules (Table 2).

Table 2. Mean values of global radiation (GR), photosynthetically active radiation (PAR), PAR/GR ratio (%) maximum and minimum temperatures in tomato seedling production under different environments. Boa Vista, Roraima, Brazil, 2015.

	Solar radiation ($\mu mol\ s^{-1}\ m^{-2}$)									Temperature (°C)	
	Data collection timing										
	------------ 08:00 h ---------			----------- 12:00 h ---------			-------- 17:00 h ---------			-- 08:00 h --	
**	GR	PAR	PAR/GR	GR	PAR	PAR/GR	GR	PAR	PAR/GR	Max.	Min.
EE	2071.6	726.8	35.1 %	3649.9	1594	43.6 %	350.4	235.6	67.5 %	32.9	24.4
A1	1066.9	439.7	41.2 %	2062.5	870.7	42.2 %	275.1	138.8	50.6 %	37.3	22.1
A2	1188.3	477.1	40.2 %	2236.1	897.2	40.1 %	218.5	102.1	47.1 %	42.3	24.3
A3	863.9	364.4	42.2 %	1731.3	723.9	41.8 %	92.8	56.0	60.4 %	41.2	23.1
A4	1159.4	431.9	37.3 %	2233.9	863.4	38.7 %	184.6	90.4	49.4 %	40.1	22.3
A5	954.1	387.5	35.1 %	1879.5	775.5	41.3 %	101.7	51.1	50.6 %	39.2	23.6

** EE= External environment (open sky), A1= Greenhouse with plastic cover, A2= photoconverter shading net with 35%, A3= photoconverter shading net at 50%, A4= Silver photoconverter shading net at 35%, A5= Silver photoconverter shading net at 50%.

GR and PAR variables were obtained through pyrometer model L1-200 and a quantum sensor model L1-190, respectively. Daily values of maximum and minimum temperatures were also checked using thermometers installed inside and outside the evaluated environments. The sowing was carried out in plastic containers of 180 cm^3, 7.54 cm high, 6.32 cm in diameter at the top and 4.39 cm in diameter at the base. These were drilled in the bottom and filled in their bases with type 0 gravel (4.8 - 9.5 mm). Seedlings were irrigated daily with the use of micro sprinkler irrigation system in two shifts (morning and afternoon) throughout the experimental period.

At 25 days after emergence (DAE), variables were evaluated as follows: number of leaves (NL), plant height (PH), stem diameter (SD), dry shoot mass and root dry mass (DSM), following the methodology proposed by Monteiro Neto *et al.* (2016). Plant height / stem diameter (PH/SD) and Dickson quality index (DQI), were determined following Equation1 and were evaluated as seedling quality indexes.

$$DQI = \frac{RDM}{\left(\frac{PH}{SD} + \frac{DSM}{RDM}\right)}$$

Equation 1

The collected data were submitted to analysis of variance, in which, to identify significant difference among treatments and statistical significance for all comparisons was made at $p<0.05$ by the Scott-Knott test, both with the support of Sisvar ® software (Ferreira, 2011).

Results

The mean values of global radiation (GR) and photosynthetically active radiation (PAR) were higher in external environment (Table 2). Greenhouse (A1) and greenhouses with 35% shading (A2 and A4), promoted greater transmittance of global radiation (GR) and photosynthetically active radiation (PAR), but the highest proportions of PAR / GR were found in the red photoconverter shading net at 50% (A3). As expected, the protected environments considerably had achieved an increasing in local temperature, however, A1 environment, in addition to presenting a greater transmissibility of photosynthetically active radiation (PAR), also promoted a decreasing in the average values of temperature compared to other environments.

The results of plant growth variables of tomato seedlings are presented in Table 3 (number of leaves (NL), plant height (PH) and stem diameter (SD) and Table 4 (dry shoot mass) and dry root mass (DSM)].

Table 3. Mean values of plant growth variables (number of leaves, plant height and stem diameter) of two tomato cultivars grown in different environments and substrates. Boa Vista, Roraima, Brazil, 2015

**	IPA 06					Santamélia				
	Number of leaves									
	S1	S2	S3	S4	*m*	S1	S2	S3	S4	*m*
A1	3.3 Cb	4.3 Aa	4.5 Aa	4.4 Aa	4.1	3.5 Ba	4.0 Aa	3.5 Ba	3.5 Ba	3.6
A2	3.4 Bb	3.5 Bb	3.5 Bc	4.1 Ab	3.6	3.1 Ba	3.7 Ab	3.6 Aa	3.4 Ba	3.5
A3	3.4 Bb	4.4 Aa	4.2 Ab	3.8 Bb	4.0	3.2 Ba	4.1 Aa	3.9 Aa	3.5 Ba	3.7
A4	3.7 Ba	3.9 Ab	4.0 Ab	3.4 Bc	3.8	3.4 Aa	3.6 Ab	3.6 Aa	3.2 Ab	3.5
A5	3.8 Ba	4.3 Aa	3.8 Bc	3.0 Cd	3.7	3.6 Ba	4.1 Aa	3.7 Ba	3.0 Cb	3.6
M	3.5	4.1	4.0	3.7		3.4	3.9	3.7	3.3	
	Plant height (cm)									
	S1	S2	S3	S4	*m*	S1	S2	S3	S4	*m*
A1	11.3 Ba	12.6 Ab	12.2 Ab	12.1 Aa	12.1	11.1 Aa	10.2 Bc	9.4 Cb	11.4 Aa	10.5
A2	9.5 Bb	11.5 Ac	9.1 Bd	8.4 Cc	9.6	8.4 Bb	10.4 Ac	9.0 Bb	8.0 Bc	9.0
A3	10.5 Ca	15.1 Aa	13.4 Ba	11.0 Cb	11.8	10.5 Ba	13.4 Aa	11.8 Ba	9.8 Cb	11.4
A4	10.8 Ba	12.6 Ab	10.2 Bc	8.3 Cc	10.5	8.7 Bb	9.8 Ac	9.6 Ab	6.3 Cd	8.6
A5	9.1 Bb	11.8 Ac	9.4 Bd	7.4 Cd	9.0	8.7 Bb	11.3 Ab	9.0 Bb	6.7 Cd	8.9
m	10.2	12.7	10.9	9.4		9.5	11.0	9.7	8.4	
	Stem diameter (mm)									
	S1	S2	S3	S4	*m*	S1	S2	S3	S4	*m*
A1	2.9 Aa	2.7 Aa	2.7 Aa	2.5 Aa	2.7	2.2 Aa	2.7 Aa	1.9 Ba	1.6 Bb	2.1
A2	2.2 Bb	2.4 Ab	1.8 Bb	1.7 Bb	2.1	1.7 Ab	1.7 Ac	1.6 Ad	1.5 Bb	1.6
A3	1.7 Cc	2.3 Ab	1.9 Bb	1.9 Bb	2.0	1.4 Cc	1.9 Ab	1.8 Bc	1.4 Cb	1.6
A4	2.1 Bb	2.4 Ab	1.9 Bb	1.8 Bb	2.1	1.4 Bc	1.6 Ac	1.3 Be	1.1 Cc	1.4
A5	1.7 Bc	2.0 Ac	1.8 Ab	1.5 Cc	1.8	2.1 Ba	2.5 Aa	2.1 Ba	1.9 Ca	2.2
m	2.1	2.4	2.0	1.9		1.8	2.1	1.7	1.5	

Values followed by the same letter, lowercase in the columns and uppercase in the lines, do not differ by Scott-Knott's test (p≤0.05); m = mean. A5 = Red photoconverter shading net at 50%, A4 = Silver photoconverter shading net at 35%, A5 = Silver photoconverter shading net at 50%, S1 (OrganoAmazon®), S4 (OrganoAmazon® + PuroHumus® + soil + bovine manure + CRH), S3 (OrganoAmazon® + PuroHumus®), S3 (OrganoAmazon® + PuroHumus® + soil + bovine manure).

Table 4. Mean values of dry shoot biomass and dry root biomass of tomato cultivars produced under different environments and substrates. Boa Vista, Roraima, Brazil, 2015.

**	IPA 06					Santamélia				
	Aerial shoot dry mass (g)									
	S1	S2	S3	S4	*m*	S1	S2	S3	S4	*m*
A1	0.12 Ba	0.14 Aa	0.13 Aa	0.11 Ba	0.13	0.19 Ba	0.20 Aa	0.19 Ba	0.18 Ba	0.19
A2	0.07 Bb	0.09 Ac	0.05 Cc	0.05 Ce	0.07	0.08 Bc	0.11 Ae	0.11 Ac	0.08 Bc	0.10
A3	0.07 Cb	0.14 Aa	0.08 Cb	0.09 Bb	0.10	0.09 Cb	0.17 Ab	0.14 Bb	0.09 Cb	0.12
A4	0.12 Aa	0.11 Ac	0.06 Cb	0.07 Bc	0.09	0.09 Cb	0.12 Ad	0.10 Bd	0.06 Dd	0.09
A5	0.08 Bb	0.12 Ab	0.08 Bb	0.06 Cd	0.08	0.09 Cb	0.15 Ac	0.12 Bb	0.06 Dd	0.11
m	0.09	0.12	0.08	0.08		0.11	0.15	0.13	0.09	
	Dry root mass (g)									
	S1	S2	S3	S4	*m*	S1	S2	S3	S4	*m*
A1	0.07 Ba	0.11 Aa	0.12 Aa	0.12 Aa	0.11	0.10 Ba	0.09 Ba	0.09 Ba	0.18 Aa	0.12
A2	0.03 Bc	0.04 Bb	0.07 Ac	0.03 Bc	0.04	0.05 Bb	0.04 Cc	0.06 Ac	0.04 Cb	0.05
A3	0.02 Cd	0.05 Ad	0.04 Bd	0.06 Ab	0.04	0.03 Cc	0.07 Ab	0.05 Bb	0.05 Bb	0.05
A4	0.05 Cb	0.06 Bc	0.08 Ab	0.03 Dc	0.06	0.05 Cb	0.10 Aa	0.08 Ba	0.04 Db	0.07
A5	0.04 Bb	0.05 Bd	0.07 Ac	0.03 Cc	0.05	0.04 Cb	0.07 Ab	0.06 Bc	0.03 Dc	0.05
m	0.04	0.06	0.08	0.05		0.05	0.07	0.07	0.07	

Values followed by the same letter, lowercase in the columns and uppercase in the lines, do not differ by Scott-Knott's test (p≤0.05); m = mean. A5 = Red photoconverter shading net at 50%, A4 = Silver photoconverter shading net at 35%, A5 = Silver photoconverter shading net at 50%. S1 (OrganoAmazon®), S4 (OrganoAmazon® + PuroHumus® + soil + bovine manure + CRH), S3 (OrganoAmazon® + PuroHumus), S3 (OrganoAmazon® + PuroHumus® + soil + bovine manure).

The effect of interaction between environments (E) and substrates (S) was significant in all analyzed variables in both cultivars, where S2 substrate, followed by S3, was always superior to the others, characterizing itself as the promoting substrate with highest quantitative values in seedlings of the two cultivars, independently of the associated environment.

For number of leaves (NL) variable, when analyzing the means of the isolated factors, it is noticed that, in general, S2 substrate and the environments A1 and A3 promoted increased values of this variable. In cv. 'IPA 06'; under the influence of greenhouse (A1), associated to S2 and S3 substrates, as well as ChromatiNet® 50% Red (A3), favored by S2; were highlighted on the other environments in the number of leaves variable. For Santamélia, S2 and S4 were the most efficient substrates within the A1, which together with A3, as well as in the cultivar IPA 06, were the environments that most promoted the number of leaves (NF) and had achieved an increasing in the produced seedlings.

For plant height (PH) variable, it is observed that the environment A3, influenced mainly by S2 and S3 substrates, which promoted a significant increasing in the values of the two evaluated cultivars. However, this environment did not promote stem diameter (SD), which results similar to those observed in plant height (PH), evidencing that the conditions of this environment did not promote uniform plant growth between plant height (PH) and stem diameter (SD), regardless of the type of substrate. On the other hand, S2 continued to be the main substrate, in the same way, A1 was the environment that provided the most conditions for seedling development of both cultivars IPA 06 and 'Santamélia'. When analyzing the dry mass of aerial part (SDM) (Table 4); A3, when associated to the best substrate (S2), presented superiority to lower shading, indicating that biomass of aerial part may be more affected by plant sprouting growth than by leaves formation, a fact observed in number of leaves (NL) , plant height (PH) and shoot dry mass (SDM) variables of the two tomato cultivars. However, aerial biomass as well as root biomass (RDM) were also favored by A1 when associated with S2 and S3 in the two evaluated cultivars. When comparing only the environments constituted by photoconverter shading nets, taking into account the substrates with greatest effect on plant growth variables (S2 and S3), it was verified that biomass accumulation in the seedlings of the two evaluated tomato cultivars was directly associated to shading net coloration, in which shading net influenced positively the biomass accumulation of the aerial part, and the silver shading net favored the greater concentration of root biomass (Table 4). The quality indexes presented in Table 5 confirm a positive influence of the A1 environment and the S2 and S3 substrates on seedlings development of the two evaluated tomato cultivars.

It is worth noting that in experiments inherent to qualitative production of seedlings in different segments of agriculture, the adoption of these indices is essential to the correct choice of treatments with high potential of practical application by seedlings producers. The effect of unbalanced plant growth was evident with the PH / SD ratio, which results especially in the A3 environment, in the two evaluated cultivars. These results indicate an increasing in plant height (PH), which was not proportionally accompanied by an increasing in stem diameter (SD) in the evaluated seedlings.

The quality index of Dickson (DQI) was a good indicator of seedlings quality in the two evaluated tomato cultivars, confirming the best results obtained with the treatments inherent to A1 environment and S2 and S3 substrates.

Table 5. Mean values of seed quality indexes of two tomato cultivars produced under different environments and substrates. Boa Vista, Roraima, Brazil, 2015.

**	IPA 06					Santamélia				
	PH/SD									
	S1	S2	S3	S4	*m*	S1	S2	S3	S4	*m*
A1	39.0 Bd	46.7 Ad	45.2 Ac	48.4 Ac	44.8	51.0 Bc	37.8 Dd	49.5 Cd	71.3 Aa	42.4
A2	43.2 Cd	4.9 Bd	50.6 Ab	49.4 Ab	47.8	49.4 Dc	61.2 Ab	56.3 Bc	53.3 Cd	55.1
A3	61.8 Ca	65.7 Ba	70.5 Aa	57.9 Da	64.0	75.0 Aa	70.5 Ba	65.6 Cb	70.0 Ba	70.3
A4	51.4 Bc	52.5 Ac	53.7 Ab	46.1 Cc	50.9	62.21 Bb	61.3 Bb	73.8 Aa	57.3 Cc	63.7
A5	53.5 Bc	5.0 Ab	52.2 Bb	49.3 Cb	53.5	41.4 Bd	45.2 Ac	42.9 Be	35.3 Ce	41.2
m	49.8	54.4	54.4	50.2		55.8	55.2	57.6	57.6	
	DQI									
	S1	S2	S3	S4	*m*	S1	S2	S3	S4	*m*
A1	0.034 Ba	0.042 Aa	0.045 Aa	0.040 Aa	0.04	0.042 Ba	0.048 Aa	0.040 Ba	0.044 Ba	0.044
A2	0.015 Bc	0.018 Bc	0.021 b	0.012 Cc	0.01	0.020 Ab	0.017 Bd	0.023 Ac	0.016 Bb	0.019
A3	0.009 Bd	0.020 Ac	0.013 Bc	0.021 Ab	0.02	0.011 Dc	0.025 Ac	0.020 Bc	0.016 Cb	0.018
A4	0.023 Ab	0.024 Ab	0.023 Ab	0.014 Bc	0.02	0.017 Cb	0.030 Ab	0.021 Bc	0.014 Cb	0.021
A5	0.016 Cc	0.020 Bc	0.024 Ab	0.013 Dc	0.02	0.020 Bb	0.033 Ab	0.029 Ab	0.016 Cb	0.025
m	0.019	0.025	0.025	0.020		0.022	0.031	0.027	0.021	

Values followed by the same letter, lowercase in the columns and uppercase in the lines, do not differ by Scott-Knott's test (p≤0.05); m = mean. A5 = Red photoconverter shading net with 50% shading, A4 = Silver photoconverter shading net with 35% shading, A5 = Silver photoconverter shading net with 50% shading, shading. S1 (OrganoAmazon®), S4 (OrganoAmazon® + PuroHumus® + soil + bovine manure + CRH), S3 (OrganAmazon® + PuroHumus®), S3 (OrganoAmazon® + PuroHumus® + soil + bovine manure).

Discussion

By analyzing only the red colored shading net, especially A2 environment, were the ones that promoted an increasing in the environment temperature, confirming the results of temperatures found by Silva *et al.* (2013), in environments constituted by shading nets of this coloring. It is worth noting that the production of vegetable seedlings can be negatively influenced by excessive increasing temperature caused by these shading nets, since these conditions can compromise vital functions of the plant throughout its development stage, from seed germination (Wahid *et al.*, 2007).

According to Gomes, Couto, Leite, Xavier & Garcia (2002), the estimate of seedling survival after transplanting is directly related to this variable, in which, at higher value of SD in relation to PH, a greater chance of survival under field conditions can occurs, that is, at lower PH / SD ratio, this values could indicate better conditions of plant development, a fact that is expressively observed in A1 environment, especially when is associated to S2 and S3 substrates in the cultivar IPA06 and, more expressively, in 'Santamélia'.

As for inherent results to A3 for PH and aerial part biomass, it is evident, as confirmed by Costa et al. (2011b), that a high degree of shading positively affects plant growth, however, these same conditions inversely affect the number of leaves and stem diameter, which could compromise the establishment of uniform seddlings and the productivity of the evaluated tomato cultivars.

The unsatisfactory results obtained in the majority of variables submitted to treatments inherent to A2 environment and to S1 and S4 substrates in the two evaluated tomato cultivars were possibly obtained due to the excess of solar radiation added to high temperatures recorded in A2, since these conditions promote the plant growth retardation of seedlings (Wahid *et al.*, 2007).

Regarding the commercial substrate OrganoAmazon® (S1), studies demonstrating its low efficiency when used soil were also developed in the production of camu-camu (*Myrciaria dubia*) (Chagas, Ribeiro, Souza, Santos, Lozano & Bacelar, 2013) and bell pepper (*Capsicum annuum* L.) (Monteiro Neto *et al.*, 2016), which reinforces the need for detailed research on the use of this compound.

The addition of carbonized rice husk (CRH), by reducing the amount of available nutrients in the substrates when used in large proportions (Freitas *et al.*, 2013), possibly, was the determining factor in low yield of seedlings submitted to S4 substrate, since the best substrates (S2 and S3) did not present CRH in their composition.

As reported by Monteiro Neto *et al.* (2016), in bell pepper seedlings, the shading nets here evaluated promoted an imbalance in biomass distribution of the seedlings in the two evaluated tomato cultivars, that is, there was no balanced development between aerial part and root biomass of seedlings produced in all the studied plots. The highest accumulation of biomass in the aerial part of seedlings produced in the environments with higher shading, especially in A3, may have occurred due to lower values of maximum temperature and higher values of PAR/GR in two of the three collection times recorded in these environments (Table 2), since these conditions favored the increasing of number of leaves (Table 3).

On the other hand, the best results obtained in the quality of seedlings produced in A1 were probably due to good transmissibility of the photosynthetically active radiation (PAR) and, mainly, the containment of excessive increasing temperature by this environment. Low productive performance of seedlings produced under photoconverter shading nets, since these environments performed adverse conditions of temperature and solar radiation to seedlings production (Table 2).

As for the substrate made with only OrganoAmazon® + PuroHumus® (S2), an increasing in nutrient availability was effective in plant development of tomato seedlings due to significant improvement in chemical quality carried out by PuroHumus®, since OrganoAmazon®, evaluated in isolation, was inefficient in seedlings development in both cultivars.

According to Trevisan, Pizzeghello, Ruperti, Francioso, Sassi, Palme, Quaggiotti & Nardi (2010), compounds produced by vermicomposting, such as PuroHumus®, besides improving the physicochemical conditions, promote the biotic enrichment of the substrates, a fact that can be directly related to good performance of S2 and S3 substrates in the two tomato cultivars.

All the results of greater relevance found in the two evaluated tomato cultivars are in agreement with those obtained by Monteiro Neto *et al.* (2016), in the production of bell pepper seedlings submitted to the same conditions of the present study, indicating that greenhouse (A1) and S2 and S3 substrates can be suggested to seedlings production of some solanaceous species, mainly bell pepper and tomato cultivars IPA 06 and Santamélia. Likewise, it is suggested that the isolated use of the OrganoAmazon® compound, as well as the use of environments constructed with photoconverter shading nets under climatic conditions similar to Boa Vista-RR, Brazil should not be indicated for the large-scale production of such species before that they are thoroughly evaluated.

Conclusion

The associated use between greenhouse and substrates OrganoAmazon® + PuroHumus® and OrganoAmazon® + PuroHumus® + soil + bovine manure, favors the obtaining of higher quality seedlings under the conditions of Boa Vista, Roraima, Brazil. The substrate formed by OrganoAmazon® + PuroHumus® + soil + bovine manure is an alternative to tomato seedlings production. Photoconverter shading nets did not favor the seedlings qualitative production of the tomato cultivars IPA 06 and Santamélia under the influence of climatic conditions of Boa Vista, Roraima, Brazil.

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