Ambience and substrates for the development of pepper seedlings (*Capsicum chinense* Jacq.)

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ABSTRACT
In order to evaluate the influence of different environments and substrates on the production of chili pepper seedlings, an experiment was installed in a completely randomized design (DIC), with treatments arranged in subdivided plots. Five environments were evaluated: EA - agricultural greenhouse; TV35 - red screen with 35% shading; TV50 - red screen with 50% shading; TP35 - silver screened with 35% shading and TP50 - silver screened with 50% shading, and four substrates: S1 - OrganoAmazon®; S2 - OrganoAmazon® and PuroHumus®; S3 - OrganoAmazon, PuroHumus, soil and manure, and S4 (OrganoAmazon®®, PuroHumus®®, soil, manure and carbonized rice husk). In the photoconverter meshes TP35 and TP50, the pepper seedlings grown in the substrate S2 provided high IQD. The combination of agricultural greenhouse (EA) and S3 substrate promote superior quality chili pepper seedlings. S4 and S3 substrates are more affordable alternatives to the production of chili pepper seedlings. The photoconverter screens, associated with alternative substrates, do not favor the production of quality pepper seedlings.

Keywords: Protected environment, colored meshes, quality seedlings, dickson's quality index.

1 INTRODUCTION

The chili pepper (*Capsicum chinense* Jacq.) is a vegetable of the Solanaceae family widely cultivated and consumed in the North and Northeast regions of Brazil (ASSIS *et al.*, 2020), due to its pleasant aroma and flavor. This olive plant, together with other species, makes up the source of income of small and medium producers (MACIEL *et al.*, 2019; PERALTA-CRUZ *et al.*, 2021).

In the production process of chili pepper, the production of quality seedlings is one of the most important stages, because it will depend on the final performance of the plants in the field, both nutritional and phytosanitary, as well as productive (COSTA *et al*., 2011; ZUFFO *et al*., 2020). In this process, one should choose environments that provide favorable conditions of temperature, humidity and solar radiation (BECKMANN *et al*., 2006). On the other hand, the adverse conditions of these factors negatively affect vital plant functions, such as photosynthesis, respiration, evapotranspiration, water relations and the stability of cell membranes (WAHID *et al*., 2007).

The use of photoconverter screens of different colors and shading levels (Aluminet and Chromatinet®®) and in monofilament (Sombrite®) is an alternative that is expanding (COSTA *et al*., 2010). These meshes, by modifying the quantity and quality of solar radiation transmitted, determine the dispersion and reflectance of light, which affects the morphological and productive variations of plants (CHAGAS *et al*., 2013).

The production of seedlings, in addition to the ambience, requires substrates that guarantee the mechanical maintenance of the root system and ensure the optimal supply of water, nutrients, oxygen and the transport of CO2 between the roots and the external environment (CAMPANHARO *et al*., 2006; Pelizza *et al*., 2013; JAEGGI *et al*., 2019). The commercial substrates OrganoAmazon® and PuroHumus have been widely used in the production of vegetable seedlings and studied in research (MONTEIRO NETO *et al*., 2016; MONTEIRO NETO *et al*., 2018). The results of these studies consider that, due to the costs of commercial substrates, there is a need for research that stimulates the formulation of substrates, using materials accessible to each region, with physical, chemical and biological characteristics desirable to the development of seedlings. For rice regions, Monteiro Neto *et al.* (2018) suggest the use of the shell due to its high availability, easy handling and efficiency in mixing with other materials.

In this sense, the objective of this work was to evaluate the influence of environments protected with photoconverter meshes and substrates on the production of seedlings of chili pepper (*Capsicum chinense* Jacq.) in the conditions of Boa Vista, Roraima.

2 MATERIAL AND METHODS

The experiment was carried out in the experimental area of the Center for Agricultural Sciences of the Federal University of Roraima – CCA/UFRR, in Boa Vista-RR, whose geographical coordinates of reference are recorded at 2º49'11" N, 60º40'24" W and altitude of 90 m.

The experimental design was completely randomized (IHD), with treatments arranged in subdivided plots and submitted to five replications, each experimental unit consisting of five pepper seedlings, one per container. The plots were composed of five types of protected environments: EA - agricultural greenhouse, arc type, covered with low density polyethylene (LDPE); TV35 - screened with red photoconverter mesh with 35% shading (ChromatiNet® Red); TV50 - screened with red photoconverter mesh with 50% shading (ChromatiNet® Red); TP35 - screened with silver photoconverter mesh with 35% shading (ChromatiNet Silver) and TP50 - screened with silver photoconverter mesh with 50% shading (ChromatiNet®® Silver). In the subplots, the substrates were randomized: S1 - OrganoAmazon, S2 - OrganoAmazon®® + PuroHumus® (1:1 v/v); S3 - OrganoAmazon, PuroHumus, soil and manure (1:1:1:1 v/v) and S4 - OrganoAmazon®®, PuroHumus®®, soil, manure and carbonized rice husk (CAC) (1:1:1:1:1 v/v).

The cultivation environments consisted of an agricultural greenhouse and four roofs. The arch-type greenhouse, arranged in the East-West direction, surrounded by Sombrite with 50% shading on the sides, built with wood and covered with transparent plastic of low-density polyethylene® (LDPE), 150 µm thick, with the following dimensions: 3.4 m wide by 6 m long and right foot of 2.4 m. The screens were standardized in terms of their dimensions in: 17 m long, 4 m wide and 2.5 m ceiling height. All environments had countertops to hold the containers that received the seedlings.

For the formulation of the substrates, the following were used: commercial compost OrganoAmazon®, commercial organic fertilizer PuroHumus®, soil, carbonized rice husk (CAC) and cattle manure. The compost and the organic fertilizer were acquired in the specialized local trade. The soil, typical distrocoeso Yellow Latosol (LAdx), was collected 1 m^3 in the 0-20 cm deep layer, air-dried, passed through a 6 mm mesh sieve and corrected with 1.9 t ha-1 of dolomitic limestone.

The characterization of the light incidence in the environments (external and internal) was defined by the average of the accumulated daily records of global solar radiation (GR), photosynthetically active radiation (RFA) and RFA/RG ratio, already reported by Monteiro Neto *et al*. (2016) and Monteiro Neto *et al*. (2018).

The sowing of the pepper-of-smell was done in plastic cups of 180 cm3, containing the substrates, perforated at the bottom and filled in their bases with type 0 gravel (4.8 to 9.5 mm), using five seeds per container. After germination, when the seedlings had two fully expanded leaves, thinning was done, leaving only one per container. The seedlings were irrigated daily by a microsprinkler system with a flow rate of 8 L $^{h-1,}$ in two shifts (morning and afternoon) of 20 minutes, until the end of the experiment.

At 25 days after emergence (DAE), the following variables were evaluated: number of leaves (NF), plant height (AP), stem diameter (DC), shoot dry matter mass (MSPA), root dry matter mass (MSR) and Dickson's quality index (DQI), determined by: DQI = MSTotal / (AP/DC + MSPA/MSR).

Data were submitted to the Shapiro-Wilk normality test. Once the normal distribution was met, the analysis of variance was carried out, in which, observed significant effect, the means were grouped and compared by the Scott-Knott test at 5% probability with the aid of the SISVAR 5.1 software (FERREIRA, 2011).

3 RESULTS AND DISCUSSION

The environments evaluated show variation between the mean values of global radiation (GR) and photosynthetically active radiation (RFA) (Monteiro Neto et al., 2018). The coverage of the agricultural greenhouse (EA) and the screens with 35% shading (TV35 and TP35) promote greater transmittance of RG and RFA, increasing the development of pepper and tomato seedlings, respectively, according to Monteiro Neto *et al*. (2016) and Monteiro Neto *et al*. (2018). These results reinforce the hypothesis that the type of coverage of the environments promotes variations in the growth of the pepper seedlings evaluated here.

For the NF (Table 1), the plants grown in the greenhouse (EA) had the highest growth with the use of substrates S1 and S3; in TV35, the substrates S2 and S3 were the most efficient; in TV50, the substrates S2 and S4 stood out; in TP35, S2 and S3 were the most efficient; and in the TP50, the S2 was the one that promoted the largest NF.

Table 1. Mean values of leaf number (NF), plant height (AP) and stem diameter (DC) of chili seedlings grown in different environments and substrates

Number of Sheets					
	S1	S2	S3	S4	*m*
SHE	7,22 Aa	6,70 Bb	7,24 Aa	6,30 Bb	6,87
TV35	4,76 Cb	6.98 Ba	6.56 Ba	4,78 Db	5,77
TV50	6,39 Bb	7,73 Aa	6,96 From	7,40 Aa	7,12
TP35	6.70 Ba	7.20 Ba	7,30 Aa	5,64 Cb	6,71
TP50	6,42 Bb	7,92 Aa	6,38 Bb	6,16 Bb	6,72
m	6,30	7,31	6,89	6,10	
Floor height (cm)					
	S1	S2	S3	S4	*m*
SHE	5,82 From	3.78 cc	7,82 Aa	7,58 Aa	6,25
TV35	2,78 Dd	4,68 Bb	5.30 Ba	3.58 cc	4,09
TV50	3.82 cc	6,48 Aa	4,53 Cb	5.97 Ba	5,20
TP35	5,24 Aa	4,25 Bb	5.42 Ba	3,70 Cb	4,65
TP50	4,62 Bb	5,90 Aa	5,02 Bb	3.50 cc	4,76
m	4,46	5,02	5,62	4,87	
Stem Diameter (mm)					
	S1	S2	S3	S4	*m*
SHE	1,86 AM	1,51 Cd	2,43 Aa	2,21 From	2,00
TV35	1.20 cc	1.71 Ba	1.85 Ba	1,55 Cb	1,58
TV50	1.12 cc	1,71 Bb	1,63 Cb	1.90 Ba	1,59
TP35	1,83 from	2,08 Aa	1,88 Bb	1.42 cc	1,80
TP50	1,53 Bb	1.80 Ba	1,60 Cb	1,26 Dc	1,55
m	1,51	1,76	1,88	1,67	

Values followed by the same letter, lowercase in the rows and uppercase in the columns, do not differ from each other by the Scott-Knott test ($p \leq 0.05$); ** EA = Greenhouse with plastic cover, TV35 = Red photoconverter screen (35%), TV50 = Red photoconverter screen (50%), TP35 = Silver photoconverter screen (35%), TP50 = Silver photoconverter screen (50%); S1 = Commercial organic compound (CO); S2 = CO + Humus; S3 = CO + Humus + Soil + Manure and S4 = CO + Humus + Soil + Manure + CAC. *m* = mean.

For the variables AP and DC, the combination of the S3 substrate and the EA environment was more efficient, while the combination of the S2 substrate and the TP50 environment provided higher NF. These results indicate that the growth of the seedlings was favored by the greater shading, either in the greenhouse or in the screen (Table 3), which favors the reduction of the maximum temperature (37.3 °C in the EA).

Table 4 shows the values of seedling dry matter biomass (MSPA and MSR). For MSPA, S3, in particular, was the substrate that best expressed the action of the TV50, TP35 and TP50 environments, indicating its potential for use in the production of chili pepper seedlings. Among the environments within each substrate level, the agricultural greenhouse (EA), except in S2, was the one that most favored the increase of biomass of the seedlings.

Table 2. Mean values of shoot dry matter mass (MSPA) and root dry matter mass (MSR) of chili pepper seedlings grown in different environments and substrates

MSPA (g)					
	S1	S2	S3	S4	*M*
SHE	0,18 AM	0,08 Cd	0,33 Aa	0,26 from	0,21
TV35	0.03 and	0,11 Bb	0.13 da	0,06 Dc	0,08
TV50	0,06 Dc	0,16 Aa	0,11 EC	0.16 Ba	0,12
TP35	0,15 Bb	0.09 cc	0.20 Ba	0.09 cc	0,13
TP50	0,11 Cb	0,17 Aa	0,16 ca	0,06 Dc	0,12
m	0,11	0,12	0,19	0,13	
MSR (g)					
	S1	S2	S3	S4	*m*
SHE	0,07 AM	0.05 and	0,17 Aa	0,11 From	0,10
TV35	0,02 Dd	0.07 from	0,05 Cb	0,03 Dc	0,04
TV50	0.03 cc	0.08 Ca	0,05 Cb	0.08 Ba	0,06
TP35	0,07 AM	0,12 Aa	0,09 Bb	0,04 Cd	0,08
TP50	0,05 Bb	0.10 Ba	0,05 Cb	0.04 cc	0,06
m	0,05	0,08	0,08	0,06	

Values followed by the same letter, lowercase in the rows and uppercase in the columns, do not differ from each other by the Scott-Knott test (p≤*0.05); ** EA = Greenhouse with plastic cover,* TV35 = Red photoconverter screen (35%), TV50 = Red photoconverter screen (50%), TP35 = Silver photoconverter screen (35%), TP50 = Silver photoconverter screen (50%); S1 = Commercial organic compound (CO); S2 = CO + Humus; S3 = CO + Humus + Soil + Manure and S4 = CO + Humus + Soil + Manure + CAC. *m* = mean.

For the MSPA and MSR, the results obtained in AS were superior to the others, when associated with the S3 substrate. This substrate has in its composition, in addition to commercial organic compost, soil and manure, providing the producer with the reduction in the final cost of the substrate and giving utility to a residue obtained on the property. These results were also identified by Monteiro Neto *et al.* (2016) in the production of pepper seedlings, which reinforces its potential as a viable alternative to commercial compounds to the production of seedlings of various olerícola species.

The S4, associated with the EA environment also provided good performance in the development of seedlings. According to Monteiro Neto *et al.* (2018), substrates containing rice husks are suggested for the production of seedlings in regions with availability of this material, due to the easy handling, improvement of physical conditions and efficiency in mixing with other materials.

Among the environments evaluated, the agricultural greenhouse (EA) was the most efficient, because it contains the excessive increase in maximum temperature and good transmissibility (MONTEIRO NETO *et al.* 2016), both in quantity and proportion of photosynthetically active radiation (RFA). These conditions found in AS were probably determinant in the better development of seedlings, because they favor vital functions of the plant, such as: photosynthesis, respiration, evapotranspiration, water relations and the stability of cell membranes, in addition to influencing the hormonal and metabolic apparatus of plants (WAHID *et al*., 2007). This explains, in part, the low productive performance of seedlings under the photoconverter screens.

The isolated use of the commercial substrate OrganoAmazon® (S1), a compound formed, according to the manufacturer, by the mixture of cattle, horse, chicken and sheep manure, saw powder, aged and charred rice straw, peat, sugarcane bagasse, grass trimming, galls and foliage; did not offer good growth conditions to the pepper seedlings, probably due to the low nutrient intake offered to the plants by this (Table 1). In studies conducted with seedlings of desert rose (*Adenium obesum*), tomato, pepper and yellow passion fruit (*Passiflora edulis*) in Roraima, the use of OrganoAmazon® associated with PuroHumus® was more efficient than its use alone, due to its low nutrient intake. This is due to the fact that PuroHumus® has a higher nutritional intake, however, it has the characteristic of retaining high humidity (Table 1), which prevents the further development of seedlings when grown in this isolated substrate (MONTEIRO NETO *et al*., 2016; 2018; 2019; SIQUEIRA *et al*., 2020).

The qualitative results of the seedlings (DQI) are presented in Table 5. According to Fonseca *et al*. (2002), the non-adoption of these quality indexes in the evaluation of seedlings may result in the selection of taller but weak seedlings, discarding the smaller ones, but with greater vigor. Therefore, the higher plant growth and the greater accumulation of biomass are not necessarily indicators of quality seedlings. This fact refers to the evaluator of this type of experiment the need to associate with each other the quantitative parameters of the plants.

Table 3. Mean values of the Dickson quality index (DQI) of chili seedlings grown in different environments and substrates

IQD					
	S1	S2	S3	S4	*m*
SHE	0,75 AM	0,48 Dd	1,46 Aa	1,00 from	0,92
TV35	0.20 cc	0.60 Ca	0.60 Ca	0,35 Db	0,44
TV50	0.26 cc	0,61 Cb	0,55 Cb	0.72 Ba	0,54
TP35	0,72 from	0,97 Aa	0.93 Ba	0.45 cc	0,77
TP50	0,49 Bc	0.79 Ba	0,63 Cb	0,34 Dd	0,56
m	0,49	0,69	0,83	0,57	

Values followed by the same letter, lowercase in the rows and uppercase in the columns, do not differ from each other by the Scott-Knott test (p≤*0.05); ** EA = Greenhouse with plastic cover,* TV35 = Red photoconverter screen (35%), TV50 = Red photoconverter screen (50%), TP35 = Silver photoconverter screen (35%), TP50 = Silver photoconverter screen (50%); S1 = Commercial organic compound (CO); S2 = CO + Humus; S3 = CO + Humus + Soil + Manure and S4 = CO + Humus + Soil + Manure + CAC. *m* = mean.

The DQI, for including morphological variables of height, diameter and biomass in its formula, was a good indicator of the quality standard of pepper seedlings, because, according to Gomes et al. (2002), the higher the index value, the higher the quality of the seedlings. Thus, the EA environment associated with S3 and S4 substrates were the treatments that best influenced the development of quality seedlings (Table 5), that is, the cultivated seedlings showed better vigor and better uniform development between shoot and root (COSTA *et al*., 2010; COSTA *et al*., 2011).

The containment of the excessive increase in temperature and the good transmissibility, both in quantity and proportion of photosynthetically active radiation (RFA), were probably the determining factors in the better development of seedlings produced in the greenhouse (EA). The adverse conditions of these factors negatively affect vital plant functions, such as photosynthesis, respiration, evapotranspiration, water relations and the stability of cell membranes, in addition to influencing the hormonal and metabolic apparatus of plants (WAHID *et al*., 2007). This explains, in part, the low productive performance of seedlings under photoconverter screens compared to the agricultural greenhouse (EA).

Although the records in the literature on the use of photoconverter screens in the production of seedlings of olerícola species are still scarce, especially to the culture of chili pepper, there are studies (HENRIQUE *et al*., 2011; SAKAZAKI *et al.*, 2019) that indicate its use for horticultural production.

We emphasize that the results obtained here are part of a framework of information compiled about the positive effect of these environments on the development of seedlings of some commercial species, such as: bell pepper - *Capsicum annuum* (MONTEIRO NETO et al., 2016), tomato - Solanum lycopersicum *(MONTEIRO NETO* et al., 2018) and ata - Annona squamosa *(SAKAZAKI et al.*, 2019*).*

4 CONCLUSIONS

The use of an agricultural greenhouse associated with the substrate formulated by the mixture of OrganoAmazon®, PuroHumus®, soil and manure (1:1 v/v) increases the quality of the pepper seedlings.

The substrate formed by OrganoAmazon®, PuroHumus®, soil, cattle manure and carbonized rice husk (v / *v*) is an alternative to the production of pepper seedlings.

The photoconverter screens did not favor the production of pepper seedlings under the conditions of this study.

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