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# Initial growth of sweet pepper in different substrates and light environments

## Crescimento inicial de pimentão em diferentes substratos e ambientes de luz

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### Abstract

The aim of this work was to evaluate the initial growth of sweet pepper in different substrates and light environments. The experiment was conducted at the Federal University of Recôncavo da Bahia, in the municipality of Cruz das Almas, BA. The sowing was performed directly in 12 x 20 cm polyethylene bags and the design was completely randomized, in a 4x4 factorial scheme, with 4 replications. The substrates were: CC (commercial compound), SCC (soil (50%) + commercial compound (50%)), SV (soil (50%) + vermiculite (50%)) and SVH (soil (50%) + vermiculite (25%) + earthworm humus (25%)); and light environments: red ChromatiNet®, thermo-reflective screen (Aluminet®) and black screen (all with 50% shading) and full sun. The red screen provided higher values of height, stem dry mass, number of leaves, leaf area ratio, specific leaf area of sweet pepper seedlings; the black screen, in turn, provided higher values of root volume, leaf dry mass, stem diameter, total dry mass, root dry mass, Dickson quality index and leaf area. The quality of the seedlings produced on substrates CC and SCC was superior than that of seedlings grown on substrates SV and SVH. The treatments with screens and substrates CC and SCC favored the growth of sweet pepper seedlings.

**Additional keywords:** *Capsicum annuum* L.; luminosity; shading screens.

### Resumo

O objetivo deste trabalho foi avaliar o crescimento inicial do pimentão em diferentes substratos e ambientes de luz. O experimento foi conduzido na Universidade Federal do Recôncavo da Bahia, no município de Cruz das Almas-BA. A semeadura foi realizada diretamente em sacos de polietileno com 12 x 20 cm, foi utilizado o delineamento inteiramente casualizado, em esquema fatorial 4x4, com 4 repetições. Os substratos utilizados foram: CC (substrato comercial), substrato SCC (solo (50%) + substrato comercial (50%)), SV (solo (50%) + vermiculita (50%)) e SVH (solo (50%) + vermiculita (25%) + húmus de minhoca (25%)) e os ambientes de luz: malha vermelha ChromatiNet®, termorrefletora Aluminet® e preta (todas com 50% de sombreamento) e pleno sol. A malha vermelha proporcionou maiores valores de altura, massa seca do caule, número de folhas, razão de área foliar, área foliar específica das mudas de pimentão; já a malha preta proporcionou maiores valores de volume de raiz, massa seca da folha, diâmetro do caule, massa seca total, massa seca de raiz, índice de qualidade de Dickson e área foliar. A qualidade das mudas produzidas nos substratos CC e SCC foi melhor do que quando cultivadas nos substratos SV e SVH. Os tratamentos com malhas e os substratos CC e SCC favoreceram o crescimento das mudas de pimentão.

**Palavras-chave adicionais:** *Capsicum annuum* L.; luminosidade; telas de sombreamento.

### Introduction

Sweet pepper (*Capsicum annuum* L.) belongs to the family Solanaceae, originating in Mexico and Central America, and being cultivated as an annual crop, although it is a perennial species (Paiva et al., 2012). Due to its good acceptance by consumers, it is used in different ways in human food, having great importance in the Brazilian market of vegetables (Coêlho et al., 2013).

The production of quality seedlings is one of the main stages of the production system, since these influence the final performance of the plants in the production field (Araujo Neto et al., 2009). The use of protected environments, using substrate, provides standard seedlings to be taken to the field, forming more uniform and productive beds.

The substrate corresponds to the component with greater complexity in the seedling production chain and must provide adequate physical, chemical and biological properties for proper growth of the root system and shoots (Ferreira et al., 2014). According to Freitas et al. (2013), the production of seedlings uses a significant volume of substrates, an essential input in different segments of horticulture. Depending on the container and the way of producing the seedlings, the substrate composition varies, but most are made from decomposed organic material, vermiculite, fertilizers and soil in different amounts (Santos & Coelho, 2013).

In addition to the substrate, the growth environment is fundamental for the seedling formation. Seedlings derived from protected environments have greater size and vigor, showing better results in the field, since these environments alter the humidity, temperature and light quality, besides providing physical protection (Costa et al., 2010, Polysack, 2017). Thus, there is an expressive increase of the incorporation of protected environment by the producers of vegetables for seedling production, due to the benefits that it offers (Souza et al., 2007).

Light is an important component for seedling formation, since it influences the morphophysiological characteristics of the plants from the moment the seeds germinate. The quality of light affects several processes of the plants, causing them to have broad physiological and anatomical plasticity depending on changes in this factor (Ferreira et al., 2014). According to Corrêa et al. (2012), changes in light quality affecting plants are related to their sensitivity to environmental variations, and the cell growth rate is influenced by the intensity and composition of the incident light.

The aim of this work was to evaluate the initial growth of sweet pepper in different substrates and light environments.

## Material and methods

The experiment was conducted from October to November 2016, at the Federal University of Recôncavo da Bahia (UFRB), in the municipality of Cruz das Almas-BA, a humid and sub-humid region with a mean annual temperature of 24.5 °C.

The sowing was performed directly in 12 x 20 cm polypropylene bags laterally perforated, which were filled with the substrates. Three seeds of the sweet pepper cultivar Cascadura Ikeda (Feltrin® Seeds) were placed per container.

The experiment was installed under a completely randomized design, in a 4x4 factorial scheme, with four replications. The substrates were: CC (commercial compound), SCC (soil (50%) + commercial compound (50%)), SV (soil (50%) + vermiculite (50%)) and SVH (soil (50%) + vermiculite (25%) + earthworm humus (25%)), and light environments: red ChromatiNet®, thermo-reflective screen (Aluminet®) and black screen (all with 50% shading) and full sun.

The commercial compound used was Vivatto® SLIM Plus (Technes), which has the following characteristics: pH of 5.6 ± 0.5; E.C. (mS $cm^{-1}$): 1.2 ± 0.3; W.R.C: 200%; Humidity: 48%; Density: 260 kg $cm^3$ and the components: bio-stabilized pinus bark, vermiculite, ground charcoal, water, phenolic foam and additives. The soil and substrate chemical analysis was performed by the AKLO Laboratory of Soil, Water and Plant Analysis (Table 1).

**Table 1** - Chemical analysis of soil and substrates used in the experiment.

| Substrate | pH | P | K | Ca | Mg | Al | CEC(T) |
|---|---|---|---|---|---|---|---|
| | | (mg $dm^{-3}$) | | -------- ($cmol_c$ $dm^{-3}$) -------- | | | |
| Soil | 6.6 | 3.52 | 3.91 | 1.7 | 1.3 | 0 | 4.01 |
| SCC (50%soll + 50% commercial compound) | 5.6 | 27.55 | 54.74 | 7.5 | 2.1 | 0.4 | 15.94 |
| SV(50% soil + 50% vermiculite) | 5.6 | 1.71 | 11.73 | 9.4 | 1.8 | 0.2 | 13.23 |
| SVH (50% soil + 25% vermiculite + 25% earthworm humus) | 6.2 | 70.92 | 125.12 | 13.2 | 1.5 | 0 | 14.02 |

AKLO Laboratory of water, soil and plant analysis. Mangabeira city, Bahia.

The plants were cultivated for 39 days under the treatments, with irrigation being performed manually in the amount of 100 ml, on alternate days.

The characteristics evaluated were: Height: measured with a millimeter ruler, from the neck to the apex of the plant (terminal bud); Stem diameter: measured at 1 cm above the substrate, with the aid of a pachymeter with an accuracy of 0.01 mm; Number of leaves: counting of the number of leaves; Root volume: obtained by the beaker method, having a known volume of water and measuring the volume of water displaced by the root insertion; Plant leaf area: determined by using the leaf dry mass (DM) ratio and the dry mass of 10 leaf discs, collected from the base to the apex of the plant, with the aid of a puncher through pre-established areas, avoiding the central vein, as described by Benincasa (2004); Dry mass of leaves, stem and roots: the plants were separated in leaves, stem and roots and dried in a greenhouse with forced air circulation at 40 ± 2 ºC until constant mass, when they were weighed. According to Benincasa (2004), the following variables were calculated: leaf area ratio (LAR), obtained by the ratio between LA and TDM; Leaf mass ratio (LMR), by the ratio between LDM and TDM (total dry mass), and specific leaf area (SLA), by the ratio between LA and LDM. The Dickson Quality Index (DQI) was obtained, according to Dickson et al. (1960), by the formula DQI = [TDM (SH/SD) + (LDM/RDM)], where SH/SD is the ratio between shoot height and stem diameter and LDM/RDM is the ratio between leaf dry mass and root dry mass.

The data were submitted to analysis of variance using the statistical program SISVAR (Ferreira, 2008) and when significant the means were compared by the Tukey test at 5% probability.

## Results and discussion

Height, root volume, stem and leaf dry mass and leaf mass ratio were influenced by the interaction between the factors substrate and light quality. The other characteristics were influenced by the isolated factors (Table 2 and 3).

**Table 2 –** Analysis of variance for the height (H), stem diameter (SD), leaf number (LN), root volume (R), leaf dry mass (LDM) and stem dry mass (SDM) of pepper seedlings as a function of substrate and light environment.

| Causes of variation | H | SD | LN | RV | LDM | SDM |
|---|---|---|---|---|---|---|
| | Mean squares | | | | | |
| Substrate (S) | 627.51** | 15.66** | 189.47** | 0.72** | 1.42** | 0.35** |
| Light (L) | 146.82** | 0.76** | 41.81** | 0.13** | 0.11** | 0.03** |
| S x L | 15.42** | $0.11^{ns}$ | $1.13^{ns}$ | 0.03** | 0.02* | 0.01* |
| Residue | 4.61 | 0.18 | 2.57 | 0.004 | 0.01 | 0.002 |
| (1)CV(%) | 14.58 | 14.50 | 17.06 | 24.46 | 27.46 | 30.43 |

(1) Coefficient of variation; ns – non significant; ** – significant at 1% probability by F test; *– significant at 5% probability by the F test.

**Table 3 –** Analysis of variance for root dry mass (RDM), total dry mass (TDM), leaf area (LA), specific leaf area (SLA), leaf/area ratio (LAR), leaf/mass ration (LMR) and Dickson Quality Index (DQI) of the pepper seedlings as a function of substrate and light environment.

| Causes of variation | RDM | TDM | LA | SLA | LAR | LMR | DQI |
|---|---|---|---|---|---|---|---|
| | Mean squares | | | | | | |
| Substrate (S) | 0.13** | 4.57** | 676792.40** | $25643.45^{ns}$ | 33798.81* | 0.09** | 0.06** |
| Light (L) | 0.03** | 0.39** | 95164.77** | 117220.73* | 41028.09* | $0.001^{ns}$ | 0.01** |
| S x L | $0.003^{ns}$ | $0.07^{ns}$ | $18449.05^{ns}$ | $13682.38^{ns}$ | $6639.10^{ns}$ | 0.009* | $0.001^{ns}$ |
| Residue | 0.002 | 0.04 | 9050.61 | 28832.80 | 8082.81 | 0.004 | 0.001 |
| (1)CV(%) | 36.05 | 28.00 | 38.85 | 35.57 | 26.55 | 11.54 | 25.64 |

(1) Coefficient of variation; ns – non significant; ** – significant at 1% probability by F test; *– significant at 5% probability by the F test.

Treatments commercial compound (CC) and soil + commercial compound (SCC) provided the best plant heights in all light environments. Substrates soil + vermiculite (SV) and soil + vermiculite + humus (SVH) provided the lowest heights of sweet pepper seedlings in the different environments. All substrates showed lower seedling height when compared to the full sun environment (Table 4).

The treatment SVH did not provide statistical difference for height within the light environments. The other substrates, in turn, presented better results for the red screen. This result corroborates that found by Souza et al. (2013), who obtained higher main stem height of *Mentha piperita* L. plants under the red screen. The red screen increases the light transmittance of the spectrum in far-red and red waves (Corrêa et al., 2012). In response to the far-red/red ratio, the plants increase the elongation rate of stems and petioles (Melo & Alvarenga, 2009).

The highest plant height occurred with treatment CC under the red screen and the lowest with substrate SVH under full sun (Table 4). Quinto et al. (2011), studying watermelon seedlings on substrates, found higher plant height when these were grown with commercial compound. Souza et al. (2014), studying *Rosmarinus officinalis*, found different results, where the full sun environment provided higher plant height in relation to shaded environments. The plants present evolutionary characteristics that allow them to adapt to different environments (Lima et al., 2007). However, each plant species may express distinct responses in the uptake and use of light (Saraiva et al., 2014).

The root volume of the plants differed according to the substrate and light environment (Table 4). Treatment CC provided the highest volumes in all environments, especially under the black screen. Substrate SVH provided the lowest values compared to the other substrates. Rocha et al. (2003) found higher root volume of pumpkin seedlings when grown with commercial compound. Echer et al. (2007) reported that in order to have a large number of nutrients available for plants between the transplant and the growth of new roots, a greater number of roots must be obtained.

When cultivated with substrate SCC, there was no change in the root volume of the seedlings under black, red and Aluminet® screens, but these differed from the control. With SVH, in turn, the root volume did not differ between the environments. The black screen provided higher root volume for seedlings grown on substrate SV.

**Table 4 –** Height, root volume, stem and leaf dry mass of the pepper plant as a function of the interaction between substrates and light environment.

| Light environment | (1)Substrates | | | |
|---|---|---|---|---|
| | CC | SCC | SV | SVH |
| | Height of plant (cm) | | | |
| Full sun | 16.63 aC | 13.25 aB | 7.63 bC | 6.13 bA |
| Aluminet® | 21.38 aB | 21.25 aA | 11.88 bB | 7.75 cA |
| Red ChromatiNet® | 26.88 aA | 21.88 bA | 16.50 cA | 7.50 dA |
| Black screen | 19.88 aBC | 17.00 aB | 12.38 bB | 7.63 cA |
| | Root volume (mL) | | | |
| Full sun | 0.30 aC | 0.20 abB | 0.09 bcB | 0.01 cA |
| Aluminet® | 0.47 aB | 0.50 aA | 0.10 bAB | 0.05 bA |
| Red ChromatiNet® | 0.50 aB | 0.50 aA | 0.18 bAB | 0.05 bA |
| Black screen | 0.70 aA | 0.45 bA | 0.23 cA | 0.08 dA |
| | Stem dry mass (g) | | | |
| Full sun | 0.26 aB | 0.16 bB | 0.04 cA | 0.02 cA |
| Aluminet® | 0.33 aAB | 0.31 aA | 0.04 bA | 0.03 bA |
| Red ChromatiNet® | 0.42 aA | 0.33 aA | 0.10 bA | 0.03 bA |
| Black screen | 0.34 aAB | 0.20 bB | 0.08 cA | 0.03 cA |
| | Leaf dry mass (g) | | | |
| Full sun | 0.53 aB | 0.34 bB | 0.09 cA | 0.03 cA |
| Aluminet® | 0.67 aB | 0.64 aA | 0.14 bA | 0.04 bA |
| Red ChromatiNet® | 0.72 aAB | 0.60 aA | 0.25 bA | 0.08 bA |
| Black screen | 0.86 aA | 0.55 bA | 0.26 cA | 0.06 dA |

(1) CC (commercial substrate); SCC (soil (50%) + commercial substrate (50%)); SV (soil(50%) + vermiculite (50%)), and SVH (soil (50%) + vermiculite (25%) + earthworm humus (25%)). Means followed by the same letter, upper case in the column and lower case in the row, do not differ statistically from each other, by the Tukey test (P> 0.05).

The control treatment showed the lowest values for root volume in all substrates (Table 4). When the roots of seedlings have some restriction in their growth, they have difficulties in transpiration when transplanted to the field (Echer et al., 2007).

For stem dry mass, the seedlings grown with substrates SVH and SV did not differ between the environments (Table 4). Regarding substrates CC and SCC, however, there were differences in the environments. The red and Aluminet® screens provided the highest values of dry mass with these substrates, and the black screen with substrate CC. According to Costa et al. (2009), solar radiation in excess is the limiting factor in the growth of protected plants, but Aluminet® and red screens decrease the incident solar rays.

When the plants were grown on different substrates within each environment, treatments CC and SCC showed the highest values of stem dry mass. Substrate SVH provided the lowest values in all environments, diverging from the results found by Marana et al. (2008), who studied coffee seedlings and found greater stem dry mass with the vermicompost substrate.

Substrate CC showed a statistical difference for leaf dry mass in the different environments, where the black screen did not differ from the red one, but was different from the others. Treatment SCC did not present statistical difference for leaf dry mass under red, black and Aluminet® screens, however the control obtained a different result from the others. For plants grown on substrates SV and SVH, the means showed no statistical difference in the different environments (Table 4).

The highest leaf dry mass values of the seedlings were obtained when these were grown on substrates CC and SCC in all environments, while the lowest values were found when they were grown on substrates SV and SVH.

Costa et al. (2015) reported that the Aluminet® screen interferes with the reduction of nighttime transpiration and, consequently, of the heat consumed by transpiration. Notwithstanding, these variables did not contribute to the formation of better quality seedlings, when compared to black or red screens.

The seedlings cultured with substrate CC under black screen showed a higher leaf dry mass. Marana et al. (2008) found opposite results, where the vermicompost substrate provided greater leaf dry mass of coffee seedlings, when compared to the commercial compound.

It can be observed in Table 5 that the plants grown on substrates CC and SCC did not differ statistically between the different light environments for leaf mass ratio, which did not occur when grown on treatments SV and SVH. The highest leaf mass ratio of the seedlings was in treatment SV under the Aluminet® screen, due to the lower stem and root dry mass in these treatments.

In substrates SV and SVH, the seedlings obtained a lower leaf mass ratio under full sun and Aluminet®, respectively. They showed higher values under the red screen with substrate SVH and under the Aluminet® screen with substrate SV. Souza et al. (2014) found a lower leaf mass ratio in rosemary plants under full sun.

When we observed the substrates inside the environments, the plants grown under full sun, black and Aluminet® screens presented a similar leaf mass ratio in substrates CC, SCC and SV. Substrates under the red screen were not statistically different (Table 5).

**Table 5 –** Leaf mass ratio of the pepper plant as a function of the interaction between substrates and light environments.

| Light environment | [(1)]Substrates | | | |
|---|---|---|---|---|
| | CC | SCC | SV | SVH |
| | Leaf mass ratio | | | |
| Full sun | 0.54 abA | 0.57 aA | 0.51 abB | 0.43 bAB |
| Aluminet® | 0.56 aA | 0.55 aA | 0.63 aA | 0.35 bB |
| Red ChromatiNet® | 0.52 aA | 0.52 aA | 0.56 aAB | 0.47 aA |
| Black screen | 0.57 aA | 0.55 aA | 0.53 aAB | 0.36 bB |

[(1)] CC (commercial substrate); SCC (soil (50%) + commercial substrate (50%)); SV (soil (50%) + vermiculite (50%)), and SVH (soil (50%) + vermiculite (25%) + earthworm humus (25%)). Means followed by the same letter, upper case in the column and lower case in the row, do not differ statistically from each other, by the Tukey test (P> 0.05).

It is observed in Table 6 that the stem diameter of the sweet pepper seedlings was higher in the plants grown under black screen and lower in those grown under Aluminet® screen and full sun. The results differed from those found by Souza et al. (2014), where rosemary plants grown under full sun presented greater stem diameter. According to the authors, the larger stem diameter is a desirable attribute in seedlings, since it guarantees greater sustentation of shoots.

Regarding the number of leaves, the plants grown under Aluminet®, red and black screens showed no statistically difference between each other, but they differed from those in the full sun environment, with the red screen providing the highest value.

The leaf area ratio did not differ statistically between plants grown under Aluminet® and red screens, with the red screen differing from the black screen and the full sun environment (Table 6). According to Henrique et al. (2011), the leaf area ratio is the measure of the extent of the photosynthetic apparatus. It represents the ratio between leaf area (responsible for light interception), carbon dioxide and total dry mass, resulting from photosynthesis.

The leaf area value did not differ between plants grown under Aluminet®, red and black screens, differing, however, from the value of plants under full sun, with the screens providing a larger leaf area. Plants with higher number of leaves tend to have a larger leaf area (Reis et al., 2013). To compensate for the low incidence of light, plants expand their leaves (Tullio et al., 2013). The smaller leaf area obtained in the seedlings under full sun is related to the solar radiation and the high temperatures to which they were submitted, causing them to diminish the evaporative area, that is, their leaf area.

The specific leaf area of the sweet pepper seedlings grown under Aluminet®, red and black screens did not present statistical difference, with the red screen differing from the control treatment (Table 6). Lima et al. (2013) found greater specific leaf area in plants grown under full sun, not differing from those grown under the screens. According to the authors, this characteristic represents leaf thickness, where plants grown under intense radiation develop thick leaves, which occurred with the sweet pepper seedlings. The red screen provided the smallest leaf thickness.

The total dry mass did not differ between Aluminet®, red and black screens, but these values differed from that obtained in the control, where a lower dry mass was obtained. Melo & Alvarenga (2009) obtained higher total dry mass of *Catharanthus roseus* when grown under a red screen, according to the authors, the distribution of dry mass between the different organs of a plant is a behavior of plant species themselves and demonstrates their adaptation to the different environment conditions.

The root dry mass was higher in the seedlings grown under black screen, differing from the other treatments, where the full sun provided a lower root dry mass (Table 6). Souza et al. (2014) reported higher gains of root dry mass of rosemary plants when these were cultivated under full sun, in comparison to those grown in shaded environments.

The Dickson quality index (DQI) is an important index, being a well-considered morphological measure, and can be a good indicator of seedling quality, since it considers the robustness and the balance of the seedling biomass distribution, with adjustment of several parameters considered important; the higher the QDI, the better the seedling quality (Oliveira et al., 2015). In this work, the QDI presented a higher value in the plants grown under the black screen, differing from the other treatments. Thus, the sweet pepper seedlings produced under the black screen showed better quality.

**Table 6 –** Stem diameter, number of leaves, leaf area ratio, specific leaf area, leaf area, total and root dry mass, and Dickson quality index of pepper seedlings as a function of the light environment.

| Characteristics | [(1)]Light environmet | | | |
|---|---|---|---|---|
| | Full sun | Aluminet® | Red ChromatiNet® | Black screen |
| Stem diameter (mm) | 2.72 B | 2.72 B | 2.97 AB | 3.21 A |
| Number of leaves | 7.00 B | 10. 31 A | 10.44 A | 9.81 A |
| Leaf area ratio ($cm^2$ $g^{-1}$) | 290. 70 B | 358.37 AB | 400.79 A | 304.84 B |
| Specif leaf area ($cm^2$ $g^{-1}$) | 576.83 B | 692.71 AB | 767.99 A | 611.52 AB |
| Leaf area ($cm^2$) | 137.53 B | 251.05 A | 271.29 A | 319.61 A |
| Total dry mass (g) | 0.45 B | 0.67 A | 0.78 A | 0.79 A |
| Root dry mass (g) | 0.09 C | 0.12 BC | 0.15 B | 0.20 A |
| Dickson quality index (IDQ) | 0.06 B | 0.08 B | 0.08 B | 0.12 A |

[(1)] Means followed by distinct letters in the lines differ statistically from each other by the Tukey test ($P < 0.05$).

It was verified in Table 7 that the stem diameter of seedlings was higher when these were cultivated in the substrates commercial compound (CC) and soil + commercial compound (SCC), and lower when grown on the substrate soil + vermiculite + humus (SVH). Quinto et al. (2011) found greater stem diameter of watermelon seedlings when grown on a commercial substrate, corroborating the finding of this study.

**Table 7 –** Stem diameter, number of leaves, leaf area ratio, leaf area, total and root dry mass, and Dickson quality index of pepper seedlings as a function of the substrate.

| Characteristics | [(1)]Substrates | | | |
|---|---|---|---|---|
| | CC | SCC | SV | SVH |
| Stem diameter (mm) | 3,60 A | 3,60 A | 2,37 B | 1,82 C |
| Number of leaves | 13,31 A | 11,19 B | 7,06 C | 6,00 C |
| Leaf area ratio ($cm^2$ $g^{-1}$) | 381,05 A | 355,55 AB | 344,43 AB | 273,68 B |
| Leaf area ($cm^2$) | 477,49 A | 352,94 B | 113,74 C | 35,32 C |
| Total dry mass (g) | 1,27 A | 0,97 B | 0,34 C | 0,13 D |
| Root dry mass (g) | 0,23 A | 0,19 A | 0,08 B | 0,04 B |
| Dickson Quality Index (IDQ) | 0,15 A | 0,12 B | 0,04 C | 0,02 C |

[(1)] CC (commercial substrate); SCC (soil (50%) + commercial substrate (50%)); SV (soil(50%) + vermiculite (50%)), and SVH (soil (50%) + vermiculite (25%) + earthworm humus (25%)). Means followed by distinct letters in the lines differ statistically from each other by the Tukey test ($P < 0.05$).

The number of leaves, in turn, was higher in treatment CC, differing from the other treatments. The lowest value was found with substrate SVH. These results differed from those of Menezes Júnior et al. (2000), who found a higher number of lettuce leaves in vermicompost substrates.

The leaf area ratio did not differ when the seedlings were cultivated on substrates CC, SCC and SV, with treatment CC differing from SVH (Table 7). Different behavior was observed in relation to the leaf area, where substrate CC differed from the other substrates, being superior. Ferreira et al. (2014) found a greater leaf area of arugula with the commercial compound treatment.

The total dry mass was influenced positively by substrate CC, and negatively by substrate SVH (Table 7). Smiderle et al. (2001) found a higher dry mass of sweet pepper seedlings with the commercial substrate.

Regarding root dry mass, substrates CC and SCC did not differ between each other, but differed from SV and SVH (Table 7). Substrate CC provided higher dry mass. Different results were found by Rocha et al. (2003), where the substrates did not provide statistical difference for the dry mass of pumpkin roots. Echer et al. (2007) stated that tissues rich in dry mass favor the rooting and development of the plant after transplantation.

Regarding DQI, the best substrate was the commercial compound (CC), which differed statistically from substrates soil + commercial compound (SCC), soil + vermiculite (SV) and soil + vermiculite + humus (SVH), with the latter showing the worst performance (Table 7). This result was contrary to that reported by Marana et al. (2008), who found higher DQI for coffee seedlings with the vermicompost treatment. On the other hand, Paulino et al. (2011) found higher DQI value for jatropha seedlings with the commercial substrate. According to Souza et al. (2011), the Dickson quality index takes into account the phytomass distribution balance.

Bicca et al. (2011), studying the effect of substrates on the formation of cabbage seedlings, realized that the substrates with higher amount of vermicompost did not favor the quality of the seedlings. The authors associated the result with the high water retention capacity of the vermicompost, which made it difficult to aerate the substrate

The commercial substrate Vivatto, pure or mixed with soil, favored the growth of sweet pepper plants. According to Technes (2017), Vivatto is a substrate that has balanced and suitable physical and chemical attributes for proper development of the seedlings, according to the author, the substrate has a high CEC.

## Conclusions

The red screen provides higher height, stem dry mass, number of leaves, leaf area ratio and specific leaf area of sweet pepper seedlings.

The black screen positively influences root volume, leaf dry mass, stem diameter, total dry mass, root dry mass, Dickson quality index and leaf area.

Seedlings produced in the substrates 100% commercial compound and 50% soil + 50% commercial compound show better quality than those cultivated in the substrates 50% soil + 50% vermiculite and 50% soil + 25% vermiculite + 25% earthworm humus.

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