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Production and quality of ornamental peppers cultivated under colored shade nets

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Abstract
The cultivation of ornamental peppers in places with high temperature and incidence of solar radiation limits the production and quality of plants and fruits. The colored shade nets were introduced and adopted, because they reduce the temperature and intensity of solar radiation, as well as, low cost and simple to handle. The aimed was to evaluate the production and quality of *C. chinense* and *C. frutescens* cultivated under colored shade nets. The experiment was developed in the Floriculture Sector of the Agronomy Department of the Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brazil from February to August 2021 in entirely randomized design. *C. chinense* and *C. frutescens* were cultivated under red, pearl and aluminet nets with 35% shading and without net. At 150 days, production variables were quantified. The red net reduced the maximum temperature by at 4.1°C and the pearl and aluminet nets reduced the minimum temperature by 3°C. The maximum and minimum relative humidity was increased by 2.6 and 8.5%, respectively, by the red net. The pearl net obtained the lowest percentage of solar radiation incidence. Plant height was greater in the red and pearl nets, and *C. frutescens*. The diameter and stem fresh matter did not differ statistically between treatments. Root length was greater in the red and aluminet nets. The longitudinal and transverse canopy ratio was higher in *C. chinense* cultivated under the aluminet net. The number of leaves and leaves fresh matter was higher in pearl and aluminet net, and in *C. frutescens*, but leaves dry matter was higher in *C. chinense*. The number of flower buds and flowers, and flower buds dry matter was higher in *C. chinense*. The root fresh matter and dry matter was greater in *C. chinese*. The use of colored shade nets during the cultivation period effectively reduced temperature and light intensity. The aluminet net in association with C. chinense are recommended considering the compactness of height, pot coverage, greater number, shape and arrangement of fruits.
Keywords: *Capsicum spp.,* floriculture, potential ornamental, shading

Introduction

The *Capsicum* genus consists of vegetables are widely produced and consumed (Olatunji & Afolayan, 2019), due to they have multiple marketable aptitudes such as use in food (Antonious, 2017), pesticide (Valková et al., 2021), pharmaceutical (Olatunji & Afolayan, 2019), nanotechnology (Velsankar et al., 2021) and ornamental (Lee et al., 2016) industries.

In recent years, the growth of the ornamental sector has occurred due to consumers being attracted to various species of the *Capsicum* genus due to the following characteristics that confer ornamental quality such as compact architecture; number, shape and position of fruits; coloration, shape and density of leaves and fruits, ease of cultivation, durability of leaves and fruits and continuous fruit production (Neitzke et al., 2016)

Among the species cultivated as ornamental pepper, *C. chinense and C. frutescens* gain notoriety, due to *C. chinense* having height between 50 to 100 cm, oval leaves and slightly wrinkled surface, white flowers and arranged in up 3 per node and elongated fruits with 5 to 7 cm long with 2.5 to 3.0 cm in diameter and coloration between light green to orange (Sarwa et al., 2012). *C. frutescens* has a height of up to 1.2 m, smooth and simple leaves, while to yellowish flowers and small, pungent, erect and slightly pointed fruits (Jaiswal et al., 2021).

The cultivation of ornamental pepper plants in locations with high temperature and incidence of solar radiation limits the production and quality of plants and fruits (Lekala et al., 2019), because CO_2 assimilation of most C3 species saturates at low irradiance (600-900 μmol m^{-2} s^{-1}) and excess of solar radiation causes heat stress, stomata closure, and reduced net photosynthesis (Ilić & Fallik, 2017). In addition, temperatures above 35 °C impair cell division, leaf expansion and the abortion of buds,

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flowers and fruits; as well as, burns on leaves and fruits (Flashman et al., 2015), compromising their availability and commercialization in the market.

Among the available technologies in crop production, the colored shade nets have been introduced and adopted because they reduce the temperature and intensity of solar radiation, as well as the attacks of pests and strong winds. Furthermore, they are low cost and simple to handle (Angmo et al., 2022). These nets transmit modified light spectrum from the sunlight that touches their wires, which, is spread over their canopy increasing production, quality and post-harvest (Ilić & Fallik, 2017; Mohawesh et al., 2022; Zha et al, 2022) through positive morphological and physiological responses, as reported in peppers grown under pearl net (Ilić et al, 2017), tomato grown under pearl and red net (Ilić et al., 2015), fresh herbs grown under red and pearl net (Buthelezi et al., 2016), lettuce grown under pearl and black net (Ntsoane et al., 2015), marigold and violet in red and yellow net (Zhare et al., 2019).

Linked to this, the choice of shading percentage should be made carefully, because excessive shading compromises the growth and development of crops, as it does not allow them to maintain effective photosynthesis during cultivation and subsequently compromises the production and quality of the final product (Martinez-Luscher et al., 2017). In view of the above, the use of colored shade nets in ornamental peppers needs to be studied to identify materials that reduce temperature and incidence of solar radiation conferring production and quality throughout cultivation. The aimed was to evaluate the production and quality of *C. chinense and C. frutescens* cultivated under colored shade nets.

Material and Methods

Experimental Design

The experiment was conducted in a 2x4 factorial scheme (varieties x colored shade nets), resulting in 8 treatments distributed in an entirely randomized design with five repetitions.

Localization and Experimental Conduct

The experiment was developed in the Floriculture Sector of the Agronomy Department of the Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brazil from February to August 2021.

According to the Köppen climate classification, mapped in Brazil by (Alvares et al., 2013), the climate in the region varies between the Cwa and Cwb types. The climate types correspond to Cwa: tropical humid zone with dry winter and with hot summer; and Cwb: tropical humid zone with dry winter and with temperate summer.

Seedlings of *C. chinense* cv. Biquinho Iracema and *C. frutescens* cv. Etna were purchased from Isla Sementes® (São Paulo, Brazil). These were grown in rigid polypropylene trays filled with Tropstrato® commercial substrate in a greenhouse, and when the seedlings presented two to three pairs of true leaves, they were transplanted into number 16 pots filled with the same substrate to roofs covered with red, pearl, and aluminet nets with 35% shading, purchased from Ginegar (São Paulo, Brazil) and without net.

These wooden structures had of 0.50x 0.50 x 0.70 m (width x length x height) arranged in the open air 2.0 m apart in the rows and 3.0 m between rows so that there was no shading from one to the other. The ornamental peppers were fertilized with 2 g of NPK 10-10-10 fertilizer, once a week, irrigation until the substrate reached field capacity and weeds were removed as necessary.

Environment data

Maximum and minimum temperature and relative humidity were recorded every 1 min in each shed using an AKSO AK-174 datalogger with a thermometer and hygrometer. Temperature was expressed in °C and relative humidity in %. Wavelength and solar radiation intensity intercepted by the colored nets were quantified by optical absorption using a spectrometer model USB4000, Ocean Optics. The spectra were processed using SpectraSuite software. The wavelength was expressed in nanometers (nm) and the intensity in percentage (%).

Production and quality variables

The following variables were quantified at 150 days after sowing:

Plant height: was measured from the lower base of the pot to the last fully expanded leaf with the aid of a tape measure and the results were expressed in centimeters (cm).

Stem diameter: was determined with the aid of a pachymeter and the results were expressed millimeters (mm).

Root length: the plants were removed from the pots and the substrate adhered to the roots was removed with the aid of weak jets of water. The roots were the dried and the measurements taken with the aid of a ruler, starting at the neck of the plant and the results were expressed in cm.

Longitudinal and transverse canopy ratio: was the quotient between the longitudinal and transverse canopy diameters. The results were expressed in mm.

Number of leaves, flower buds, flowers and fruits:

were obtained at the end of the experiment based on their respective counts.

Production: was obtained by weighing the total number of fruits on each plant and expressed in grams (g).

Fruits length and diameter: four sampled fruits from each batch for spectral collection and reference analyses were measured, with the length being determined in cm. The mean of three measurements performed with the aid of a calliper in the peduncle region, central and at the apex of the fruit, was determined, and the diameter was obtained in mm.

Stem, leaves, flower buds, flowers and root fresh matter: a cut close to the neck of the plant was made with the objective of separating the aerial part from the roots. The stem, leaves, flowers buds, flowers and were separated. The root system was carefully removed from the pot and crushed manually with the aid of weak water jates. Then they were weighed. The results were obtained from weighing on a semi-analytical balance (Mark S2) with precision of ± 0.005g and were expressed in g.

Stem, leaves, flowers, buds and root dry matter: were placed, separately, in 5kg Kraft paper bags, and placed in the oven at 70 °C until they reached constant weight. The results were expressed in %. The dry matter percentage was determinated for following expression:

$$\%DM: \frac{\text{Total dry matter}}{\text{Total fresh matter}} \times 100$$

Statistical Analysis

The data obtained were subjected to normality (Shapiro-Wilk) and homogeneity (Bartlett) test of variances, analysis of variance (ANOVA) and test of means (Tukey at 5%) were performed in programming language R in version 3.6.3 (R Core Team, 2021). The graphs were made in the software Sigma Plot.

Results and Discussions

The temperature was reduced with colored shade nets, the red net being the one that promoted the most significant reduction of the maximum temperature, at 4.1°C and the pearl and aluminet nets the ones that promoted the most significant reduction of the minimum temperature at 3°C. Concerning the control, the maximum and minimum relative humidity increased with red shade net by 2.6 and 8.5%, respectively. The wavelength was concentrated between blue and far red (500-710 nm), and the intensity of solar radiation had an amplitude of 30.5 to 80.2% between treatments (**Figure 1**).

The optimal temperature for developing *C. chinense* and *C. frutescens* is around 21 to 33 °C (Lekala et al., 2019; Angmo et al., 2022). At temperatures higher than 35 °C, there is a reduction in cell division, leaf expansion, number of fruits, flower tip rot, and fruit burn (Mditshwa et al., 2017; Ilić & Fallik, 2017). Shading nets such as colored ones reduce the temperature by 1 to 5 °C, depending on shading level, coloring, and growing location (Angmo et al., 2022). In this study, the control showed plants with leaf burns due to the high monthly maximum temperature of 36.1°C. Although the temperature surpasses the optimal range of development of ornamental pepper (>33.1°C), the plants cultivated under the pearl and aluminet nets did not show burns on the leaves.

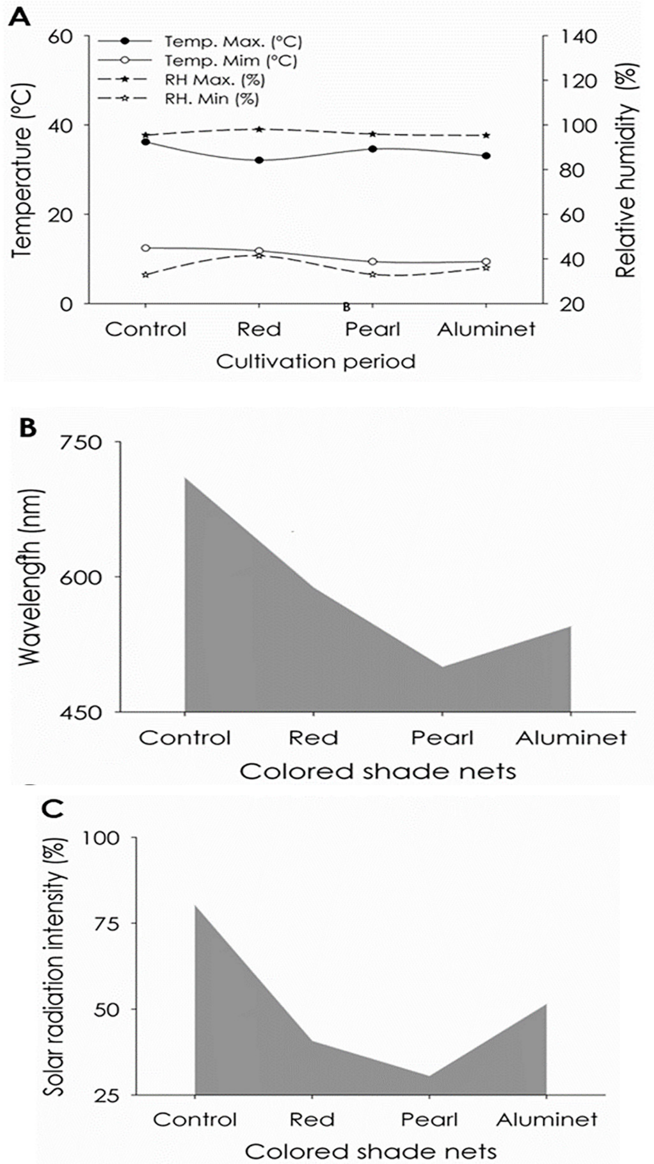

Figure 1. Temperature and relative humidity (A), wavelength (B) and solar radiation intensity (C) of the control, red, pearl and aluminet nets.

Colored shade nets can raise the relative humidity from 3.2 to 12.9% (Mditshwa et al., 2019). In this study, the interval between the colored shade nets was lower, ranging from 0.1 in control to 8.5% in red shade net. This variation occurs as a function of the interaction between temperature, relative humidity, and intensity of solar radiation (Zhou et al., 2018).

C3 plants, such as pepper plants, need low irradiance between 600-900 μmol $m^{-2}s^{-1}$ and this corresponds to 40% incidence of solar radiation throughout the day (Flaishman et al., 2015). Above that, as presented by the control, can cause photoinhibition, heat stress, and stomatal closure resulting in decreased photosynthesis and carbohydrate distribution, affecting plant growth and fruit formation (Flaishman et al., 2015; Ilić & Fallik, 2017). On the other hand, the red and pearl nets presented the ideal amount of 40.7 and 31.5% of incidence of solar radiation, respectively, for developing ornamental pepper, optimizing agronomic performance (Mditshwa et al., 2019).

The fraction of light passed through the holes of the colored shade nets has its quality unchanged, but the fraction of light reached by the wires is spectrally modified (Zare et al., 2019). The red net transmits in red and far-red, while the pearl transmits in blue, yellow, green, red, and infrared (Ilić & Fallik, 2017).

The plant height was greater in the red and pearl compared to aluminet, but did not differ statistically from the control. Also, *C. frutescens* obtained greater height compared to *C. chinense* (**Figure 2**A and B). Stem diameter did not differ statistically between treatments (x= 11.74 ± 1.55 mm). Root length was greater in red and aluminet nets compared to the other treatments (Figure 2C). The longitudinal and transverse canopy ratio was higher in *C. chinense* grown under aluminet net compared to the control (Figure 2D).

Plant height was greater in red and pearl shade nets compared to aluminet, due to the balance in the ratio of red light (R): far red (FR), due to the light reaching the wires of these nets being filtered and transmitted as red light in greater proportion to far red, reducing plant compaction (Silva et al., 2016; Ilić & Fallik, 2017). This occurs, because stem elongation is associated with phytochrome being active by red light and deactivated by far red (Díaz-Pérez & John, 2019; Johnson et al., 2020). Plant height was higher in *C. frutescens,* because, morphologically, this pepper has greater height than *C. chinense* (Olatunji & Afolayan, 2018). In contrast, the height obtained in this study is shorter than that reported by (Sarwa et al., 2012) and (Jaiswal et al., 2021), thus, these compact ornamental peppers are easily accepted by consumers due to the ease of growing them in pots, ease of displaying them in places with limited space, and durability compared to the medium and tall sizes

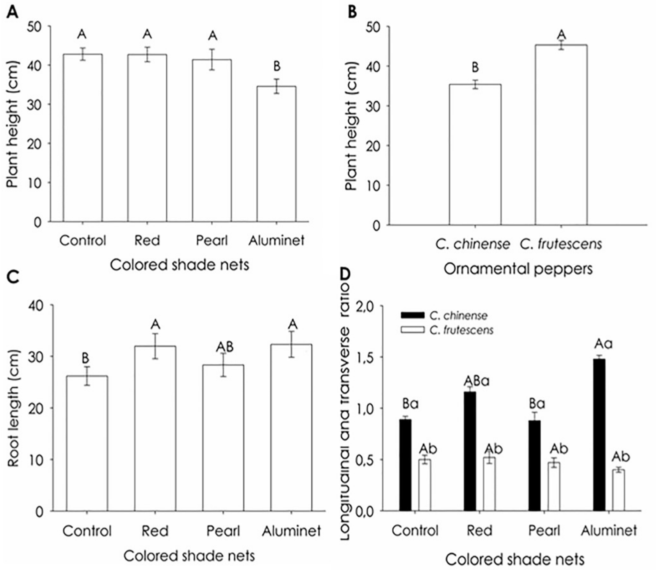

Figure 2. Plant height (A and B), root length (C) and longitudinal and transverse canopy ratio (D) of *C. chinense* and *C. frutescens* cultivated under colored shade nets. *Capital letters refer to colored shade nets, and lowercase letters refer ornamental peppers. Different capital and lowercase letters differ from each other by the Tukey test at 5%.

intended for landscaping (Neitzke et al., 2016).

Generally, plants grown in full sun have their height reduced, due to the light temperatures and intensity of solar radiation causing damage to the photosynthetic organs causing the photoinhibition, closure of stomata, reduction of photosynthesis and distribution of carbohydrates for investment in growth (Silva et al., 2016; Ilić & Fallik, 2017). On the other hand, in the literature, there are reports of species in which the plant height in full sun and under colored shade nets did not differ as obtained in this study (Souza et al., 2014; Silva et al., 2016).

This occurs in species that are adapted to warm climate and cultivation in full sun as the pepper (Souza et al., 2014), however, these climatic conditions may affect the visual characteristics of the plant and the fruits causing them to burn as observed in this study in the control treatment that obtained a temperature of 36.2 °C and solar radiation intensity of 80.2%, and consequently, consumer repulsion (Souza et al., 2014). This repulsion is explained by the fact that the burns affect the surface texture, brightness and coloration of the leaves and fruits, which are characteristics observed in the purchase decision making of ornamental pepper plants (Neitzke et al., 2016).

Plants grown in full sun obtain a greater stem diameter in comparison with shaded plants, which have thin stems due to stretching (Silva et al., 2016). However, in this study, plants under all shade nets did not show such behavior because 35% shading did not compromise light interception as much as nets with shading higher than > 40% as observed in (Díaz-Pérez & John, 2019) and (Souza et al., 2014).

On the other hand, the greatest root length was observed in both ornamental peppers shaded by the red and aluminet nets. In red net, the ratio of red light (R): far red (FR) was higher, consequently, phytochrome B (PHYB) is activated and induces root formation via auxin signaling (Chen et al., 2016; Rosado et al., 2021). The aluminet net, on the other hand, has lower red light (R): far red (FR) ratio, i.e., there is no PHYB actuation in root formation and growth (Rosado et al., 2021). On the other hand, the canopy of *C. frutescens* had the highest number of leaves and *C. chinense* had the highest longitudinal and transverse canopy ratio, contributing to light uptake under the canopy, production of photoassimilates and investment in root growth (Ribeiro et al., 2018).

The longitudinal and transverse canopy ration allows the evaluation of the equilibrium of the canopy of potted peppers in ornamental industry, which should have good coverage of the pot, swelling and firm stems with good support (Cruz et al., 2017). The longitudinal and transverse canopy ratio was higher in *C. chinense* cultivated on the aluminet shade net, because the oval leaves, although spaced apart, had greater pot coverage in the longitudinal direction compared to the other treatments (Sarwa et al., 2012). In addition, the aluminet net provided greater root length, ensuring effective support of the plant without tipping (Silva et al., 2016; Ribeiro et al., 2018).

The number of leaves was higher in the pearl and aluminet nets compared to the other treatments. Also, *C. frutescens* had more leaves compared to *C. chinense* (**Figure 3**A and B). The number of flower buds and flowers was higher in C. *chinense* compared to *C. frutescens* (Figure 3C and D).

The leaves fresh and stem matter was higher in *C. frutescens* compared to *C. chinese* (**Figure 4**A and D). Root fresh matter was higher in *C. chinese* compared to *C. frutescens* (Figure 4 F). The stem fresh matter did not differ statistically among the treatments with the nets compared to the control (Figure 4C). Leaves, stem, bud, and root dry matter was greater in *C. chinese* compared to *C. frutescens* (Figure 4B, E, G and H).

The number of leaves was higher in the pearl and aluminet nets, because plants shaded by nets tend to produce more leaves as a phenotypic adaptation to the reduction of light intensity as an alternative to the improvement of the capture of incident light in the

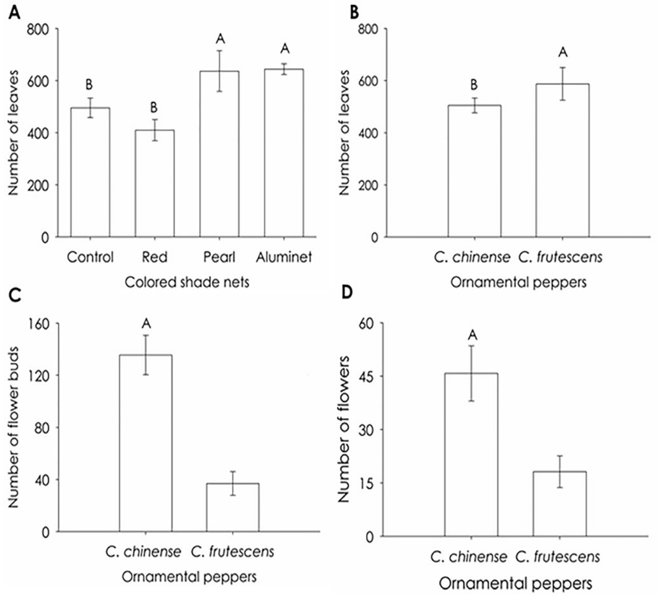

Figure 3. Number of leaves (A and B), flower buds (C) and flowers (D) of *C. chinense* and *C. frutescens* cultivated under colored shade nets. *Capital letters refer to colored shade nets, and lowercase letters refer ornamental peppers. Different capital and lowercase letters differ from each other by the Tukey test at 5%.

canopy (Mathuer et al., 2018). Otherwise, ATP production would be insufficient for carbon fixation and biosynthesis, due to low ATPase activity, and Rubisco, thus reducing growth, development, and fruit formation (Shao et al., 2014; Mathuer et al., 2018).

The number of leaves and leaves fresh matter was higher in *C. frutescens*, because, it has a dense canopy with a greater number of leaves (Mditshwa et al., 2019). The dense canopy along with the coloration and brightness of this ornamental pepper allows contrast with the red of the fruits, which is highly appreciated in the ornamental sphere by consumers (Neitzke et al., 2016). Leaves dry matter was higher in *C. chinense* because the leaf area of this pepper is larger than that of *C. frutescens*, and the greater longitudinal and transverse canopy ratio promoted greater uptake of solar radiation, which increased the production of photoassimilates, which were converted into greater dry matter (Gao et al., 2021).

C. chinense, morphologically, has flower buds and flowers covered by leaves and the shading caused by the nets reduced the temperature (<35°C) promoting less buds and flowers abortion via heat stress (Mditshwa et al., 2017 and 2019; Ilić & Fallik, 2017). As well as, higher flower buds dry matter, due to lower of incidence of bud abortion and reduction in temperature (Ilić & Fallik, 2017).

The fresh matter of flowers and buds did not differ statistically between treatments, but was greater in

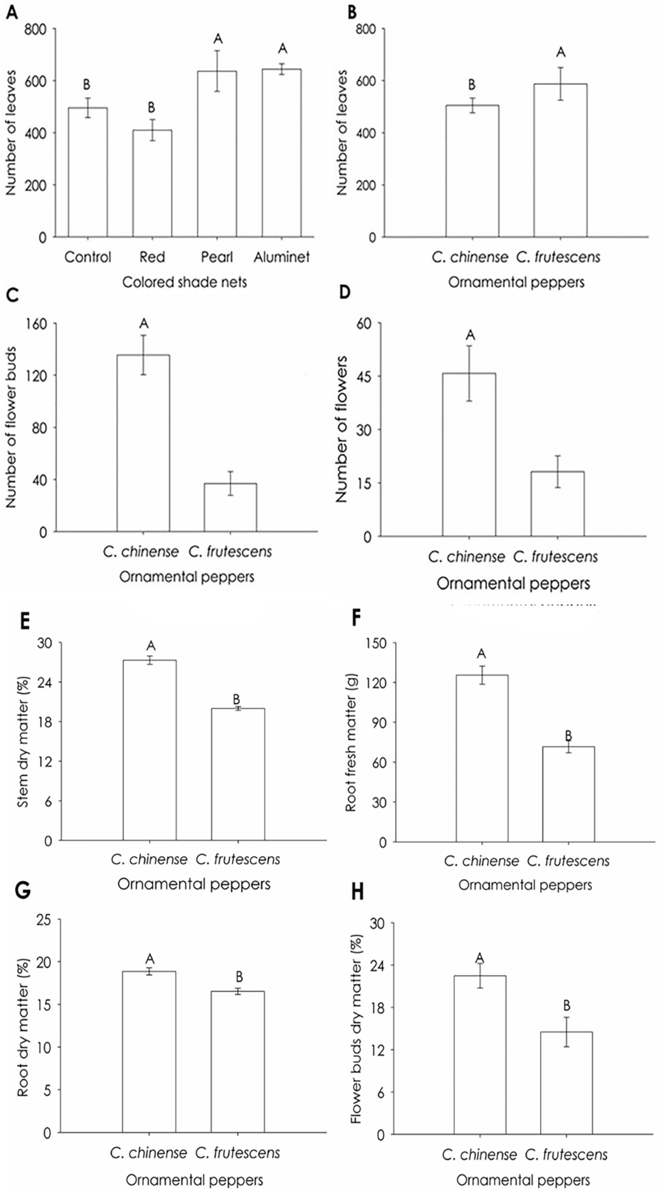

Figure 4. Leaves fresh (A), leaves dry (B), stem fresh (C and D), stem dry (E), root fresh (F), root dry (G) and flower buds dry matter (H) of *C. chinense* and *C. frutescens* cultivated under colored shade nets. *Capital letters refer to colored shade nets, and lowercase letters refer ornamental peppers. Different capital and lowercase letters differ from each other by the Tukey test at 5%.

treatment with pearl (x= 1.52 g) and aluminet (x=1.32 g) shade nets. The red shade net transmits the red and far-red spectrums, while the pearl net transmits in the blue, yellow, green, red and infrared spectrums and aluminet net absorbs in all spectra but does not transmit in any spectrum (Ilić & Fallik, 2017). In view of this, pearl and aluminet shade nets have lower ratio of the red light (R) to far red (FR) compared to red net (Mahmood et al., 2018; Zhou et al., 2018), thus, photoreversibility of phytochrome and higher flowering and flower bud formation occured (Ilić & Fallik, 2017; Mditshwa et al., 2019).

C. chinense obtained greater longitudinal and transverse canopy ratio in all treatments compared to *C. frutescens*, but the latter showed shorter root length (x= 29.1 cm), there being the need to balance the area and roots, it showed a greater number of lateral roots to support the weight of the canopy and consequently, greater fresh and dry root matter (Silva et al., 2016; Ribeiro et al., 2018).

The fresh and dry matter of the stem did not differ in the red, pearl and aluminet shade nets because these all plants cultivated under nets had greater height and root length in view of this, the dense stem was a phenotypic strategy to balance the aerial part with roots (Souza et al., 2014). As well as, *C. chinense* obtained greater dry matter of the stem, due to the greater longitudinal and transversal relationship of the canopy, being necessary, the balance between the support of the canopy and roots.

The number of fruits was higher in *C. chinense* cultivated under the aluminet net compared the other treatments (**Figure 5**A). Production was higher in *C. chinense* in comparison with *C. frutescens* (Figure 5B). *C. frutescens* presented fruits with greater length and smaller diameter than *C. chinense*, which were not altered by the colored shade nets (Figure 5C e D).

Aluminet net transmit smaller red-light (Mahmood et al., 2018; Zhou et al., 2018), promoting the photoreversibility of phytochrome and flowering swimsuits (Ilić & Fallik, 2017; Mditshwa et al., 2019), which led to higher fruit production. Despite *C. chinense* showed

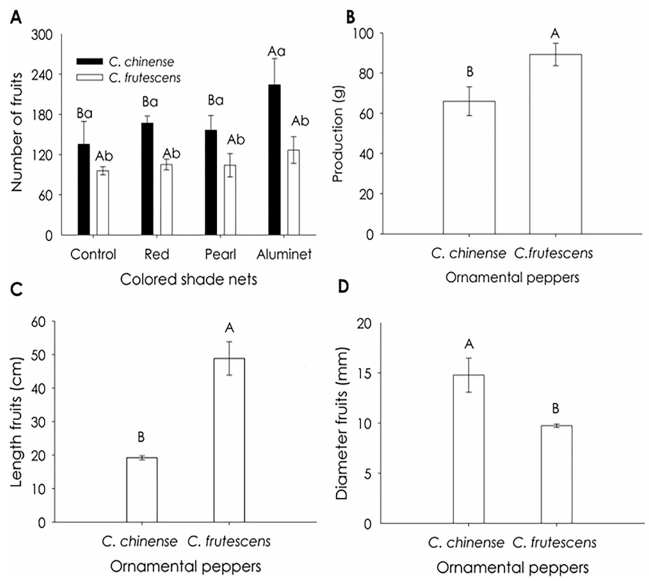

Figure 5. Number (A), production (B), length (C), and diameter fruits of *C. chinense* and *C. frutescens* cultivated under colored shade nets. *Capital letters refer to colored shade nets, and lowercase letters refer ornamental peppers. Different capital and lowercase letters differ from each other by the Tukey test at 5%.

higher longitudinal and transverse canopy ratio, a more significant number of fruits occurred due to greater light penetration in the canopy allowing the direction of photoassimilates to the drains (Mditshwa et al., 2019). Ornamentally, consumers prefer pepper plants with a larger number of fruits, due to the contrast of these with the foliage, as well as for consumption or preparation of by-products, such as jams and jellies (Neitzke et al., 2016).

On the other hand, *C. frustescens* obtained higher fruit production, this may have occurred, due to the lower number of flowers of this pepper plant were not aborted, due to the temperature reduction obtained by the screens, these being reverted also in few fruits, which, obtained greater use in the photoassimilates distribution and consequently, higher weight gain (Mditshwa et al., 2017 and 2019; Ilić & Fallik, 2017).

Morphologically, the fruits of *C. chinense* have the shape of spherical berries, and the fruits of *C. frutescens* have an elongated shape, corroborating the result found (Nascimento et al., 2019). Spherical fruits like *C. chinense* are preferred by consumers for ornamentation of dishes and low pungency (Nascimento et al., 2019).

Conclusion

The use of colored shade nets during the cultivation period effectively reduced temperature and light intensity. The aluminet net in association with *C. chinense* are recommended considering the compactness of height, pot coverage, greater number, shape and arrangement of fruits.

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References

Alvares, C.A., Stape, J.L., Sentelhas, P.C., Gonçalves, J.D.M., Sparovek, G. 2013. Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift* 22: 711-728.

Antonious, G.F. 2017. Diversity in capsaicin and dihydrocapsaicin content in hot pepper genotypes. *Journal of Environmental Science & Ecology* 5: 1042.

Angmo, P., Phuntsog, N., Namgail, D., Chaurasia, O.P., Stobdan, T. 2021. Effect of shading and high temperature amplitude in greenhouse on growth, photosynthesis, yield and phenolic contents of tomato (*Lycopersicum esculentum* Mill.). *Physiology and Molecular Biology of Plants* 27: 1539-154.

Buthelezi, M.N.D., Soundy, P., Jifon, J., Sivakumar, D. 2016. Spectral quality of photo-selective nets improves phytochemicals and aroma volatiles in coriander leaves (*Coriandrum sativum* L.) after postharvest storage. *Journal of Photochemistry and Photobiology B: Biology* 161: 328-334.

Cruz, R.R.P., Bezerra, A.C., Travassos, A.P., Silva, E.N., Finger, F.L., Ribeiro, W.S. 2017. Influência da poda de formação sobre o ciclo fenológico de pimenteiras em vaso. *Revista Brasileira de Agropecuária Sustentável* 7: 60-65.

Díaz-Pérez, J.C., John, K.S. 2019. Bell Pepper (*Capsicum annum* L.) under colored shade nets: Plant Growth and physiological responses. *HortScience* 54: 1795-1801.

Flaishman, M.A., Peles, Y., Dahan, Y., Milo-Cochavi, S., Frieman, A., Naor, A. 2015. Differential response of cell-cycle and cell-expansion regulators to heat stress in apple (*Malus domestica*) fruitlets. *Plant Science* 233: 82-94.

Chen, X., Yao, Q., Gao, X., Jiang, C., Harberd, N.P., Fu, X. 2016. Shoot-to-root mobile transcription factor HY5 coordinates plant carbon and nitrogen acquisition. *Current Biology* 26: 640-646.

Gao, S., Liu, X., Liu, Y., Cao, B., Chen, Z., Xu, K. 2021. The spectral irradiance, growth, photosynthetic characteristics, antioxidant system, and nutritional status of green onion (*Allium fistulosum* L.) grown under different photo-selective nets. *Frontiers in Plant Science* 12: 650471.

Ilić, Z.S., Fallik, E. 2017. Light quality manipulation improves vegetable quality at harvest and postharvest: A review. *Environmental and Experimental Botany* 139: 79-90.

Ilić, S.Z., Milenković, L., Dimitrijević, A., Stanojević, L., Cvetković, D., Mastilović, J., Kevrešan, Ž. 2017. Effect of coloured shade-nets on yield and quality of lettuce (Lactuca sativa L.) during summer production. *Scientia Horticulturae* 226: 389-397.

Ilić, Z.S., Milenković, L., Šunić, L., Fallik, E. 2015. Effect of coloured shade□nets on plant leaf parameters and tomato fruit quality. *Journal of the Science of Food and Agriculture* 95: 2660-2667.

Jaiswal, V., Gahlaut, V., Kumar, N., Ramchiary, N. 2021. Genetics, Genomics and Breeding of Chili Pepper *Capsicum frutescens* L. and Other *Capsicum* Species. In: Al-Khayri, J.M., Jain, S.M., Johnson, D.V. *Advances in Plant Breeding Strategies: Vegetable Crops*. Springer Cham, New York, USA. 476 p.

Johnson, R.E., Kong, Y., Zheng, Y. Elongation growth mediated by blue light varies with light intensities and plant species: A comparison with red light in arugula and mustard seedlings. *Environmental and Experimental Botany* 169: 103898.

Lee, J., Park, S.J., Hong, S.C., Han, J.H., Choi, D., Yoon, J.B. 2016. QTL mapping for capsaicin and dihydrocapsaicin content in a population of *Capsicum annuum* 'NB 1'× *Capsicum chinense* 'Bhut Jolokia'. *Plant Breeding* 135: 376-383.

Lekala, C.S., Madani, K.S.H., Phan, A.D.T., Maboko, M.M., Fotouo, H., Soundy, P., Sultanbawa, Y., Sivakumar, D.

2019. Cultivar-specific responses in red sweet peppers grown under shade nets and controlled-temperature plastic tunnel environment on antioxidant constituents at harvest. *Food chemistry* 275: 85-94.

Mahmood, A., Hu, Y., Tanny, J., Asante, E.A. 2018. Effects of shading and insect-proof screens on crop microclimate and production: A review of recent advances. *Scientia Horticulturae* 241: 241-251.

Martinez-Luscher, J., Chen, C.C.L., Brillante, L., Kurtural, S.K. 2017. Partial solar radiation exclusion with color shade nets reduces the degradation of organic acids and flavonoids of grape berry (*Vitis vinifera* L.). *Journal of Agricultural and Food Chemistry* 65: 10693-10702.

Mditshwa, A., Magwaza, L.S., Tesfay, S.Z. 2019. Shade netting on subtropical fruit: Effect on environmental conditions, tree physiology and fruit quality. *Scientia Horticulturae* 256: 108556.

Mditshwa, A., Magwaza, L.S., Tesfay, S.Z., Mbili, N. 2017. Postharvest quality and composition of organically and conventionally produced fruits: A review. *Scientia Horticulturae* 216: 148-159.

Mohawesh, O., Albalasmeh, A., Deb, S., Singh, S., Simpson, C., AlKafaween, N., Mahadeen, A. 2022. Effect of colored shading nets on the growth and water use efficiency of sweet pepper grown under semi-arid conditions. *HortTechnology* 32: 21-27.

Nascimento, N.F.F., Rêgo, E.R., Nascimento, M.F., Bruckner, C.H., Finger, F.L., Rêgo, M.M. 2019. Avaliação da produção e caracteres de qualidade em híbridos interespecíficos de pimenteiras ornamentais. *Horticultura Brasileira* 37: 315-323.

Olatunji, T.L., Afolayan, A.J. 2019. Comparative quantitative study on phytochemical contents and antioxidant activities of *Capsicum annuum* L. *and Capsicum frutescens* L. *The Scientific World Journal* 2019: 4705140.

Olatunji, T.L., Afolayan, A.J. 2018. Contributions to the Classification of *Capsicum annuum* L. and *Capsicum frutescens* L. in West Africa Using Morphological Traits. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* 47:135–142.

R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. 2021. Disponível em: https://www.R-project.org/ <Acesso em: 30 mar. 2022>

Ribeiro, A.S., Ribeiro, M.S., Bertolucci, S.K., Bittencourt, W.J., Carvalho, A.A., Tostes, W.N., Pinto, J.E. 2018. Colored shade nets induced changes in growth, anatomy and essential oil of *Pogostemon cablin*. *Anais da Academia Brasileira de Ciências* 90: 1823-1835.

Rosado, D., Ackermann, A., Spassibojko, O., Rossi, M., Pedmale, U.V. 2022. WRKY transcription factors and ethylene signaling modify root growth during the shade-avoidance response. *Plant Physiology* 188: 1294-1311.

Sarwa, K.K., Kira, J., Sahu, J., Rudrapal, M., Debnath, M. 2012. A short rewiew on *Capsicum chinense* Jacq. *Journal of Herbal Medicine and Toxicology* 6: 7-10.

Shao, Q., Wang, H., Guo, H., Zhou, A., Huang, Y., Sun, Y., Li, M. 2014. Effects of shade treatments on photosynthetic characteristics, chloroplast ultrastructure, and physiology of *Anoectochilus roxburghii*. *PloS one* 9: e85996.

Silva, D.F.D., Pio, R., Soares, J.D.R., Nogueira, P.V., Peche, P.M., Villa, F. 2016. The production of *Physalis* spp. seedlings grown under different-colored shade nets. *Acta Scientiarum. Agronomy* 38: 257-263.

Souza, G.D., Silva, J.D.S., Oliveira, U.D., Santos Neto, R.D., Santos, A.D. 2014. Crescimento vegetativo e produção de óleo essencial de plantas de alecrim cultivadas sob telas coloridas. *Bioscience Journal* 30: 232-239.

Valková, V., Ďúranová, H., Ivanišová, E., Galovičová, L., Godočíková, L., Borotová, P., Kunová, S., Miklášová, K., Lopašovský, L., Mňahončáková, E., Kačániová M. 2021. Antioxidant and antimicrobial activities of fruit extracts from different fresh chili peppers. *Acta Scientiarum Polonorum Technologia Alimentaria* 20: 465-472.

Velsankar, K., Suganya, S., Muthumari, P., Mohandoss, S., Sudhahar, S. 2021. Ecofriendly green synthesis, characterization and biomedical applications of CuO nanoparticles synthesized using leaf extract of *Capsicum frutescens*. *Journal of Environmental Chemical Engineering* 9: 106299.

Zha, Q., Yin, X., Xi, X., Jiang, A. 2022. Colored shade nets can relieve abnormal fruit softening and premature leaf senescence of "Jumeigui" grapes during ripening under greenhouse conditions. *Plants* 11: 1227.

Zhare, S.K.A., Sedaghathoor, S., Dahkaei, M.N.P., Hashemabadi, D. 2019. The effect of light variations by photoselective shade nets on pigments, antioxidant capacity, and growth of two ornamental plant species: Marigold (*Calendula officinalis* L.) and violet (*Viola tricolor*). *Cogent Food & Agriculture* 5: 1650415.

Zhou, K., Jerszurki, D., Sadka, A., Shlizerman, L., Rachmilevitch, S., Ephrath, J. 2018. Effects of photoselective netting on root growth and development of young grafted orange trees under semi-arid climate. *Scientia Horticulturae* 238: 272-280.

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