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Production of cut chrysanthemum cultivated under different shading screen in the Northwest of Espirito Santo, Brazil

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Abstract

The flower market has grown significantly in Brazil lately, for both, domestic market and foreign market, improving its participation in agribusiness. The shading screen has been used to manipulate the vegetative development, improving the use of solar radiation in ornamental plants. The aim of this study was evaluate the productive performance of cut chrysanthemum flower under different shading screen in northwest of Espírito Santo state. The treatments were assessed in a randomized blocks design, with four repetitions and three different luminous environments (T1- red screen 35%; T2 black screen 35%; T3 Aluminet® 35%) and one control treatment conducted at the field (T4 - no shading screen). Among the luminous environment studied, the aluminet® shading screen and red shading screen provided better flower production, growth and development of these plants.

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Introduction

The floriculture sector has been growing during the past years in Brazil, incrising the domestic market and exportation, becoming important for the Brazlian agribusiness. The growth of the floriculture sector in 2013 reached 8.6%, generating R$ 5.22 billion. This result led many producers to become flower farmer, increasing the supply of flower for both, domestic and foreign market (Junqueira and Peetz, 2014). The cultivation of flowers in Espirito Santo has been shown an activity with great potential, beyond to be an alternative of income for farmers. In Espirito Santo state 180 ha, comprising 40 counties, are designated to flower exploitation (Sebrae, 2015). The flower industry generates more than eight thousand employments in all the productive chain, moving more than R$ 10 million a year.

Chrysanthemum is one of the main ornamental plants cultivated in Brazil and in Espirito Santo state, belonging to Asteraceae family, whose center of origin is Asia, it is considered a national symbol in Japan. Chrysanthemum was introduced in Europe in 1700, and genetically improved until today. There are more than 100 species, and more than 800 varieties of chrysanthemum commercialized in worldwide. The Chrysanthemum is a year-around flowering plant, it is a short day plant with a better development in warm-wet climates. According to Instituto Brasileiro de Floricultura (Ibraflor, 2017), color diversity and beauty are characteristics that promoted the growth of commercial production of Chrysanthemum in Brazil.

Currently, several alternatives are used to cultivate flowers, as field crop, cultivation on soil, protected environment and hydroponic system. However, protected environment cultivation not only is efficient in partial control of edaphoclimatic conditions, but also allows plants development in adverse seasons, when it will not be appropriated in open-air conditions (Purquerio and Tivelli, 2006). Based on this characteristics, shading screen with pigmentation and additives has been studied to be used in protected environment cultivation. According to Queiroga *et al.* (2001), shading screen are capable to reduce solar radiation incidence over the plant, consequently, reduce the greenhouse air temperature and improve plant's yield. Holcman and Sentelhas (2012) verified that the net color and type of shading screen affects microclimatic of the greenhouse, mainly, the radiation intensity and quality. The blue net transmit light on spectrum of 470nm (blue), beyond of others peaks on the region of far-red (over 750nm), while the red n*et al*lows more transmittance over 590nm (red), and one smaller peak around of 400nm (violet), reducing the transmittance of blue, green and yellow wavelengths (Shahak *et al.* 2004). The thermoreflective screen allow to manage the difference of temperature between day and night, which makes possible a more propitious microclimate formation to better development of plant, protecting them against excessive solar radiation and conserving the heat energy in the internal environment. The black net is neutral in relation to transmittance of light (Henrique *et al.*, 2011).

The Northwest region of Espirito Santo state is recognized for presenting an unfavorable climate to the majority of the plant cultivated in floriculture, including Chrysanthemum. In this sense, thus, the use of photoselective shading screen could be an option to minimize the effects of high temperature and high solar irradiation, typical of this region, providing more productive plants and better quality flowers. Therefore, the objective of this study was to evaluate de productive performance of cut Crysanthemum flowers, conducted under different photoselective shading screens in the Northwest of Espirito Santo.

Material and methods

Study site

The study was developed in the horticulture sector of Federal Institute of Espirito Santo – Itapina *Campus*, located in the municipality of Colatina, state of Espirito Santo, Brazil, covered area of Northeast Development Superintendence (Sudene), with geographical coordinate 19°32' 22" south latitude, 40°37' 50" west longitude, 71m of altitude. The climate of the region is Tropical Aw, according the de Koppen climatic classification (Peel *et al.* 2007), with well defined rainy season between October and

January and average climatological precipitation of 1029.9mm (Sales *et al.* 2018). The soil of the experimental area is classified as Dystrophic Red-Yellow Latosol (Embrapa, 2013).

Treatments and experimental design

The experiment was carried out in high tunnel of cultive, with 2.10m of height and 3.3 m of width. The treatments were assessed in randomized blocks design with 4 repetitions. The experimental unit consisted of 2 plots for each tunnel, and each individual plot had measurements of 6 m of length by 1.2m of width, and 0.5m between plots, with 7 planting lines in each plot. In each treatment, three luminous environments were artificially generated using different photoselective shading screen (T1- red screen 35%; T2 black screen 35%; T3 Aluminet® 35%) and one control treatment conducted at the field (T4 - no shading screen), to create environments with different light quality and one control treatment conducted at the field without shading screen.

Crop management

The *Chrysanthemum* seedlings, cultivar Zembala, was acquired from Terra Viva Company, Holambra/SP, with 20cm of height and already rooted. To prepare te bed, it was added 10kg m^{-2} of tanned bovine manure, and mineral fertilized, according to the soil analysis result and floriculture recommendation (50g of simple superphosphate, 30g of potassium chloride, 120g of ammonium sulfate per m^2 of bed divided in two portions. The irrigation was performed using the microjet system with flow rate of 29L h^{-1}, in order to meet the daily needs of the plants.

On March 12, 2018, the seedlings were transplanted to the experimental beds, with spacing of 15 x 15cm between plants. A nylon screen, fasten on the sides in every 2 meters, was stretched in the bed, which worked as holder during the plants development, when it was raised through the lateral tutors every 7 days. For light supplementation, lamps of 25W were installed to provide 4 hours of light until the flower stems reached the commercial length of 70cm. During the experiment time, from March 12 to June 20, 2018, temperature and luminosity were daily registered in each microenvironment using a Data Logger Hobo installed at the canopy of the plants, adjusting as the plants were growing. The harvest was carried out when 50% of the flowers presented harvest point, with 70 cm of height.

Measured parameters

In this point was evaluated the number of stems, number of flowers, diameter of flowers by using a pachymeter, the fresh matter and dry matter of the stems and flowers by using a semi analytical scale. To assess the dry matter, plants were separated into, leaves, stems and flowers and wrap in paper bags immediately after been harvested. All samples were transferred to a forced-draught oven at 70ºC for 72h, until reach a constant weight to record the dry matter.

For the evaluation of the insect's damages in each treatment during the stage of flowering, the standard IBRAFLOR (Brazilian Institute of Floriculture) of quality. Three evaluators analyzed 10 plants of each parcel by means of visual scale.

The following scale was adopted: 0 – no damage (IBRAFLOR quality A1), 1 - slight damage (IBRAFLOR A2), 2 – average damage (IBRAFLOR quality B) e 3 – severe damage (no commercial). In this way, average values of notes, for each treatment, which were later demonstrated by descriptive statistics, grouping cultivars according to the color of flower.

Statistical analysis

The data were subjected to ANOVA test and the means were compared by the Tukey test at 5% ($p<0.05$) of probability. The statistical analyzes were performed using R Core team.

Result and discussion

The mean air temperature data collected during the cultivate of cut *Chrysanthemum* in high tunnel (Fig. 1), show a slight variation in its means, considering the different microenvironments, which demonstrate to be higher in the microenvironment without photoselective shading screen, especially in days with higher temperature. It was observed that, during the experiment´s development, March to June, the average temperatures were 24.9, 25.1 and 25.8°C for silver, black and red screens, respectively. Streck (2004), working with chrysanthemum response as a function of temperature, observed that temperatures between 22 and 35°C are reasonable for the development of plants. When the average open air temperature treatment was evaluated during the development of the crop, a value of 25.9°C was observed. The reduction observed in this study was lower than registered by Abaurre *et al.* (2004), where the screenings presented the possibility of 10 to 20% of reduction in air temperature.

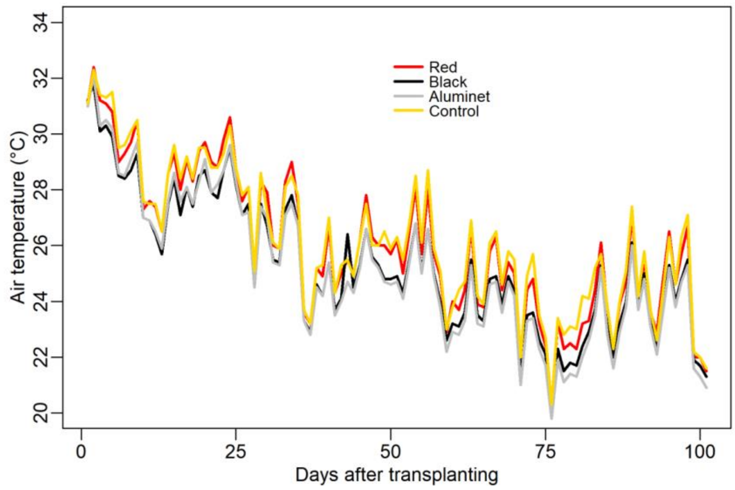

Fig. 1. Variations of daily average temperature of the air recorded inside of the high tunnels of culture with different coverings in cut chrysanthemum.

In relation to variable luminosity, registered as the light intensity inside of each environment (Fig. 2) a considerable variation was noted. According to Martins *et al.* (2009), the intensity and the quality spectral of the radiation interferes with morphological development of the plant, increasing its photosynthetic efficiency. Among the protected environments, the red screen provided greater input of light into the environment, followed by silver and black screens respectively, and in the environment without screen (open air) the intensity of light was higher than in the screened environment. This difference is due the fact of greater exposure to sunlight, since the open air cultivation doesn't have shading, been totally unprotected to the light incidence.

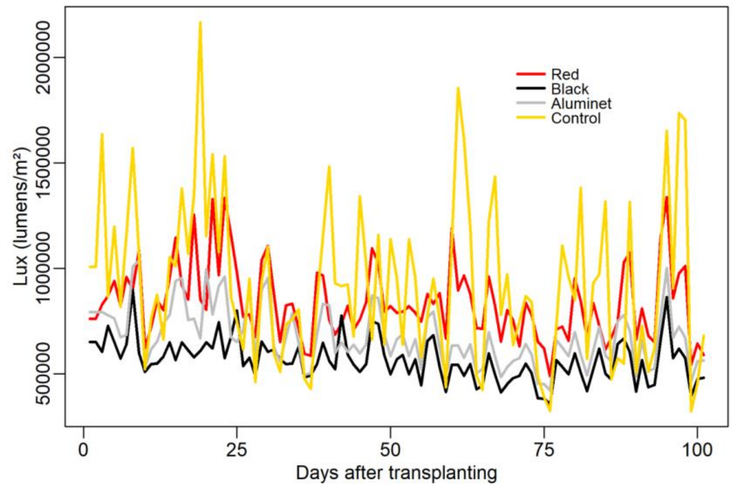

Fig. 2. Light intensity (LUX) registered inside of high tunnels of cultivation with different screens in cut *Chrysanthemum*.

The luminosity has been understood as climatic factor that can interfere positively or negatively to the plant´s development (Boyer, 1982). According to Silva (2015), working with different luminosity conditions, observed that shading screens, independently of the coloration, reduced the radiation reaching the plants. The same author, reports tha the radiation that effectively reaches the plants in environments with screens is lower than those registered in open air environment, with lowest values observed in screens environments using black screens, and slight higher in red screens environments. The cut *Chrysanthemum* grown under silver and red screens show larger size in comparison to the control, although it was not statistically different. The increase in height of the plant grown under lower level of radiation can be associated with the apical dominance, and it is considered a typical morphogenic response (Ryle, 1961), related with decrease of photoassimilate level and increase of auxin leve (Phillips, 1975). Thus, the reduction of incident radiation level induced the plant to invest greater proportion of their source in the growth.

Almeida (2017), working with three cultivates of *Lisianthus,* observed that plants growing under the red screen were statistically different, presenting higher averages of size, independently the cultivar. It was also noted that plants growing under the black screen presented the smaller average of size, this corroborated with the result obtained in the present study, where the plants cultivated under the back screen presented small size. Since the beginner of the experiment, the plants cultivated under the red shading screen presented bigger size, one characteristic of the red screen, that promotes elongation of the stem and accelerates the grow of the plants, described by Oren-Shamir *et al.* (2001). Paulus *et al.* (2016) working with *Ocimum basilicum* L verified that plants grown under the aluminized screen presented greater sizes when compared to plants cultivated in open air environment.

Table 1. Size of plants (SP), number of stems (NS), number of flowers (NF), diameter of flower (DF), fresh matter of stem (FMS), dry matter of stem (DMS), fresh matter of flower (FMF), dry matter of flower (DMF) of Zembala cultivar grown under different photoselective shadings.

Treatment	SP (cm)	NS	NF	DF	MFS (g)	DMS (g)	FMF (g)	DMF (g)
Red screen	58.8ab	17.3a	23.6a	6.3a	61.1c	64.2a	21.0ab	9.0a
Black screen	43.9c	17.9a	19.3ab	6.8a	61.3c	58.5b	14.0c	5.5b
Aluminet® screen	63.6a	17.3a	22.6a	6.7a	71.4a	61.9a	18.8b	8.6a
Control treatment	46.8bc	12.1b	16.3b	6.8a	66.5b	42.6c	23.9a	7.6a
CV (%)	12.5	11.7	10.3	6.8	2.0	2.0	8.4	10.6

Means followed by the same letter in the column do not differ by Tukey´s test at least at 5% significance.

No significant difference regard in the number of stems *Chrysanthemum* plants. among the different photosselective shading screen. However. when evaluated this characteristic in all the treatments. it was possible that the plants cultivated in open air environment presented inferior results to the plants cultivated under photosselective screen (Table 1). Regard to diameter of flower (Table 1) observed no significant difference among the treatments.

Nomura *et al.* (2009) observed similar results studying Anthurium cultivated under different shading screen where the average number of flower stems produced plant^{-1} year^{-1} was higher in plants cultivated under black shading screen and thermal reflector presenting no significant difference. Overall plants cultivated under black shading screen presented superior development when comparing to plants cultivated under thermal reflector screen. it might be explained by the increase in the ratio of photosynthetically active radiation and global radiation (PAR/Qg) which does not occur under the reflective screen (Nomura *et al.*, 2009). The increase of the number of stem per plant is positive trait once this specie is frequently commercialized as cut flower generating higher profit to the producer. The number of flower was different from the control which presented lower values to the other hand plants cultivated under silver and red screen showed higher number of flowers. Muniz and Santos (2014) working with gladiolus (*Gladiolus grandiflorus* L.) var. Amsterdam verified that spectrum of light was influenced by the shading screen characteristic where the thermal reflective (Aluminet) and red shading screen provided peak of absorption in the wave range of 650 nm higher than full sun. According to Taiz *et al.* (2017) and Cheng *et al.* (2015) the phytochrome is a protein pigment located in the chloroplast the strongly absorbs energy in range spectrum of red and far red (600 to 750nm) in this way the presence of this range of light promotes beyond the other alteration stimulates the flowering explaining the incensement of number of flowers in plants cultivated under red and thermal reflector shading screen. Studying *Zantedeschia* sp. under red shading screen the number of flower was higher indicating that red screen influences the productivity and stem length (Fagnani and Leite, 2003).

The analysis of fresh and dry matter of the stems performed in Zembala variety showed significate difference among the different photosselective screen evaluated. Analyzing fresh matter of stem the higher average was observed using silver screen reaching values of 71.4g however analyzing the dry matter of stem of plants grown under the silver screen the values were lower than expected reaching 18g.

The analysis of the control plants cultivated in open air observed that the average value was 66.5g for fresh matter of stem been above of averages reached when using black and red screen. 61.3 and 61.1g respectively. For the values referring to stem´s dry matter of the control it was possible to observe that this treatment presented superior average with a value of 23.9g. Studying *Strelitzia reginae* Fava *et al.* (2016) found that as the shading increases the fresh matter of stem reduces.

When analyzing the data of fresh and dry matter of the flower it was possible to observed there were significant difference among all the different screen shading tested in field. Regarding to flower´s fresh matter red and silver screen enable higher average 64.0 and 61.9g respectively. The average of number of flower in control was lower affecting negatively the gain in fresh matter of the flower. For a dry matter of flower the red and silver screen obtained higher average with 9.0 and 8.6g respectively.

In the descriptive analysis of the data the quality of flower was generated analyzing the damage caused by pests diseases and mechanical damages. The average of scores for flower quality attributed to the white variety (Zembala) shows a better quality for plants cultivated under silver screen Fig. 3.

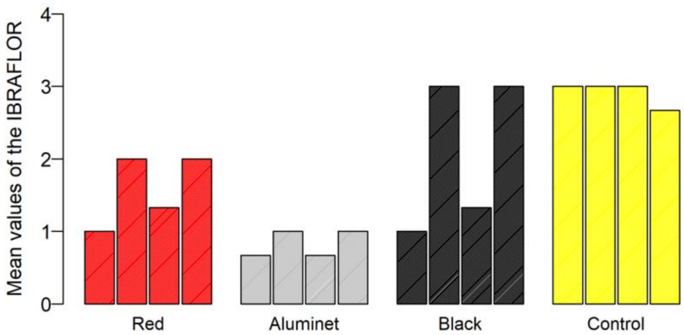

Fig. 3. Scores attributed to the quality of flowers according to IBRAFLOR standard: 0 - no damages (quality A1 IBRAFLOR). 1 – slight damages (quality A2 IBRAFLOR) and 2 – medium damages (quality B IBRAFLOR) and 3 – severe damages (no commercialized).

For the *Chrysanthemum* culture no published works on the influence of colored screen on the development growth production and quality of plants were found. However. colored screen are designed specifically to modify the incident radiation in terms of spectrum and dispersion (Elad *et al.* 2007).

Thus according to the screen color used it possible to verify the modifications in pattern of development. anatomic characteristics changes. physiological and biochemical of the plants (Brant *et al.* 2009).

Conclusion

1. The photoselective shading screen promoted changes in the microclimate. mainly related to the quantity of light that reaches the cut Chrysantemum plants.
2. Analyzing flower production the Zembala variety presented better response when cultivated under the silver and red shading screen in edafoclimatic conditions of Colatina, ES.
3. For an earlier harvest and lower consuption of energy the producer may opt for the cultivation of the Chrysanthemum in silver and red shading screen once the plants did not differ and reached the size pattern for the commercialization in advance.
4. Regard to the flower quality the silver shading screen was the one that achieved the best performance according to the IBRAFLOR standard.

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