Influence of color shading nets on ornamental sunflower development [1]

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ABSTRACT

One of the many functions of sunflower (*Helianthus annuus* L.) is related to the use of its inflorescences in the flower market, which has guaranteed space for this species in floriculture in recent years. Sunflower has been highlighted as an ornamental plant for cutting. Studies have been performed aimed at reducing the size of this species, in order to improve its commercial production, which facilitates the production in field and in protected environments. The use of color shading nets can lead to growth manipulation and to the development of this species. The objective of this study was to evaluate the effect of full sun and the use of color shading nets Aluminet®, blue and red (Chromatinet®), on the development of ornamental sunflower cv. Pollenless Sunflower Sunbright. The studied variables were plant height, leaf number, diameter of the floral stem, inflorescence width and dry matter of leaves, stem and inflorescences. By the anatomical analysis of the leaves, it was possible to determine stomatal density, polar (DP) and equatorial (DE) diameters, as well as the relation DP/DE of adaxial and abaxial epidermis and leaf thickness. It is concluded that the best development of ornamental sunflower plants is observed in full sun and under Aluminet®.
Keywords: *Helianthus annuus*, cut flower, floriculture.

RESUMO

Influência de telas fotoconversoras no desenvolvimento de girassol ornamental

Uma das muitas utilizações do girassol (*Helianthus annuus* L.) é o aproveitamento de inflorescência no mercado de flores, o que tem garantido à espécie espaço na floricultura nos últimos anos. O girassol vem se destacando como planta ornamental para corte, assim visando adequar a produção comercial, estuda-se a redução de porte desta espécie, o que facilita a produção tanto a campo como em ambientes protegidos. O uso de telas fotoconversoras poderá promover a manipulação do crescimento e desenvolvimento dessa espécie. Objetivou-se avaliar o efeito do pleno sol e o uso das telas fotoconversoras tipo Aluminet®, ChromatiNet®azul e ChromatiNet®vermelha no desenvolvimento de plantas de girassol ornamental cultivar Sunflower Pollenless Sunbright. As variáveis analisadas foram altura da planta, número de folhas, diâmetro da haste floral, diâmetro do capítulo e massa seca das folhas, haste e capítulos. Nas análises anatômicas das folhas determinou-se a densidade estomática, diâmetro polar (DP) e diâmetro equatorial (DE), a relação DP/DE das faces adaxial e abaxial e espessura do limbo foliar. Conclui-se que o melhor desenvolvimento das plantas de girassol ornamental é observado no cultivo a pleno sol e com uso de tela fotoconversora Aluminet®.
Palavras-chave: *Helianthus annuus*, flor de corte, floricultura.

1. INTRODUCTION

Floriculture is characterized by growing cut plants (flowers and foliage), potted plants, flowering or not, to the production of seeds, bulbs and seedlings (LANDGRAF and PAIVA, 2009). The production and consumption of cut flowers and foliage have been increasing in Brazil in recent years, mainly due to the domestic market growth and expansion of production centers (JUNQUEIRA and PEETZ, 2014).

Floriculture and cultivation of ornamental plants are considered advanced forms of agriculture, making use of modern techniques, being one of the most profitable sectors per acreage.

Sunflower is an ornamental plant which can be used in both pot cultivation and cutting. In general, they are used in decoration, since the exotic shape and the intense orange-yellowish color of their flowers give life and dynamism to landscapes (ANDRADE et al., 2012). Moreover, it can become an alternative source of income for small farmers, since it does not require large areas and contribute to securing manpower in the field (CURTI et al., 2012).

The characteristics of sunflower, such as height, inflorescence width, which range according to genotype, and edaphoclimatic conditions, as well as sowing time, can be changed as a function of sowing time (MELLO et al., 2006).

Sunflower has been gaining prominence as an ornamental plant for cutting. Therefore, in order to adjust the commercial production of ornamental sunflower, the use of color shading nets may be an alternative to the production of ornamental sunflower, and allow to obtain

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flowers with suitable agronomical characteristics for ornamental use, increased productivity and reduced costs.

The effects of color shading nets have been studied in recent years in flower growing (LIMA et al., 2010). Colored nets have the characteristic of changing the spectral quality of radiation, thus allowing the manipulation of growth and development of plants (NOMURA et al., 2009). Most commercial ornamental plants are grown in nets that produce shading, and the most used ones are black. However, color screens represent a new agrotechnological concept for purposes of combining physical protection and differential sunlight filtering, in order to lead to specific physiological responses that are regulated by light (BRANT et al., 2009).

The intensity and spectral quality of radiation interfere with the morphological development of the plants, in order to increase their photosynthetic efficiency (MARTINS et al., 2009), as a function of adaptations in leaf anatomy and cultivation environment (SCHLUTER et al., 2003). Furthermore, the unique properties that shading nets have lead to variations in microclimate, altering the metabolism of plants grown under such nets (LIMA et al., 2010). Therefore, the objective of this study was to assess the influence of color shading nets on the physiological and anatomical characteristics of ornamental sunflower plants.

2. MATERIAL AND METHODS

Sunflower seeds from cultivar Sunflower Pollenless Sunbright were seeded directly on the soil in plots of 1 m wide and 5 m long, with a spacing of 20 x 20 cm. Throughout the experiment, daily manual irrigation was performed, using a watering can. Soil analysis was performed to determine the need for liming and fertilization, which was carried out in accordance with the recommendation of the 5th approximation for sunflower (ALVAREZ et al., 1999). The treatments consisted of planting in full sun, and three types of color shading nets: Aluminet®, ChromatiNet®blue, and ChromatiNet®red, all with 50% shading (POLYSACK INDUSTRIAS Ltda, 2011). The experimental design was completely randomized, with four treatments and thirty replications.

Sixty-five days after sowing, when the plants already had fully expanded inflorescences, 30 stems were collected close to the ground with pruning shears. Plant height was measured with the aid of a graduated ruler, the diameter of the flower stem and the diameter of the inflorescence were measured with calipers and the total number of leaves was quantified. The dry matter of leaves, stems and inflorescences was determined; these parts were separately washed in running water, packed in permeable paper bags and taken to a forced circulation oven at 65° C, until constant weight.

At the end of the experiment, two leaves from the middle third of five plants per treatment were collected for anatomical assessments. The leaves were collected in the morning, between 9 - 10 am, fixed and preserved in 70% alcohol. Free-hand cuts were made in the median region of the leaves with steel blades, clarified in 50%sodium hypochlorite solution and stained with Astra Blue and Safranin, at a ratio of 7:3, according to Kraus and Arduin (1997). Subsequently, semi-permanent slides were mounted, observed and photographed under a microscope (ZeissScope AX10®), coupled to a digital camera, and photomicrographed using the software AxioVision R.L. 4.8®.

Stomatal density (number of stomata/mm^2), polar diameter (DP) and equatorial diameter (DE) were determined, as well as the evaluation of leaf thickness and the ratio DP/DE, according to Castro et al. (2009). Three leaves of two plants per treatment were used, 10 anatomical sections were made per leaf, totaling 30 replications.

The experimental design was completely randomized. Data were submitted to analysis of variance and the means were compared by Tukey's test at 5% probability ($P<0.05$), using the statistical software Sisvar 4.3 (FERREIRA, 2011).

3. RESULTS AND DISCUSSION

The development of ornamental sunflower plants was affected by different cultivation conditions. It was observed that plant growth was higher in full sun, compared to blue and red shading nets. However, no differences were observed in relation to cultivation under Aluminet® for the parameters stem diameter and inflorescence (Table 1).

Table 1. Plant height, stem diameter, number of leaves and inflorescence width of ornamental sunflower plants cultivated in full sun and under different color shading nets.

Treatments	Plant height (cm)	Stem diameter (mm^2)	Number of leaves	Inflorescence width (mm)
Full sun	100.28 a	8.95 a	16.73 a	89.40 a
Aluminet®	84.79 b	8.95a	14.10 b	83.91a
Blue net	63.75 c	6.57 b	12.50 b	69.68b
Red net	60.97 c	6.29 b	12.20 b	76.30ab
CV (%)	28.3	30.31	24.98	24.58

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

Plants grown in full sun presented medium height (100.28cm) and number of leaves (16.73) higher than other treatments, and stem diameter equal to that of plants grown under Aluminet® (8.95mm). A significant reduction in plants cultivated under colored nets was observed (Table 1).

Plants grown under Aluminet® showed a development similar to that of plants grown in full sun; stem diameter and inflorescence values did not differ significantly (Table 1). It is observed that the increase in diffuse light transmission led by Aluminet® shading net allowed better plant growth, when compared to the red and blue nets. Therefore, the identification of an appropriate shading range and spectral light quality, can play a key role in the physiological performance of plants (ILIC et al., 2012).

In an experiment conducted with blue shading net (30% shading) under plastic film and with the Sunflower variety 'Sunbright Supreme', Mateus et al. (2009) concluded that there was no reduction in plant height. However, for all agronomic characteristics evaluated in this experiment, the plants under blue net showed lower values. Different results were also obtained for raffia palm (*Rhapis excelsa*) (MEIRELLES et al., 2007) and *Dracaena marginata* 'Colorama', where there was an increase in height and number of leaves under red net (KOBAYASHI et al., 2006).

There were differences for dry matter of leaves, stem and inflorescences, and higher means for the treatment in full sun were observed (Table 2).

Table 2. Dry matter accumulated in the leaves (MSF) (g), stem (MSH) (g) and inflorescences (MSC) of ornamental sunflower plants cultivated in full sun and under different color shading nets.

Treatments	MSF (g)	MSH (g)	MSC (g)
Full sun	6.42 a	16.96 a	7.26 a
Aluminet®	3.50 b	6.93 b	2.48 b
Blue net	1.82 b	2.50 b	1.64 b
Red net	1.99 b	2.86b	1.86 b
CV (%)	7.70	6.05	30.4

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

Light controls the accumulation of dry matter in the plant, contributing to plant growth, and plasticity is related to the adaptation to different radiation situations, leading to changes in the photosynthetic apparatus, in order to result in an efficient accumulation of dry matter and lead to growth (ALVARENGA et al., 2003). Ornamental sunflower plants grown in full sun had higher dry matter values, allowing to infer that, based on the obtained results, plants growing under strong radiation develop thick leaves and have a more active metabolism; as a consequence, these plants have an increased dry matter production (LARCHER, 2004).

The presence of stomata was observed in the adaxial and abaxial epidermis of leaf blades in ornamental sunflower plants, which characterizes the species as amphistomatic, with diacytic stomata.

It was found that plants grown under Aluminet® showed higher stomatal density on the adaxial and abaxial sides in relation to cultivation in full sun, which can be justified as a function of the increase in brightness led by the net (FOGAÇA et al., 2007). Regarding leaf thickness, there were no significant differences between plants grown in full sun and under Aluminet®, and a lower leaf thickness was observed in plants exposed to the blue screen (Table 3). Sunflower is a halophytic plant, which explains the greater thickness of their leaves in the absence of shading nets. These results are in agreement with those obtained by Schuerger et al. (1997), who also found no significant differences in the thickness of the epidermis in *Capsicum annuum* and stated that the mesophyll is more responsive to anatomical plasticity when subjected to spectral variation.

Table 3. Stomatal density (number of stomata per mm^2) in adaxial and abaxial epidermis and leaf thickness (μm) of ornamental sunflower plants cultivated in full sun and under different color shading nets.

Treatments	Stomatal density on the abaxial side (stomata/mm^2)	Stomatal density on the adaxial side (stomata/mm^2)	Leaf thickness (μm)
Full sun	198.81c	168.72b	353.53ab
Aluminet®	361.12a	244.69a	373.85a
Blue net	256.04b	215.09a	298.10c
Red net	210.65b	180.56b	343.50b
CV(%)	22.21	23.33	7.73

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

Environmental changes lead to modifications in the size and number of stomata, showing the ability that plants have to rearrange these epidermal structures, thus matching the performance of the stomata in gas exchange and transpiration (ROSSATO et al., 2009).

Orchid plants grown under blue net, both in the greenhouse and in the growing room, showed lower stomatal density values (ARAÚJO et al., 2009). According to Castro et al. (2005), an increase in stomatal density may allow the plant to increase gas conductance and, therefore, prevent photosynthesis to be limited under different environmental conditions; thus, the higher number of stomata observed both on the abaxial and adaxial sides of plants grown under nets, allowed an adaptation of sunflower plants to shade conditions.

In a study conducted with *Ocimum gratissimum* grown in full sun, both the palisade and the spongy parenchyma showed greater thickness than the parenchyma of plants cultivated under colored nets, resulting in increased leaf thickness (COSTA et al., 2010). Sunflower plants in full sun and under Aluminet® showed thicker leaves than other treatments studied. However, Souza et al. (2010) reported that, for guacoplants, leaf thickening was greater when they were cultivated under blue net, when compared to other shading nets.

There was a significant difference in the values of polar and equatorial diameters of the stomata for all treatments studied (Table 4).

Table 4. Polar diameter (DP) (μm), equatorial diameter (DE) (μm) and the ratio polar/equatorial (DP/DE) diameters in the leaves of ornamental sunflower cultivated in full sun and under color shading nets.

Treatments	DP adaxial side (μm)	DE adaxial side (μm)	DP abaxial side (μm)	DE abaxial side (μm)	DP/DE abaxial side	DP/DE adaxial side
Full sun	70.09a	50.81a	69.62ab	45.22a	1.50ab	1.44b
Aluminet®	73.15a	43.03b	71.95bc	47.93a	1.55bc	1.63a
Blue net	61.44b	42.73b	63.73c	46.16a	1.45a	1.45b
Red net	72.53a	48.24b	74.32a	46.35a	1.60c	1.50b
CV (%)	9.65	9.00	8.36	9.56	9.56	10.39

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

The ratio polar diameter/equatorial diameter (DP/DE), associated with the shape of guard cells, is an important feature to infer the functionality of stomata, since the elliptical shape (higher ratio DP/DE) is characteristic of functional stomata, whereas the rounded shape is associated with stomata with no normal functionality (KHAN et al., 2002). In this study, the highest ratio DP/DE in both abaxial and adaxial sides was observed in plants grown under Aluminet®, and plants grown in full sun were not statistically different on the abaxial side.

4. CONCLUSIONS

The cultivation of ornamental sunflower in full sun and under Aluminet® provides better plant growth.

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