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LIGHT INTENSITY AND GIBERELIC ACID IN THE SEEDLING\PRODUCTION OF FOUR ORNAMENTAL SPECIES

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ABSTRACT - Ornamental species, especially those involving the use of seedlings in trays to serve residential gardens, need to be produced quickly for commercialization, which requires studies that provide such a condition. The present work aimed to evaluate the effect of light intensity and exogenous application of gibberellin on seedlings of four ornamental species (*Calendula officinalis*, *Gypsophila elegans*, *Solenostemon scutellarioides* and *Viola wittrockiana*). The experiment was carried out at the Universidade Tecnológica Federal do Paraná, *Campus* Dois Vizinhos. The seeds were sown in trays containing substrate composed of a mixture of humic Distroferric Red Latosol: medium texture sand: commercial substrate, in the volumetric proportion of 2:1:1, respectively. The trays were kept in shading environments, using black screens with 35%, 50% and 80% shading intensity, red with 35% shading, in addition to full sun. After 30 days of emergence, gibberellic acid solution was applied to the seedlings at concentrations of 0 mg L^{-1} and 300 mg L^{-1}. Emergence, emergence speed index, mean emergence time, total length, shoot and roots, number of leaves, leaf area, root volume density, shoot, root and total dry matter were evaluated. For each environmental condition of cultivation, the values of temperature and air humidity and light intensity were obtained. The use of gibberellic acid proved to be beneficial for *Viola wittrockiana* and *Solenostemon scutellarioides*. The shading environments, regardless of color and light intensity, were more favorable for the formation of seedlings of these four ornamental species.
Keywords: *Calendula officinalis* L., *Gypsophila elegans* L., *Solenostemon scutellarioides* (L.) R.Br., *Viola wittrockiana* Gams.

INTENSIDADE LUMINOSA E ÁCIDO GIBERÉLICO NA PRODUÇÃO DE MUDAS DE QUATRO ESPÉCIES ORNAMENTAIS

RESUMO - As espécies ornamentais, principalmente aquelas em que envolvem uso de mudas em bandejas alveoladas para atender jardins residenciais necessitam ser produzidas rapidamente para comercialização, o que demandam estudos que proporcionem tal condição. O presente trabalho teve como objetivo avaliar o efeito da intensidade luminosa e da aplicação exógena de giberelina em mudas de quatro espécies ornamentais (*Calendula officinalis, Gypsophila elegans, Solenostemon scutellarioides e Viola wittrockiana*). O experimento foi realizado na Universidade Tecnológica Federal do Paraná, *Campus* Dois Vizinhos. A semeadura foi em bandejas alveoladas contendo substrato composto pela mistura de Latossolo Vermelho Distroférrico húmico: areia textura média: substrato comercial, na proporção volumétricas de 2:1:1, respectivamente. As bandejas foram mantidas nos ambientes com sombreamento, utilizando telas nas cores preta com 35%, 50% e 80% de intensidade de sombreamento, vermelha com 35% de sombreamento, além do pleno sol. Após 30 dias da emergência, nas plântulas foi aplicado solução de ácido giberélico nas concentrações 0 mg L-1 e 300 mg L^{-1}. Foram avaliados a emergência, índice de velocidade de emergência, tempo médio de emergência, comprimento total, da parte aérea e raízes, número de folhas, área foliar, densidade do volume de raiz, massa de matéria seca da parte aérea, raiz e total. Para cada condição ambiental de cultivo obteve-se os valores de temperatura e umidade do ar e intensidade luminosa. A utilização de ácido giberélico mostrou-se benéfica no alongamento de amor perfeito e coleus. Os ambientes de sombreamento, independentemente da cor e intensidade luminosa foram mais favoráveis para formação das mudas destas quatro espécies ornamentais.
Palavras-chave: *Calendula officinalis* L., *Gypsophila elegans* L., *Solenostemon scutellarioides* (L.) R.Br., *Viola wittrockiana* Gams.

INTRODUCTION

Floriculture is a branch of horticulture with focus on the production and marketing of ornamental plants, in which it has been gaining ground in the country in recent years, as it is considered an excellent income alternative, especially for small properties (NASCIMENTO et al., 2019).

Therefore, the production of ornamental plants is an opportunity for family farming, with income ranging from R$ 50,000 to R$ 100,000 per ha $year^{-1}$ (DUVAL, 2014). The commercialization of ornamental plants is very

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diverse and wide, involving cut flowers, foliage, bulbs, flower pots, potted green plants, bedding and landscaping plants (VAN RIJSWICK, 2016).

In the last five years, the ornamental sector has achieved considerable growth, even with the scarcity of resources for marketing and advertising, being considered null when it comes to promoting the sector as a whole. Brazil currently has around 8,000 flower and plant producers. Together they cultivate over 2,500 species with around 17,500 varieties. This makes the flower market an important gear in the Brazilian economy, being responsible for 209,000 direct jobs, of which 81,000 (38.76%) are related to production, 9,000 (4.31%) to distribution, 112,000 (53.59%) in retail and 7,000 (3%) in other roles, mostly in support. The sector also accounts for approximately 800,000 indirect jobs (IBRAFLOR, 2022). This agricultural sector is characterized by a market with high quality products. In this sense, farmers have been investing in technologies, both in terms of the cultivation environment and in aspects involving management (JUNQUEIRA; PEETZ, 2014).

Normally, this is conditioned to the usage of light, as it is an essential factor for plant growth, both by providing energy for photosynthesis and by regulating its growth and development through light receptors that perceive the intensity and spectral quality of solar radiation. The change in luminosity can lead to different physiological responses for plants and on their photomorphogenesis (ATROCH et al., 2001).

In the production of seedlings and in the cultivation of ornamental plants, the shading screens are commonly used to minimize the hydric need, as it alters the luminosity, which favors the initial development, helping in the acclimatization process, reducing losses in the field (ARAÚJO, 2010).

The change in luminosity can cause different physiological responses for plants not only linked to the production of photoassimilates, but also on their photomorphogenesis (ATROCH et al., 2001), altering the visual presentation of the seedling.

Shading screens are available on the market with different levels of luminosity and even some with different colors than the traditional black, which may or not favor the formation of a quality seedling. According to FANTI; PEREZ (2003), the need or adaptation of the quantity and quality of light received varies from species to species. Therefore, it is necessary to carry out growth analysis to seek to indicate the most appropriate shade tolerance levels for each species.

In addition to luminosity, which is linked to environmental factors, hormone balance can also influence directly on the plants growth and development (PORTO et al., 2018), especially gibberellins. In seedlings, the exogenous application of gibberellins can stimulate stem elongation, internode length, leaf area and faster dry matter accumulation (STEFANINI et al., 2002), which could reduce its formation time, anticipating its availability to the market.

However, in order to indicate the best concentration of gibberellin to be applied, it is necessary to evaluate them. Some of the plants that have already tested exogenous application of gibberellins were pepper (*Capsicum frutescens* L.) (TORRES; BORGES, 2013), yellow passion fruit (*Passiflora edulis Sims* f. *flavicarpa* Deg) (SANTOS et al., 2010), "sangra d'água" (vascular plant) (*Croton urucurana Baill*.) (SCALON et al., 2008), eucalyptus *(Eucalyptus urophylla x Eucalyptus camaldulensis*) (AMARO et al., 2017), tomato (*Lycopersicon esculentum* Mill.) (OTONI et al., 2012), "Paricá" (*Schizolobium amazonicum* Herb) (ROSA et al., 2009) and umbu (*Spondias tuberosa* Arr. Cam) (MATOS et al., 2020), with few reports for ornamental species, especially those involving the use of seedlings in germination trays normally serving residential gardens, being produced quickly for commercialization.

This is the case of the ornamental species, *Calendula officinalis*, *Solenostemon scutellarioides*, *Viola wittrockiana* and *Gypsophila elegans*, widely used in gardens, flower beds and also in pots and planters.

The present work aimed to evaluate the effect of light intensity and exogenous application of gibberellin on seedlings of four ornamental species [*Calendula officinalis* L., *Gypsophila elegans* L., *Solenostemon scutellarioides* (L.) R.Br. and *Viola wittrockiana* Gams].

MATERIALS AND METHODS

The experiment was carried out at the Federal Technological University of Paraná - Campus Dois Vizinhos (25° 41' 49.47" S, 35° 05' 41.4" W and 520 m altitude), at the Teaching and Research Unit Nursery for Horticultural Seedling Production. The climate of the region is characterized as humid subtropical, type *Cfa*, with average temperatures of the hottest month of 22°C and the coldest of 18°C, with no defined dry season (ALVARES et al., 2013).

The experiment took place in two phases, the first related to seedling emergence and the second after this process, with evaluation of the initial development and seedling formation.

The first stage took place in a randomized block design, with five treatments (shading intensity), with 4 replications of 20 seeds per experimental unit for each species. The second phase of the experiment took place in a randomized block design, in a 5 x 2 factorial (shading intensity x gibberellic acid), with 4 replications of 20 plants per experimental unit for the four species.

Seeds of the species *Gypsophila elegans* L., *Solenostemon scutellarioides* (L.) R.Br., *Calendula officinalis* L. and *Viola wittrockiana* Gams, purchased commercially, were used. Sowing took place in 72 and 128-cell extended polystyrene germination trays, the first being used in blocks 1 and 2 and the second in the other blocks. The preparation of the substrate used in the planting was made from a mixture of humic Distroferric Red Latosol, medium textured sand and commercial substrate, in the volumetric proportion of 2:1:1, respectively (Table 1). For mixing, the materials were sieved separately and mixed with the aid of a concrete mixer.

After sowing, the trays were placed in screens, with 12 m x 5.2 m x 2 m dimensions (length x width x height), whose shading screens varied in color and shading intensity. Black screens with 35%, 50% and 80% shading intensity, and red photoconverting screen with 35% shading were tested, in addition to the treatment in full sun.

All seedlings were daily irrigated, with a micro-sprinkler irrigation system, in two shifts, whose operating time had as a parameter the point at which field capacity was reached. After 30 days of emergence, a solution of gibberellic acid at a 300 mg L^{-1} concentration was applied to the seedlings, up to the point of wetting, with the aid of a manual sprayer. The treatment without gibberellic acid consisted of the application of distilled water. After 60 days of application of the solution with or without gibberellic acid, the seedlings were removed from the trays, washed until the removal of excess substrate from the roots and taken to the Laboratory of Plant Physiology at the Federal Technological University of Paraná, Campus Dois Vizinhos, for seedling growth variables evaluations.

TABLE 1 - Chemical analysis of the mixture of red oxisol, sand and organic compost, in the proportion 2:1:1 (v/v), characterizing it in terms of potassium (K), phosphorus (P), aluminum (Al), calcium (Ca), magnesium (Mg), organic matter (OM), base saturation (SB), pH, H+Al and V% of soil analysis.

^{b}pH	P	K	Ca^{2+}	Mg^{2+}	Al^{3+}	H+Al	SB	V	MO
$CaCl_2$	mg dm^{-3}				cmol$_c$dm^{-3}			(%)	g dm^{-3}
6.70	323.82	1.0	4.90	3.40	0.0	2.36	9.30	79.76	42.89

^{b}pH in water, KCl e $CaCl_2$ = relation 1:2.5; P, K = Mehlich^{-1} extractor; Ca, Mg, Al = extractor: KCl 1molL^{-1}; H + Al = calcium acetate extractor 0.5 mol L^{-1} pH 7,0; B = hot water extractor; monocalcium phosphate extractor in acetic acid; SB = sum of bases and V = base saturation index.

In field conditions, were analysed emergence (%), emergence speed index (MAGUIRE, 1962), average emergence time (LABOURIAU, 1983), and in laboratory of total length, shoots and roots (cm), number of leaves, leaf area (cm²), root volume density (cm³), shoot, root and total dry matter mass (g). Values of air temperature and humidity, light intensity and precipitation were obtained to characterize the different environments.

The length of the shoot and root was measured with the aid of a millimeter ruler, determined through the distance between the neck and the apices. The number of leaves was determined at the end of the evaluations with their accounting. The leaf area was obtained through the analysis of all the leaves of the plants with the aid of a leaf area determiner. The root volume was obtained by displacing the water column in a graduated cylinder (ROSSIELLO et al., 1995).

To obtain the dry matter mass, for both shoots and roots, the parts were separated, where both were placed separately on Kraft paper, placed in an oven at 105°C for a sufficient time to stabilize their weight. After drying, the samples were weighed on an analytical balance, with their values determined in grams.

The meteorological variables of temperature (°C) and relative humidity (%) were daily evaluated using a Dattalogger, installed inside each screen, programmed to read every fifteen minutes. Data collection was performed at the end of the experiment. The light intensity was measured using the luxmeter, with daily assessments, between 11:00 am and 1:00 pm. The device was positioned on the trays at three heights (1.80 m, 1.00 and 0.20 m) and, later, averages were calculated based on the values obtained.

The data of the response variables were submitted to the Shapiro Wilk normality test. According to these results, for the data that required transformations to meet the assumption of normality the method proposed by Box and Cox were used (1964). Then, analysis of variance (ANOVA) was performed and, according to the degree of significance, Duncan's multiple average comparison test (α = 0.05) using the statistical program Rbio (BHERING, 2017).

RESULTS AND DISCUSSION

In the results of the analysis of variance in the first stage of the experiment, the variables: emergence (E), emergence speed index (IVE) and the average emergence time (TME) were influenced by the different light intensities in all ornamental species (Table 2). With emergence (E), it was verified that, in all ornamental species, there was a beneficial effect of the environment using some level of shading, with higher averages in relation to the condition of full sun.

It is believed that the emergence obtained in the condition of full sun is related to the lower humidity provided to the substrate, compromising the first stage of germination, which concerns imbibition, demanding more time. The influence of hydric deficiency on germination is due to the delay in the beginning of the process or decrease in germination (HARDEGREE; EMMERICH, 1990).

Very low hydric potential of the seed, especially at the beginning of imbibition, influences water absorption, delaying the sequence of germination events (ANTUNES et al., 2011). This fact can be proven with the lowest relative humidity that occurred in full sun (Figure 1A).

Likewise, the emergence velocity index (IVE) and the average emergence time (TME) were lower in all species with full sun treatment, compared to those that received some type of shading. With *Viola wittrockiana,* the highest averages for IVE were for the condition of 80% shading and with 35% using in this case the red screen. In the other species, the shading condition provided the highest IVE averages. For the TME obtained with *Gypsophila elegans* and *Calendula officinalis*, the highest averages were in the shading conditions with black screen. With this, it was verified that the condition of full sun and shading with a red screen of 35% provided shorter times.

The highest IVE averages at the lowest shading levels could possibly also have been influenced by the slower moisture loss due to the lower temperature caused by the shading, leading to lower evaporation and thus, favoring tissue rehydration and, consequently, for the intensification of respiration and all other metabolic activities that resulted in the rapid supply of energy and nutrients necessary for the resumption of embryonic axis growth (MOTA et al., 2012).

TABLE 2 - Emergence (E), emergence speed index (IVE) and average emergence time (TME) of four species of ornamental plants [*Calendula officinalis* L., *Gypsophila elegans* L., *Solenostemon scutellarioides* (L.) R.Br. and *Viola wittrockiana* Gams], in relation to the environment factor.

	Gypsophila elegans		
Environment	E (%)	IVE	TME (days)
Black screen 80%	37.5 a*	0.51 a	3.13 ab
Black screen 50%	33.12 a	0.32 a	3.86 a
Black screen 35%	28.75 a	0.31 a	3.0 ab
Red screen 35%	23.12 a	0.28 a	2.10 b
Full Sun	3.77 b	0.055 b	0.45 c
VC(%)	58.15	72.54	55.61
Box Cox (λ)	0.4646	0.2626	-
	Viola wittrockiana		
Environment	E (%)	IVE	TME (days)
Black screen 80%	30.62 a	0.34 a	3.04 a
Black screen 50%	18.12 a	0.18 bc	2.13 a
Black screen 35%	18.12 a	0.17 bc	2.17 a
Red screen 35%	24.38 a	0.23 ab	2.81 a
Full Sun	3.76 b	0.05 c	0.52 b
VC (%)	64.34	64.49	65.26
Box Cox (λ)	-	-	-
	Calendula officinalis		
Environment	E (%)	IVE	TME (days)
Black screen 80%	25 a	0.33 a	2.81 ab
Black screen 50%	26.25 a	0.28 a	3.58 a
Black screen 35%	28.12 a	0.312 a	2.49 abc
Red screen 35%	20.62 a	0.26 a	1.24 bc
Full Sun	4.39 b	0.05 b	1.01 c
VC (%)	50.44	52.74	50.26
Box Cox (λ)	-	-	-
	Solenostemon scutellarioides		
Environment	E (%)	IVE	TME (days)
Black screen 80%	20 a	0.17 a	1.77 a
Black screen 50%	16.25 a	0.12 a	1.82 a
Black screen 35%	16.25 a	0.12 a	2.04 a
Red screen 35%	16.25 a	0.12 a	1.42 a
Full Sun	1.26 b	0.028 b	0.10 b
VC(%)	43.67	35.11	47.65
Box Cox (λ)	-	-	-

*Means followed by different letters in the column, within each ornamental species, differ from each other, at a 5% error probability, by Duncan's test (α=0.05). VC – Variation coefficient.

It is assumed that in this case, the contact of direct radiation or the red screen provided a higher temperature to the substrate, causing those that had passed through stage 1 of germination to reach other stages (catabolism and anabolism) faster, since the metabolic pathways were more accelerated favoring this condition. This fact can be indirectly observed by the luminosity (Figure 1B), as environments with higher solar incidence tend to have higher temperatures. However, the indoor air temperature of the environment did not follow such trends (Figure 1C).

Leaf area (AF), number of leaves (NF), shoot length (CPA), root length (CR) and total length (TC) were significantly affected by the environment, when all ornamental species were observed, except for NF of *Gypsophila elegans*. The highest averages occurred in shade conditions, regardless of color and intensity level (Table 3).

In *Gypsophila elegans*, the variables AF, CPA, CR and CT presented the highest averages with the use of a screen. For *Viola wittrockiana*, the AF and CPA variables had higher averages with the use of the 80% screen and together with the 50% screen for NF, CR and CT. The full sun condition had the lowest averages, but without differing from the 35% color grids.

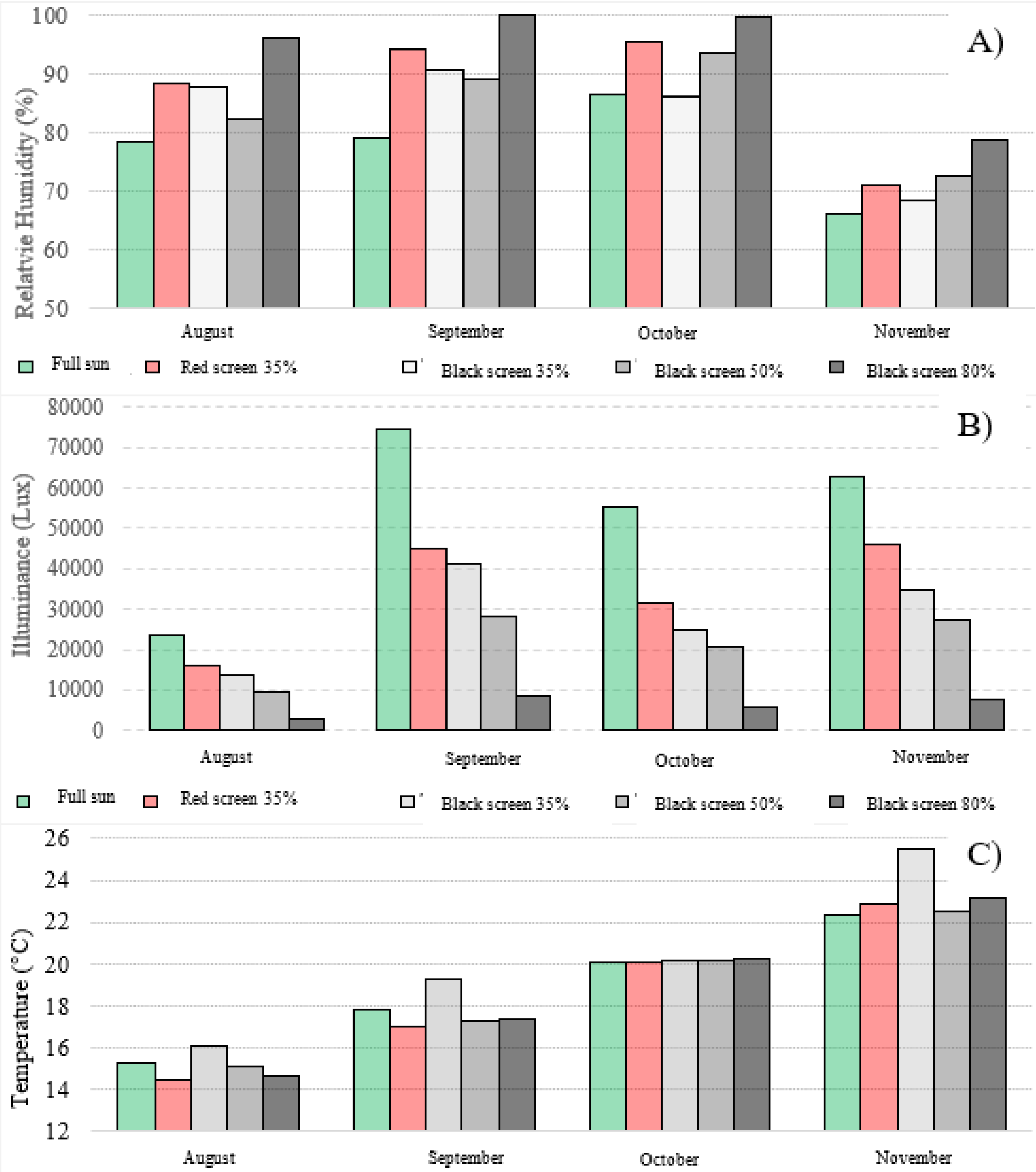

FIGURE 1 - Relative air humidity (%) (A), Illuminance (Lux) (B) and Average internal temperature (°C) (C) of each environment, during the months of August and November 2018.

In the *Calendula officinalis*, the variables AF and CPA presented the highest averages with the use of screens of any shading mesh. For the NF and CT, the most favorable condition was in the dark colored nets (black screen) with superiority through the use of 80%, without differing from the other black colored shade screens. In CR and AF, the shading conditions, regardless of the screen, had the highest averages, and the CPA was higher in the 80% shading condition.

Analyzing the same variables for *Solenostemon scutellarioides*, the environment provided by any type of shading had the highest averages, except for the CT, in which the use of the condition of the 35% (black and red) and 50% screens had the highest averages in relation to the others (Table 3). The responses obtained in all species were influenced by photomorphogenesis, increasing the leaf area and the number of leaves in the conditions of the use of the screen to compensate for the lack of direct luminosity, once with a greater number of leaves and leaf area it is possible to obtain greater production of photoassimilates, thus, compensating for the ideal condition of full sun.

Sales et al. (2009) when evaluating the growth of *Hyptis marrubioides* under three shading conditions (0%, 40% and 80%), found that with an environment of 80% shading, the leaf area showed a tendency to be greater than in plants grown in full sun. According to the same authors, the increase in AF in less irradiated environments occurs because there is a need for the plant to capture more sunlight and, for that, increase its leaf area.

TABLE 3 - Leaf area (AF), number and leaves (NF), shoot length (CPA), root length (CR), total length (TC) of four species of ornamental plants [*Calendula officinalis* L., *Gypsophila elegans* L., *Solenostemon scutellarioides* (L.) R.Br. and *Viola wittrockiana* Gams], in relation to the environment factor.

Gypsophila elegans					
Environment	AF (cm²)	NF	CPA (cm)	CR (cm)	CT (cm)
Black screen 80%	5.5 ab*	3.94ns	4.27 a*	4.37 ab*	8.64 ab*
Black screen 50%	3.55 a	7.81	4.08 a	6.78 a	10.86 a
Black screen 35%	5.55 a	9.38	4.36 a	8.99 a	13.35 a
Red screen 35%	10.00 a	11.11	5.28 a	7.92 a	13.19 a
Full Sun	1.31 b	4.15	1.82 b	0.29 b	2.08 b
VC (%)	142.84	92.51	107.13	88.18	89.54
Box Cox (λ)	-0.02	-	0.06	-	0.06
Viola wittrockiana					
Environment	AF (cm²)	NF	CPA (cm)	CR (cm)	CT (cm)
Black screen 80%	7.46 a*	6.73 a*	6.56 a*	8.25 ab*	14.82 a*
Black screen 50%	3.72 b	6.33 a	3.77 b	9.41 a	13.18 ab
Black screen 35%	1.53 bc	2.30 b	1.72 bc	4.61 bc	6.32 c
Red screen 35%	2.51 bc	2.71 b	3.02 bc	5.15 bc	8.16 bc
Full Sun	0.69 c	1.02 b	0.51 c	2.06 c	2.54 c
VC (%)	75.5	56.0	81.87	66.78	63.53
Box Cox (λ)	-	-	-	-	-
Calendula officinalis					
Environment	AF (cm²)	NF	CPA (cm)	CR (cm)	CT (cm)
Black screen 80%	17.41 a*	5.33 a*	8.42 a*	8.51 a*	16.92 a*
Black screen 50%	8.56 a	3.68 ab	3.91 b	7.44 a	11.35 ab
Black screen 35%	5.96 a	3.05 ab	3.42 b	6.78 a	10.44 ab
Red screen 35%	7.76 a	2.7 b	3.46 b	5.39 a	8.84 b
Full Sun	0.02 b	0.027 c	0.02 c	0.02 b	0.02 c
VC (%)	159.76	74.94	79.18	65.95	66.53
Box Cox (λ)	0.05	-	-	-	-
Solenostemon scutellarioides					
Environment	AF (cm²)	NF	CPA (cm)	CR (cm)	CT (cm)
Black screen 80%	5.45 a*	3.79 a*	2.02 a*	7.12 ab*	19.14 bc*
Black screen 50%	13.45 a	6.23 a	5.18 a	14.30 a	19.48 ab
Black screen 35%	31.27 a	4.97 a	6.59 a	14.03 a	20.62 a
Red screen 35%	5.12 a	3.57 a	2.08 a	7.96 a	10.04 abc
Full Sun	0.027 b	0.027 b	0.028 b	0.02 b	0.027 c
VC (%)	158.52	77.66	104.85	81.86	84.56
Box Cox (λ)	0.01	-	0.05	-	-

*Means followed by different letters in the column, within each ornamental species, differ from each other, at a 5% error probability, by Duncan's test (α=0.05). VC – Variation coefficient. ns. No significative by F test.

Similar results were obtained by Oliveira et al. (2021), where they found that shading influenced the increase in leaf area of lettuce seedlings and, by Melo and Alvarenga (2009), the use of red and black screens, both 50% shading, influenced an increase in leaf area of *Catharantus roseus*. Such responses in the increase of leaf area and number of leaves directly benefited the growth variables CPA, CR and CT, since in all species the superiority responses were related to such conditions. Determining the number of leaves and leaf area is important, as the leaves are responsible for transforming solar energy into organic matter through photosynthesis, affecting the development, growth and productivity of the plant.

The adaptation to low light is a genetic characteristic which causes the leaves to present anatomical structure and physiological properties that enable them to effectively use the available solar radiation (LARCHER, 2006). In this way, the greater growth of seedlings in height, in root, and total, when shaded, were favored by the greater AF and NF, or because it was favored by the milder temperatures in the leaves, due to the opening of the stomata and the fixation of carbon by the plants. (WALTERS et al., 1993). It is likely that in shading there was an efficient control of leaf temperature and, consequently, of the hydric status of the plant, in order to allow optimization of photosynthetic activity and turgidity necessary for growth (REIS, 1991).

The growth reduction in height in full sun is associated with an increase in leaf temperature and, consequently, in the intensification of the respiratory rate, which would induce stomata to close, reducing carbon fixation and causing an increase in the consumption of photoassimilates (GRIME, 1965; KOZLOWSKI et al., 1991). The ability to grow quickly when moderately shaded is an important adaptation mechanism of the species, which in the present work proved to be efficient for obtaining ornamental seedlings with morphological quality.

The fact that luminosity affected the morphological variables of growth did not guarantee a greater increase in shoot, root and total dry matter mass for *Gypsophila elegans*, *Viola wittrockiana* and *Calendula officinalis*, once the shade treatments did not exert a significant influence on these variables. On the other hand, in *Solenostemon scutellarioides*, the highest dry matter masses of the aerial part occurred in the conditions of full sun and 35% and 50% of black screen, being for the latter two also for the total dry matter mass (Table 4).

TABLE 4 - Root density (DR), shoot dry matter mass (MSPA), root dry matter mass (RSM) and total dry matter mass (TSM) of four species of ornamental plants [*Calendula officinalis* L., *Gypsophila elegans* L., *Solenostemon scutellarioides* (L.) R.Br. and *Viola wittrockiana* Gams], in relation to the environment factor.

Gypsophila elegans				
Environment	DR (cm³)	MSPA (g)	MSR (g)	MST (g)
Black screen 80%	0.0199 b*	0.02 ns	0.015 ns	0.0266 ns
Black screen 50%	0.076 a	0.03	0.017	0.042
Black screen 35%	0.092 a	0.05	0.046	0.089
Red screen 35%	0.096 a	0.06	0.036	0.094
Full Sun	0.05 ab	0.05	0.045	0.069
VC (%)	73.13	94.53	94.56	106.55
Box Cox (λ)	-	-	-	-
Viola wittrockiana				
Environment	DR (cm³)	MSPA (g)	MSR (g)	MST (g)
Black screen 80%	0.04 b*	0.0214ns	0.010ns	0.029ns
Black screen 50%	0.11 a	0.026	0.016	0.042
Black screen 35%	0.055 ab	0.025	0.021	0.032
Red screen 35%	0.04 b	0.029	0.02	0.037
Full Sun	0.03 b	0.034	0.026	0.038
VC (%)	107.97	65.54	63.77	66.9
Box Cox (λ)	0.2	-	-	-
Calendula officinalis				
Environment	DR (cm³)	MSPA (g)	MSR (g)	MST (g)
Black screen 80%	0.034ns	0.064 ns	0.015 ns	0.078 ns
Black screen 50%	0.048	0.059	0.033	0.087
Black screen 35%	0.052	0.04	0.023	0.057
Red screen 35%	0.049	0.067	0.036	0.086
Full Sun	0.02	0.027	0.027	0.027
VC (%)	73.6	125.01	81.56	122.04
Box Cox (λ)	-	-0.18	-	-
Solenostemon scutellarioides				
Environment	DR (cm³)	MSPA (g)	MSR (g)	MST (g)
Black screen 80%	0.026 b*	0.018 c*	0.025 ns	0.022 c*
Black screen 50%	0.063 ab	0.063ab	0.028	0.09 ab
Black screen 35%	0.074 a	0.171 a	0.043	0.21 a
Red screen 35%	0.03 ab	0.029 bc	0.017	0.037 bc
Full Sun	0.027 b	0.027 abc	0.027	0.027 bc
VC (%)	78.07	176.62	77.58	164.18
Box Cox (λ)	-0.01	-0.3	0.15	-0.2

*Means followed by different letters in the column, within each ornamental species, differ from each other, at a 5% error probability, by Duncan's test (α=0.05). VC = variation coefficient. ns = no significative by F test.

For root density, treatments had no significant influence on *Calendula officinalis*. Differently, it occurred in the other species, in which the highest averages were found in plants kept in black screens of 50% and 35% for *Viola wittrockiana*, 50% and 35% black and red for *Solenostemon scutellarioides* and, in all conditions, with the exception of 80% for *Gypsophila elegans* (Table 4).

Regarding the application of gibberellic acid, it significantly influenced AF, NF, CPA and CR in *Viola wittrockiana* and *Solenostemon scutellarioides* (Table 5). With *Viola wittrockiana* and *Solenostemon scutellarioides*, there was greater AF, NF and CR without AG3 application, different from what happened with CPA in which the use of this regulator favored the elongation of the shoot. These results confirm the active role of gibberellin in cell division and plant elongation (HIGASHI et al., 2002), which promotes cell wall extensibility (RAVEN et al., 2001).

TABLE 5 - Leaf area (AR), number of leaves (NF), shoot length (CPA), root length (CR) of four species of ornamental plants [*Calendula officinalis* L., *Gypsophila elegans* L., *Solenostemon scutellarioides* (L.) R.Br. and *Viola wittrockiana* Gams], in relation to the gibberellic acid (AG_3) application.

		Viola wittrockiana		
AG_3	AF (cm^2)	NF	CPA (cm)	CR (cm)
0 mg L^{-1}	4.32 a*	4.65 a	1.97 b	7.18 a
300 mg L^{-1}	2.04 b	2.95 b	4.27 a	4.61 b
VC (%)	75.5	56	81.87	66.78
Box Cox (λ)	-	-	-	-
		Solenostemon scutellarioides		
AG_3	AF (cm^2)	NF	CPA (cm)	CR (cm)
0 mg L^{-1}	12.5 a	4.60 a	3.05 b	11.18 a
300 mg L^{-1}	9.62 b	2.83 b	3.31 a	6.21 b
VC (%)	158.62	77.66	104.85	81.86
Box Cox (λ)	0.01	-	0.05	-

*Means followed by different letters in the column, within each ornamental species, differ from each other, at a 5% error probability, by Duncan's test (α=0.05). VC – Variation coefficient.

The positive effect of gibberellic acid over plant growth has been reported by several authors, especially when applied during early plant development (VERDOLIN et al., 2021; BERGMANN et al., 2017; SHAN et al., 2018). However, the effect does not occur in the same way, as it can be seen in the present work, in which the effect was only observed for *Viola wittrockiana* and *Solenostemon scutellarioides*. In these species, such usage can be advantageous to reduce the time of seedling formation for commercialization.

CONCLUSIONS

The utilization of gibberellic acid proved to be beneficial in stretching *Viola wittrockiana* and *Solenostemon scutellarioides*.

The shading environments, regardless of color and light intensity, were more favorable for the formation of *Calendula officinalis* L., *Gypsophila elegans* L., *Solenostemon scutellarioides* (L.) R.Br. and *Viola wittrockiana* Gams seedlings.

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