Shading levels on production and development of *Eucalyptus grandis* Hill ex Maiden seedlings

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Abstract

The goal of the work was to assess the influence of shading levels on seedling production of *Eucalyptus grandis*. The seedlings have been subjected to treatments: 0%; 18%; 30%; 50% and 70% attenuation of solar radiation through screens of polyolefins black coloring. The experiment was performed in autumn 2009 in the city hotbed of Catanduvas – PR, during a period of 90 days. The experiment design was randomized block, with five treatments and five replications. The pricking-out of sowing seedlings for tubes occurred on the 30th day after sowing. At 90 days it was evaluated: shoot height, number of leaves per plant, collar diameter, root length, fresh and dry leaf, root and collar. For all dendrometric variables evaluated, the effect of the treatment was significant. For shoot height, treatments of 30 and 50% shading were higher than the other. Collar diameter and number of sheets, processing the full sun presented the greatest values (0.20 and 15.20, respectively). For variable dry mass and fresh sheets, collar and root treatment with 30% of shading was statistically superior to the others. 30% attenuation of solar radiation has higher dendrometrics characteristics of seedlings to the variables analyzed for *E. grandis.*

Keywords: Attenuation; Transplantation; Solar Radiation; Forest population

Introduction

The cultivation of *Eucalyptus grandis* represents one of the most important way to support agrienergy, due to its fast growth, constant increase in productivity and adaptability of different habitats. It is the most planted forest species in the world, with more than 20 million hectares, being Brazil the second largest country in cultivated area, with approximately 4.7 million hectares in the year 2010 (GIT FORESTRY CONSULTING SL, 2010; ABRAF, 2011).

The success of field cultivation of *Eucalyptus,* as well as the initial growing ranges is closely related to the use of measures of quality (GOMES et al., 2002). Thus, the comprehension of the behavior of the plant facing the attenuation of the solar radiation will assure the search of seedlings with similar performance, so that they will not affect the development in field (REIS, 2008).

The attenuation of the solar radiation is one of the most important factors to the seedling production, since it acts directly in the energy balance and, consequently, in the environmental conditions (HERNANDES et al., 2004). The recommendation in a general way by several authors is 50% shading due to its significant influence in temperature (GALVÃO, 2000; LANG; BOTREL, 2008).

Some studies have evidenced the physiological plasticity of vegetal species in relation to the photosynthetically active radiation available by the means of evaluation of initial growth in relation to different shading levels (ALMEIDA et al., 2005).

For subtropical species of Eucalyptus in winter environments, in which the days are still shorter than in the tropical regions, the photoperiod may have influence in the rooting (ALFENAS et al., 2004). It must be considered that the initial growth of Eucalyptus and the quality of seedlings are factors considered decisive to take the decision in a reforestation program (SCALON et al., 2003).

Studies have reported that the efficiency in the plant growth may be related to the ability of adaptation of the plantlets to the sunlight conditions of the environment (SILVA and SILVA et al., 2007). Considering that, the objective of this work was to evaluate the influence of the shading level in the production of *E. grandis* seedlings to commercial planting.

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Material and methods

The experiment was installed in the year 2009, in the facilities of the City Hotbed of Catanduvas – PR, which is placed in the West portion of the state of Paraná, with a territorial extension of 589.61 km^2 of area, representing 0.29% of the state area. Catanduvas has the following geographic position: latitude: 25° 12' 11" S; longitude: 53° 09' 24" W and altitude of 762 meters.

According to the climate classification of Köppen, the climate in the region is characterized as Cfa – Subtropical climate (CAVIGLIONE et al., 2000). The annual average climate in the region is 19.6 °C, the annual rainfall of 1971 mm and insolation of 2462 hours per year (IAPAR, 2011).

The seeds were sown in tubes. During the stage of germination, the seeds were covered by a thin layer of sieved soil (approximately 1 cm), to protect them from sun and rain. After that, it was placed over the seeding bed a shading screen 50% of shading. The germination occurred between 10 and 15 days after seeding. The seedlings were planted out in tubers of rigid plastic with six internal stripes of 50 cm^3 of volume, with dimensions of 32 x 26 x 126 mm, 30 days after the seeding, when they were 4 to 5 cm of height and 2 pairs of leaves defined.

The substrate used was the recommended for forest species based on pine bark, vermiculture, acidity corrective, urea, ammonium sulfate, and simple superphosphate. All the treatments were fertilized with mineral fertilizer based on NPK 19-06-10, in the dosage of 100 g to each 25 kg of substrate. For the control of leaf-cutter ants of the species saúva (*Atta* sp.) in seedbed, it was performed the application of grain insecticide based on sulfluramid in the dosage of 6 to 10 g m^{-2} of beds from the germination to the transplanting.

The experimental design adopted was random blocks with 5 treatments and 5 replications, with 19 seedlings per plot, and a total of 475 seedlings. The treatments were composed from different shading levels, with use of a shading screen: Treatment 1 – full sun (control); Treatment 2 – 18% of shade; Treatment 3 – 30% shade; Treatment 4 – 50% shade and Treatment 5 – 70% shade.

The evaluations were performed 90 days after the seeding. The morphological variables analyzed were: height of the shoot (cm), number of leaves per plant, diameter of the collar (cm), measured in the mean height of the collar, root length (cm) and fresh (g) and dry matter (g) of leaf, collar and root. Seedling height was measured with a ruler graded in millimeters, the collar diameter was measured using a digital caliper.

In order to determine the dry matter weight, the seedling roots were washed in running water, to the removal of the substrate, aiming to maintain intact all its roots. After the washing, it was separated shoot and root, cutting the seedling in the inferior extremity of collar, for then be placed in paper packaging, separated and identified. The material contained in each package remained in oven at 85 °C for a period of 48 hours to dry. With help from an analytic weight, it was determined the dry matter of both parts of *E. grandis* seedlings.

For the statistic analysis of data it was used the software INFOSTAT, being used the Tukey test to the mean comparison, at the level of 5% of significance.

Results and discussion

The seedlings of Eucalyptus plants present results significantly differenced, in a level of 5% of probability, to plant height and collar diameter analyzed 60 days after transplanting. Eucalyptus seedlings disposed under shading present superior average of height growth. This differenced behavior may be attributed to the higher competition for light and space, which leads the plant to etiolation, in accordance with ATAÍDE et al. (2010).

Hereinafter it is presented the data of height and collar diameter (Table 1), evaluated for *E. grandis* seedlings, which was conducted under different levels of shading. It may be observed statistic differences between the treatments to the variables analyzed.

The coefficient of variation (CV) among the analyzed variables was 4.16% for height and 21.23% for the number of *E. grandis* leaves (Table 1). MARTINS (2002) determines that these percentages are in a low dispersion for plant height and average for collar diameter, since this author classified the coefficient of variation until 15% as

Table 1. Collar diameter and plant height in the production of *E. grandis* seedlings under different shading levels.

Shading levels	Height (cm)	Diameter of collar at medium height (cm)
0%	12.68 c	0.20 a
18%	16.12 b	0.13 b
30%	18.88 a	0.14 b
50%	19.20 a	0.11 c
70%	14.68 b	0.09 c
CV (%)	4.16	21.23

In which: averages followed by the same letter in column do not differ significantly at the level of 5% probability by Tukey test. CV (coefficient of variation)

low and from 15 to 30% as being of medium data dispersion.

When observing Table 1, it can be verified that the plants cultivated in conditions of 30 and 50% of interception of solar irradiation obtained higher growth in height (18.88 and 19.20 cm, respectively). This is a strategy used by plants to seek luminosity whereas, at full sun, it was found lower average value of height (12.68 cm), followed by the treatments at 70 and 18% of interception of solar radiation.

Other authors also found higher average values of plant height when submitted to shading, among them it can be seen: ATROCH et al. (2001); ALMEIDA et al. (2005); CÂMARA and ENDRES (2008); MARQUES et al. (1999); ZANELLA et al. (2006); FONSECA et al. (2002); ROCHA (2002); MAZZEI et al. (1999); RAMOS et al. (2003); PAEZ (2000). GOMES et al. (1978) observed that *E. grandis* seedlings produced without shading presented superior height than those produced under 25; 50 and 70% of shading.

The increase in plant height under light restriction is justified by the action of auxin, this hormone is synthesized in young leaves of the shoot and stem apex, being later transported to the root. In this case, light will function as a stimulus to this transport. When there is restriction on the light incidence, auxin is laterally distributed to epidermis and cortex cells of the hypocotyls, causing the enlargement of these tissues and, therefore, etiolation (MORELLI; RUBERTI, 2000).

The growth in diameter of the seedlings has direct relation with the photosynthesis and development of collar, which happened in the treatment at full sun where the collar length was lower, however, it increased the diameter, 0.20 cm at full sun and 0.09 cm in the treatment with 70% of shading (Table 1).

Some authors report higher collar diameters in plants submitted to higher levels of light, as in shadowing with Brazilian cherry three (*Eugenia uniflora* L.) (SCALON et al., 2001). FONSECA et al. (2002), working with *Trema micrantha* (L.) Blume, also verified a decrease in the value of stem diameter with the increase of the light restriction.

ATROCH et al. (2001) verified that *Bauhinia forficate* seedlings developed higher collar diameters at full sun. Campos and UCHIDA (2002) did not find significant differences in the collar diameter when they evaluated the influence of the attenuation of the solar radiation in three species of native Amazon seedlings. MAZZEI (1999), observed better conditions to plant development in relation to the parameter collar diameter in *Hymenaea coubaril*, which were with 50 and 70% of shading.

In Table 2 it is presented the results found for the variables root length and number of leaves. It was observed differenced between treatments, with shading influencing negatively the values of the variables, i.e., higher solar attenuation, smaller root length and lower number of leaves.

The root length (Table 2), observed in *E. grandis* seedlings presented lower values from the treatment 50% shading. Treatments with 0, 18 and 30% of solar attenuation did not differ statistically, showing that until this shadowing band there is no reduction in the root length.

Concerning the number of leaves (Table 2), the treatment at full sun presented the highest average (15.2 leaves per plant). Due to the hardening

Table 2. Number of leaves and root length in the production of *E. grandis* seedlings under different shading levels.

Shading levels	Root length (cm)	Number of leaves
0%	11.32 a	15.20 a
18%	11.36 a	12.88 ab
30%	11.32 a	13.32 ab
50%	10.40 b	12.40 ab
70%	10.90 ab	10.52 b
CV (%)	10.33	30.40

In which: averages followed by the same letter in column do not differ significantly at the level of 5% probability by Tukey test. CV (coefficient of variation)

by sun the plant was smaller, which influenced in the increase of leaves per plant, in accordance with SILVA et al. (2007), which verified a higher number of leaves at full sun, followed by 30, 50 and 70% of solar restriction. On the other hand, plants which were shaded presented less leaves, but these leaves clearly had a larger size due to the necessity of enlarging the photosynthetic surface to maximize the light absorption, in accordance with FELFILI et al. (1999), when testing different ranges in plant shading.

According to the data obtained it was observed that the treatment with 30% of shading presented higher levels of fresh matter to leaves, collar and root (Table 3). This data is accordance with ATROCH et al. (2001) in which the level of 30% of shading was the most appropriate to the initial growth of the *Bauhinia forficata* Link. tree. There was a significant difference between shading levels tested in relation to leaf fresh matter. The levels of 0, 18, 50 and 70% of shading were statistically similar and inferior to the level of 30%. This demonstrated that the adaptation of the plants to light depends on the adjustment of their photosynthetic apparatus.

According to the data of Table 3 it can be verified that, for root fresh matter, it was observed that the results of 0; 18 and 30% of shading were statistically similar and superior to the others, with mass of 0.78; 0.74 and 0.70 g, respectively. These data show that above 30% shading the development of the seedlings was affected.

For collar fresh matter (Figure 3), treatments 0, 18, 30 and 50% shading were statistically superior, but from this level it can be seen steep decrease in the collar fresh matter.

In relation to leaf dry matter (Table 4), it was observed that 30% shading differed statistically in relation to the other treatments, presenting higher accumulation of leaf dry matter, possibly due to the compensation of the lower quantity of available radiation, confirming a necessity of partial shading to a better initial development of this species.

Observing the data of Table 4, it can be verified that, for the collar dry matter, plants cultivated under 0, 30 and 50% with 0.04 g of mass and 18% shading with 0.03 g of mass were statistically equal, i.e., the sun attenuation did not result in increase of the collar mass, on the contrary, plants shaded in 70% obtained

Tabela 3. Massa fresca de folhas (MFF), massa fresca de coleto (MFC) e massa fresca de raiz (MFR) na produção de mudas de *E. grandis* sob diferentes níveis de sombreamento.

Níveis de sombreamento	MFF (g)	MFC (g)	MFR (g)
0%	1,21 b	0,13 a	0,78 a
18%	1,35 b	0,14 a	0,74 a
30%	1,83 a	0,15 a	0,70 a
50%	1,40 b	0,15 a	0,50 b
70%	0,81 c	0,09 b	0,33 c
CV (%)	25,18	26,84	32,18

Em que: Médias seguidas de mesma letra na coluna não diferem significativamente entre si ao nível de 5% de probabilidade pelo Teste de Tukey. CV (coeficiente de variação). MF = massa fresca.

Table 4. Leaf dry matter (LDM), collar dry matter (CDM) and root dry matter (RDM) in the production of *E. grandis* seedlings under different levels of shading.

Shading level	LDM (g)	CDM (g)	RDM (g)
0%	0.37 b	0.04 a	0.18 a
18%	0.36 b	0.03 ab	0.18 a
30%	0.47 a	0.04 a	0.18 a
50%	0.36 b	0.04 a	0.13 b
70%	0.19 c	0.02 b	0.08 c
CV (%)	27.96	46.63	27.25

In which: averages followed by the same letter in column do not differ significantly at the level of 5% probability by Tukey test. CV (coefficient of variation)

lower collar matter, 0.02 g.

The data observed are in accordance with works written by MARQUES et al. (1999) and UCHIDA and CAMPOS (2000), who obtained similar results when testing different levels of shading in seedlings of *Aniba rosaeodora* and *Dipteys odorata* (AUBL.) WIILD.

For root dry matter (Table 4), it was observed that treatments 0, 18 and 30% shading were statistically equal, with mass of 0.18 g and superior than the others, considering that in 50 and 70% of shading he root dry matter was 0,13 and 0.08 g, respectively. This information shows that the excessive shading affects negatively the development of root. For FONSECA et al. (2002), the higher the shadowing, the lower root dry matter.

For leaf dry matter, the treatment with 30% shading resulted in average values superior to the other attenuations analyzed, with mass of 0.47 g. Plants shaded in 70% obtained the lower mass 0.19 g, indicating that the partial shading increased the seedling development, however attenuation higher than 30% caused reduction.

Conclusions

Eucalyptus grandis seedlings cultivated in seedbeds were influenced by the shading levels used. With the results evaluated the attenuation of 30% of the solar radiation presented characteristics superior to the dendrometric variables used. Thus by the results found it is recommended the use of shading until 30% in seedbed.

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