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Scientific Article

IMPLICATIONS OF USING SHADING MESHES AND PLANT DENSITY ON THE LEAF ANATOMY OF *Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson SEEDLINGS

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ABSTRACT

Shading meshes are important techniques used during seedling cultivation. However, improper use can lead to excessive shading, which may be intensified by the distribution of seedlings in the tray, directly affecting their growth and development. This study aimed to assess the effect of using colored shading meshes combined with different plant densities on the leaf anatomy and seedling quality of *Corymbia citriodora* (Hook.) K.D. Hill and L.A.S. Johnson. The experiment was conducted in a protected environment at the Federal University of Santa Maria Frederico Westphalen campus, from May to September 2018. A completely randomized experimental design was used, in a 2 x 3 factorial scheme with two seedling densities, two shading meshes, and no mesh. The assessed densities consisted of 736 seedlings per m² (high density) and 528 seedlings per m² (medium density). The shading meshes used were in the red and blue colors, and there was a meshless (full sun) treatment as well. Assessments were conducted when seedlings reached 25 cm in height, with the following variables being analyzed: stomatal count, cuticle thickness, adaxial and abaxial epidermis thickness, spongy and palisade parenchyma thickness, as well as seedling quality through the Dickson Quality Index. The use of meshes in different colors and the plant densities altered the anatomical characteristics of *Corymbia citriodora*, such as cuticle and adaxial epidermis thickness, abaxial epidermis, palisade parenchyma, and leaf thickness. However, these anatomical changes observed in seedlings under different meshes do not necessarily indicate better seedling quality.

Keywords: Seedling quality, Stomata, Solar radiation

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IMPLICAÇÕES DO USO DE MALHAS DE SOMBREAMENTO E DENSIDADE DE PLANTAS NA ANATOMIA FOLIAR DE MUDAS DE *Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson

RESUMO – As malhas de sombreamento são importantes técnicas utilizadas durante a formação de mudas. No entanto, seu uso inadequado pode gerar grau excessivo de sombreamento, que pode ser agravado conforme a distribuição das mudas na bandeja, afetando diretamente o crescimento e desenvolvimento das plântulas. Assim, o estudo teve por objetivo avaliar uso de malhas de sombreamento coloridas, associadas a diferentes densidades de plantas, sob a anatomia foliar e qualidade de mudas de *Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson. O experimento foi realizado em ambiente protegido, na Universidade Federal de Santa Maria/campus de Frederico Westphalen, no período de maio a setembro de 2018. O delineamento experimental empregado foi inteiramente casualizado, sendo um bifatorial 2 x 3, sendo duas densidades de mudas, duas malhas de sombreamento e sem malha. As densidades avaliadas foram com 736 mudas por m^2 (alta densidade) e com 528 mudas por m^2 (média densidade). As malhas de sombreamento utilizadas foram nas cores vermelha, azul e tratamento sem malha (pleno sol). As avaliações ocorreram quando as mudas atingiram 25 cm de altura, sendo analisado as variáveis contagem do número de estômatos, espessuras da cutícula, da epiderme, do parênquima lacunoso e do parênquima paliçádico, além da qualidade de mudas por meio do índice de qualidade de Dickson. O uso de malhas de diferentes cores e densidade de plantas alteram as características anatômicas de *Corymbia citriodora*, como a espessura da cutícula e epiderme adaxial, epiderme abaxial, parênquima paliçádico e espessura da foliar. No entanto, essas mudanças anatômicas observadas nas mudas sob as diferentes malhas não indicam, necessariamente melhor qualidade das mudas.

Palavras-Chave: Qualidade de mudas, Estômatos, Radiação solar

1. INTRODUCTION

Lemon-scented gum (*Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson) is a species of the Myrtaceae family that had its taxonomy reclassified in the 1990s. Prior to that, it belonged to the *Eucalyptus* genus (Steffen et al., 2019). This species is widely used in several branches of industry, including the energy sector, for presenting high concentrations of lignin in the wood (Medeiros et al., 2016). The leaves of this species are valued as raw material for sourcing essential oil. The greatest concentration of specialized metabolism production occurs in the leaves and acts as a means for the plant to defend itself against biotic and abiotic factors, originating the essential oil. Lemon-scented eucalyptus essential oil can be applied in aromatherapy, production of disinfectant solutions, detergents, soaps, scouring cleaners, sanitary stones, and in the perfume industry (Machado et al., 2015b).

The success of forest plantations is associated with appropriate choice of forest species, with a population purpose, and with proper management. However, the implementation of forest plantations is directly influenced by the quality of the seedlings used, given that the employment of higher quality plant material will result in lower plant mortality rates, rapid and uniform establishment and, consequently, better development (Wendling et al., 2021).

The production of forest seedlings, in quantity and quality, is one of the main criteria that guarantees the establishment of forest stands (Araújo et al., 2018). In order for vigorous seedlings to be obtained, numerous factors must be considered in the production process, such as quality substrate, adequate packaging, ideal irrigation, and environmental elements such as air temperature and solar radiation. In forest species, solar radiation has an influence on photosynthetic rates and, consequently on the production of photoassimilates, which are responsible for increasing biomass in seedlings (Caron et al., 2012).

When exposed to different intensities of solar radiation, plants present distinct morphoanatomical characteristics compared to those grown with greater intensity of solar radiation. Thus, shading meshes can be used to reduce radiation over plants, in addition to thermal attenuation. However, this management can result in varied photosynthetic rates and microclimates (Guiselini et al., 2013). The use of shading meshes can also provide plants with greater physical protection, as they reduce the intensity of winds, rain and hail.

Shading meshes are widely used in horticulture and can be employed in protected or open cultivation. Successful adoption of screens with meshes of different colors has become increasingly common. These meshes are specifically designed to modify incident solar radiation by altering its spectrum, its dispersion, and the temperature of the air (Elad et al., 2007). Depending on the color of the mesh, it is possible to observe changes in the quality of solar radiation, which result in different wavelengths. These changes cause alterations in plant growth patterns (Macedo et al., 2011), in addition to impacting anatomical, physiological and morphological characteristics (Brant et al., 2009; Hirata & Hirata, 2015; Nascimento et al., 2014).

Based on the hypothesis that changes in the spectral quality of solar radiation can modify the structural characteristics of plants, and considering that these modulations have not yet been widely studied in forest species, this study aimed to assess the effect of using colored shading meshes, associated with different plant densities, on the leaf anatomy and quality of *C. citriodora*.

2. MATERIAL AND METHODS

2.1. Study site and experimental design

The study was conducted during 2018 (May to September) in a protected environment, in the city of Frederico Westphalen, Rio Grande do Sul, Brazil (27 ° 22" S, 53 ° 25" W), at an altitude of 490 m above sea level. According to the Köppen climate classification, the region's climate is of the "Cfa" type, humid subtropical (Alvares et al., 2013), characterized by an average annual air temperature of 19.4 ºC, with minimum and maximum temperatures of -2.3 ºC and 36.3 ºC, respectively (Caron et al., 2024).

The agricultural greenhouse where the study was carried out had a 150-micron-thick (μm) plastic film cover measuring 3.5 m in height, 10 m in width and 20 m in length. The curtains were adjusted daily to promote ventilation and limit temperature rise during the summer, protect the plants from strong winds and prevent the entry of cold air and rainwater during the winter. The plants were irrigated manually, in the morning and afternoon, with said irrigation being always close to the field capacity of the substrate.

C. citriodora seeds were sourced from the Institute of Forestry Science and Research Institute; sowing was carried out on May 22, 2018, directly in polypropylene tubes with an open bottom and conical shape of 90 cm³, filled with commercial organic substrate (Tecnomax®). Immediately after sowing, trays with the tubes were placed under the shading meshes, in accordance with treatment restrictions. When necessary, fungicide and insecticides were applied to control diseases and insects.

The experimental design used was completely randomized, in a 2 x 3 bifactorial scheme, characterized by two plant densities – high density (HD), with occupation of all cells in the trays, equivalent to 736 plants per m², and medium density (MD), with 528 plants per m² –, two shading meshes in the colors blue and red (30% solar radiation restriction), and a treatment without a mesh (inside the greenhouse), with four replications.

2.2. Solar radiation and air temperature

The average daily air temperature was calculated using the maximum and minimum temperatures. Maximum and minimum air temperature data were collected manually at daily time intervals by means of a thermo-hygrometer (Th-02). Values were measured inside the greenhouse and inside each mesh structure to standardize the measurement of these variables. According to statistical analysis, there was no significant difference in temperature among the different treatments. The average daily temperature was 20.2 °C, with an overall temperature range of 10.4 °C to 29.3 °C (Figure 1a).

The average global solar radiation flux during the study was obtained from data recorded by the automatic meteorological station linked to the National Institute of Meteorology, located approximately 200 m from the experiment. The data were corrected considering the transmissivity inside the greenhouse and, subsequently, under each shading mesh, with solar radiation being measured using a pyranometer (LICOR

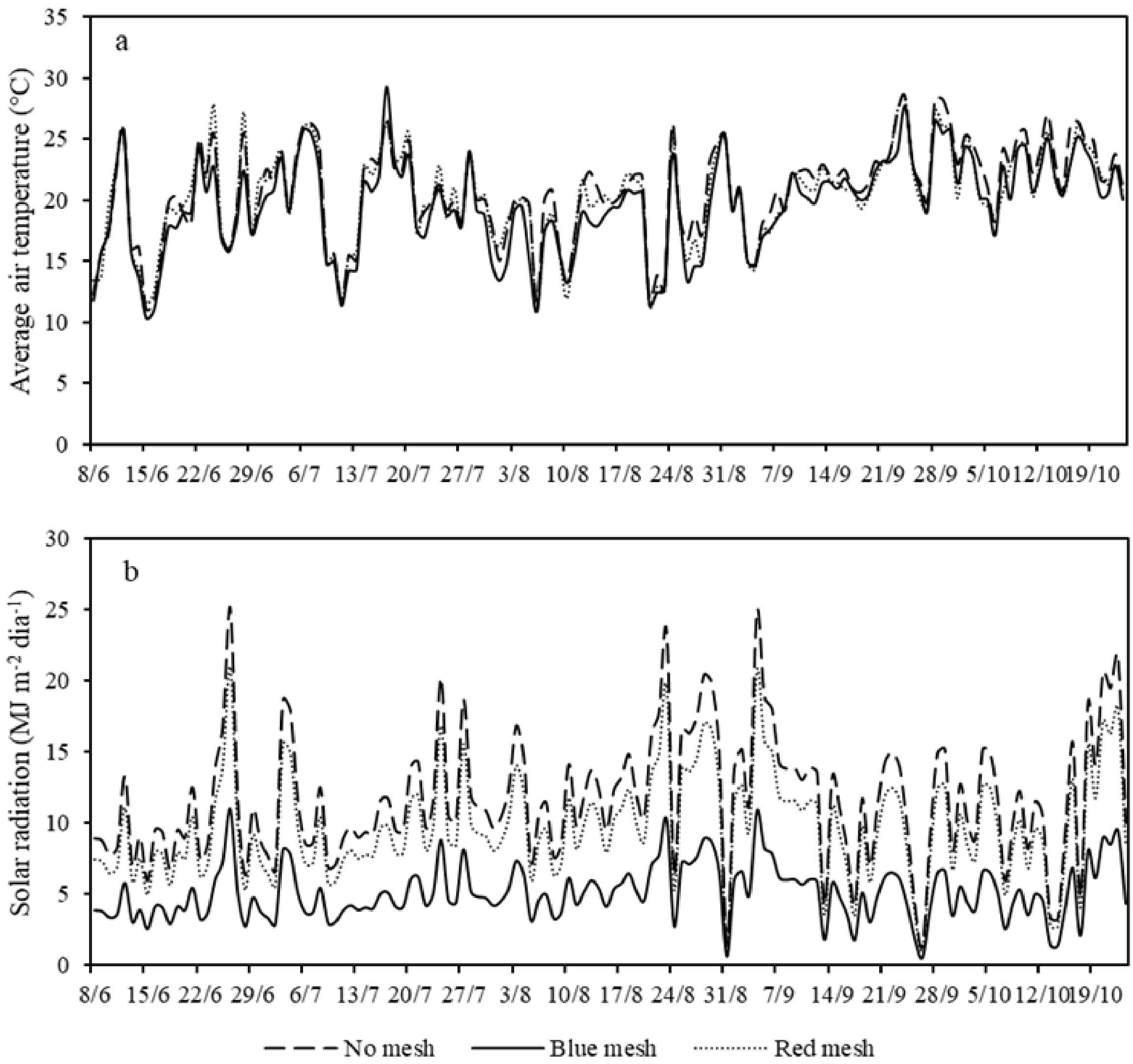

Figure 1. Average values for air temperature (a) and incident global solar radiation (b) throughout the study

Figura 1. Valores médios da temperatura do ar (a) e da radiação solar global incidente (b) ao longo do estudo

PY32164), which was coupled to a Datalogger (LICOR 1400), and recorded every 15 days at the following times: 09:00, 10:00, 14:00, 15:00 and 16:00. The average global solar radiation flux was 11.7 MJ m^{-2} day^{-1} (variation of 1.4-25.2 MJ m^{-2} day^{-1}; no mesh), 9.8 MJ m^{-2} day^{-1} (variation of 1.1-20.9 MJ m^{-2} day^{-1}; red mesh) and 5.1 MJ m^{-2} day^{-1} (variation of 0.6-10.9 MJ m^{-2} day^{-1}; blue mesh). Total cumulative solar radiation stood at 1,621 MJ m^{-2}, 1,350 MJ m^{-2} and 708 MJ m^{-2}, for no mesh, red mesh and blue mesh, respectively (Figure 1b).

2.3. Anatomical evaluations and seedling quality

The plants were evaluated 155 days after sowing, when the seedlings reached the point of transplantation to the field, with approximately 25 cm in height (Navroski et al., 2014). Anatomical evaluations were performed using the third leaf from the apex to the base of three plants in each treatment.

To prepare paradermal-sectioned blades for analysis of the stomata, the methodology proposed by Weyers & Johansen (1985) was followed, using the technique of printing the adaxial and abaxial epidermis. This technique consists of adding a drop of universal instant adhesive (cyanoacrylate ester) onto a glass slide, against which the leaf will be pressed for 30 seconds, making it possible to print the epidermis under the slide. Once made, the blades were subjected to image capture with the aid of a LEICA® optical microscope that had a camera attached, using a 40x magnification with an area of 298 x 223µm). The number of stomata was quantified with the aid of the Anati Quanti software, version 2.0, for Windows® (Aguiar et al., 2007), through counting of stomatal cells.

For the anatomical evaluation of the internal tissues of the leaf blade, the methodology proposed by Carmello-Guerreiro (1995) was followed. Finished resin blocks were cut transversely with a thickness of approximately 5 µm, using a microtome. The histological sections were placed on slides and stained with astra blue for 120 minutes; then, images with an area of 596 x 447 µm were captured using an optical microscope that had a camera attached, with a magnification of 20x. With images captured through photomicrograpy and appropriate software highlighting the structures, the anatomical components evaluated and characterized were: thickness of the cuticle, of the epidermis, of the palisade parenchyma and of the spongy parenchyma.

To determine the quality of the seedlings, the Dickson Quality Index (DQI) was used, which correlates the parameters of total dry mass (TDM), stem diameter (DIAM), aerial part height (HEI), and aerial part dry mass (APDM) – obtained by this sum: leaf dry mass (LDM) + stem dry mass (SDM) + root dry mass (RDM) (Dickson et al., 1960) (Eq. 1):

$$\frac{\text{TDM (g)}}{\frac{\text{HEI (cm)}}{\text{DIAM (cm)}} + \frac{\text{APDM (g)}}{\text{RDM (g)}}} \qquad \text{(Eq.1)}$$

2.4. Statistical analysis

Statistical analysis was performed using the R software. The data were initially analyzed for adherence of the residues to a normal distribution, and the homoscedasticity of the residual variances was analyzed through the Shapiro Wilk ($p < 0.05$) and Bartlett ($p < 0.05$) tests, respectively. Subsequently, they were subjected to analysis of variance to determine possible treatment effects and interactions. When significance was verified by the F test ($p < 0.05$), appropriate complementary analyses were carried out, with the means being compared using the Scott-Knott mean clustering test ($p < 0.05$).

3. RESULTS

3.1. Stomatal density

Analysis of the paradermal section indicated the presence of stomata in the adaxial and abaxial epidermis of the leaf, classifying the *C. citriodora* species as amphistomatic. According to the analysis of variance, there was no significant mesh x density interaction for adaxial and abaxial stomatal density. Analyzing the main effects, no significant effect as to the factors studied was identified, with an overall mean of 15.00 stomata mm^{-2} on the abaxial surface of the leaf and 7.49 stomata mm^{-2} on the adaxial epidermis of the leaf (Figure 2).

3.2. Leaf anatomy

Through the anatomical evaluation of the internal tissues of the leaf blade of *C. citriodora* seedlings, it was possible to observe the presence of cuticle, adaxial and abaxial epidermis, and palisade and spongy parenchyma under all treatments studied, with leaf anatomy being presented as follows: high density under red mesh (Figure 3A), medium density under red mesh (Figure 3B), high density under blue mesh (Figure 3C), medium density under blue mesh (Figure 3D), high density without mesh (Figure 3E) and medium density without mesh (Figure 3F). Two layers of palisade parenchyma were found both next to the adaxial epidermis and the abaxial epidermis, and spongy parenchyma was found as well; therefore, these leaves are classified as dorsiventral.

The leaf anatomy under the different spectral qualities generated by the colored meshes, associated with the different densities, resulted in significant changes in the anatomical characteristics in the leaf compartments of the *C. citriodora* seedlings (Table 1). According to the analysis of variance, there was a significant interaction between meshes and densities for these variables: adaxial epidermis, abaxial epidermis, palisade parenchyma and total leaf thickness. The adaxial cuticle variable

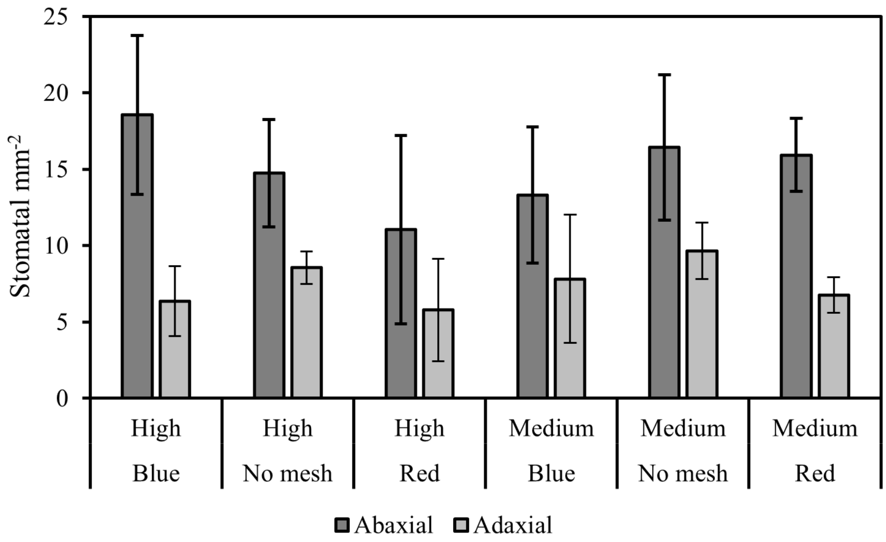

Figure 2. Stomatal density of the abaxial and adaxial leaf blades of *Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson seedlings subjected to different densities in the tray and under shading meshes

Figura 2. Densidade estomática das lâminas foliares abaxiais e adaxiais de mudas de *Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson submetidas a diferentes densidades na bandeja e sob malhas de sombreamento

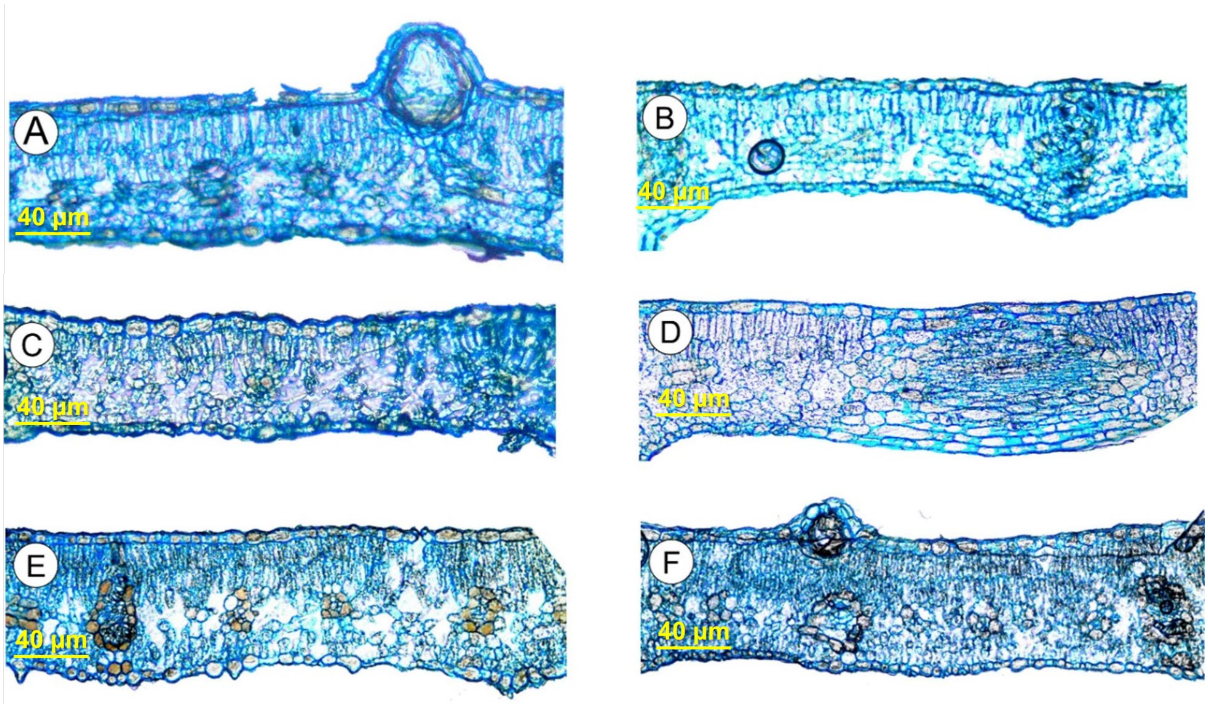

Figure 3. Anatomy of the leaf blade of *Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson seedlings subjected to different densities in the tray and under shading meshes. A - high density under red mesh, B - medium density under red mesh, C - high density under blue mesh,

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D - medium density under blue mesh, E - high density under no mesh, F - medium density under no mesh

Figura 3. Anatomia da lâmina foliar de mudas de *Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson submetidas a diferentes densidades na bandeja e sob malhas de sombreamento. A - alta densidade sob malha vermelha, B - média densidade sob malha vermelha, C - alta densidade sob malha azul, D - média densidade sob malha azul, E - alta densidade sem malha, F - média densidade sem malha

Table 1. Thickness of the anatomical components (µm) of the leaf blade of *Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson seedlings subjected to different densities and under shading meshes

Tabela. Espessura dos componentes anatômicos (µm) do limbo foliar de mudas de *Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson submetidas a diferentes densidades e sob malhas de sombreamento

Anatomical components (µm)	Density	No mesh	Red mesh	Blue mesh
Adaxial cuticle	High	4.43 aA	2.38 bA	4.31 aA
	Medium	4.65 aA	3.06 bA	3.52 aA
Abaxial cuticle	High	10.21 aA	9.30 aA	13.96 aA
	Medium	11.35 aA	8.28 aA	9.76 aA
Adaxial epidermis	High	48.11 aA	39.60 bB	52.31 aA
	Medium	46.86 bA	60.02 aA	27.91 cB
Abaxial epidermis	High	35.29 bA	52.87 bA	76.13 aA
	Medium	67.40 aA	58.43 aA	38.24 aB
Palisade parenchyma	High	9.42 aA	7.60 aA	9.87 aA
	Medium	6.81 aA	9.87 aA	6.47 aB
Spongy parenchyma	High	3.18 aA	3.40 aA	3.06 aA
	Medium	3.18 aA	2.72 aA	2.87 aA
Total leaf thickness	High	110.63 bA	115.16 bB	159.64 aA
	Medium	131.28 aA	151.36 aA	88.76 bB

*Means followed by the same letter: lowercase in the row differs between meshes, and uppercase in the column differs among densities, by the Scott-Knott test, at 5% error probability level.

*Médias seguidas da mesma letra: minúsculas na linha diferem entre as malhas, e maiúsculas na coluna diferem entre as densidades, pelo teste de Scott-Knott, com nível de probabilidade de erro de 5%.

showed significant effect only for the density treatment. As for the abaxial cuticle and spongy parenchyma variables, no significant effects as to the treatments were observed, nor any interaction between them.

The seedlings arranged under blue mesh and no mesh, both for high and medium densities, did not present significant difference in the thickness of the adaxial cuticle, with means of 4.37 µm for high density and 4.08 µm for

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medium density. In contrast, seedlings under red mesh, at both densities, showed lower adaxial cuticle thicknesses. For the abaxial cuticle, there was no difference between treatments, with an overall mean of 10.48 µm.

In the adaxial epidermis, the greatest thickness was found for seedlings arranged at medium density under red mesh (60.02 µm). However, for high density, the same mesh presented the lowest value, while blue-mesh plants had the highest mean (52.31 µm). In the abaxial epidermis, the blue mesh resulted in greater thickness (76.13 µm) among the mesh treatments and seedling densities.

The palisade parenchyma did not show any difference between meshes and without a mesh at high and medium densities; only the blue mesh resulted in greater thickness in plants at high density (9.87 µm), compared to medium density (6.47 µm). In the spongy parenchyma, no difference was observed between meshes and among densities, with an overall mean of 3.07 µm. The greatest leaf thickness was found in seedlings arranged under blue mesh, at high density (159.64 µm). On the other hand, at medium density, it was found in leaves of plants arranged under the red mesh (151.36 µm).

3.3. Statistical analysis

The analysis of variance showed a significant interaction between meshes and among densities for the DQI; thus, it can be observed that the densities associated with the shading meshes affected the quality of the seedlings (Figure 4). For high density, the meshless treatment showed superior quality. As for medium density, the best results were found for the red mesh and blue mesh, with values of 0.082 and 0.078, respectively. For the meshless treatment, the best result was found for high density (0.121).

4. DISCUSSION

4.1. Stomatal density

C. citriodora has stomata on both leaf surfaces, with its leaves being classified as amphistomatic, just as found by Moura & Franzener (2014). Furthermore, this species has a greater number of stomata in its abaxial part. Stomatal density in a leaf is generally affected by the environmental factors to which the plant is subjected, with water capacity, radiation availability and ambient temperature

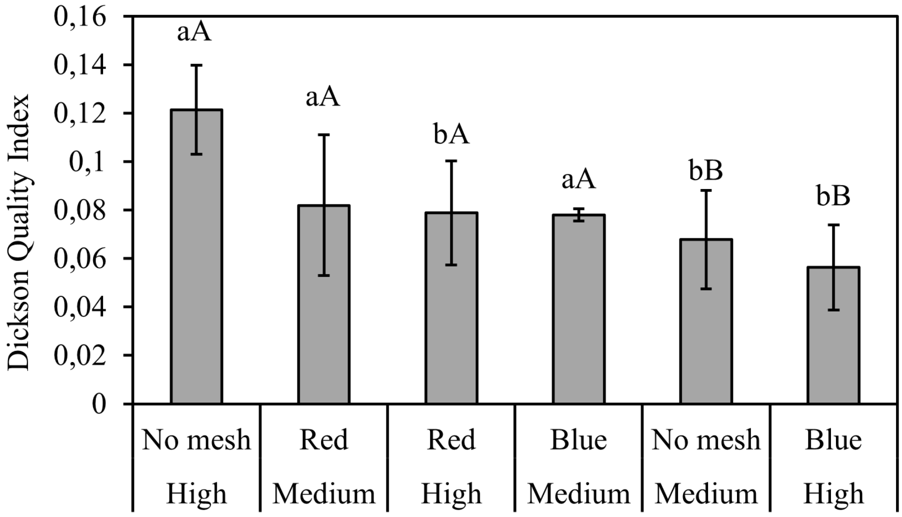

Figure 4. Dickson Quality Index (DQI) for *Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson seedlings subjected to different densities in the tray and under different shading meshes. *Lower case letters differ between shading meshes; upper case letters differ among densities under shading meshes

Figura 4. Índice de Qualidade de Dickson (IQD) para mudas de *Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson submetidas a diferentes densidades na bandeja e sob diferentes malhas de sombreamento. *Letras minúsculas diferem entre malhas de sombreamento; letras maiúsculas diferem entre densidades sob malhas de sombreamento being the main factors that contribute to this variation (Vráblová et al., 2018; Bucher et al., 2017). The adaxial surface is more sensitive to environmental factors (Hronková et al., 2015; Tulva et al., 2024), showing a lower number of stomata on this side compared to the abaxial side.

Most studies, such as those conducted by Martins et al., (2009), Silva Júnior et al., (2012) and Silva et al., (2015), who investigated stomatal density under red and blue shading meshes in different species, observed a reduction in stomatal density compared to plants grown without meshes. According to the authors, this reduction is attributed to the lower incidence of radiation and to changes in the light spectrum promoted by the shading meshes. However, in the present study, this response was not observed, as there were no differences on both sides of the leaf blade in the treatments analyzed. This aspect can be attributed to the development of some acclimatization of *C. citriodora* plants from the environment to which they were subjected.

4.2. Leaf anatomy

The cuticle plays an important role in reflecting solar radiation; it contributes to maintaining optimal leaf temperature levels, in addition to helping reduce water loss from the plant to the atmosphere, due to its lipid composition, with greater thickening generally being observed in conditions of more intense light, such as in the meshless treatment (Silva Souza et al., 2024). This factor is also responsible for the absence of significant differences in the abaxial cuticle among the treatments, as it receives little influence from light (Rossatto & Kolb, 2010; Machado et al., (2015a). Baliza et al. (2012), while working with Coffea arabica cultivation at different radiation levels, also did not observe a significant influence on the thickness of the abaxial cuticle.

The thickness of the epidermis is an anatomical characteristic of plants that tends to adapt according to the environment to which they are exposed (Melo et al., 2011), a response observed in this study. In the adaxial epidermis, the greatest thicknesses were observed at medium density, in plants under the red mesh (Table 1). This may suggest that radiation filtered by the mesh alters the photosynthetic or protection demand, resulting in structural adaptations, such as increased epidermal thickness (Taiz et al., 2017).

In the abaxial epidermis, there was a reduction in thickness in the leaves of plants subjected to high density, both without mesh and under red mesh. The blue mesh exhibited the opposite behavior, with this response being similar to that found by Corrêa et al. (2016), who observed an increase in the thickness of the adaxial epidermis of *Typha angustifolia* at high population densities. Epidermal thickness is related to the defense of plants against high levels of radiation, mechanical injuries and pathogens. The plant’s defense against microorganisms favored by a more humid microclimate generated by high density can be considered one possible factor that contributed to increasing epidermal thickening (Mussury et al., 2012).

The palisade parenchyma and spongy parenchyma did not show significant differences between the colored shading meshes and the meshless treatment. However, under blue mesh, there was a difference among densities, with high density presenting a higher value for palisade parenchyma thickness.

According to Nascimento et al. (2014), regardless of the color of the mesh used, plants tend to present adaptations in leaf thickness. Thus, the leaf structure may present different responses depending on the incident solar radiation that acts upon it (Björkman, 1981), and on the wavelengths, which may present changes with the use of colored shading meshes.

These differences in the anatomical structures found in the different production environments of *C. citriodora* seedlings resulted in different leaf blade thicknesses. In this research, it was evidenced that seedlings produced under blue mesh, at high density, promote greater leaf thickness. This result is in line with the findings by Silva Júnior et al. (2012), who studied plants of *Laelia purprat*a, and Silva et al. (2015), who worked with tamarind. An increase in leaf thickness is an adaptation strategy that the plant develops in order to better absorb solar radiation, favoring photosynthetic efficiency (Taiz et al., 2017). However, according to Martins et al. (2009) and Mesquita et al. (2022), who worked with different species under colored shading meshes, leaf blade thickness tends to be greater in plants produced in environments without meshes. This evidences the importance of the quantity and quality of solar radiation for the anatomical characteristics of plants.

4.3. Dickson Quality Index

The density of seedlings in the tray alters the DQI; this was observed by Eloy et al. (2013) when working with *Eucalyptus grandis* at different densities, with the authors verifying that this factor alters the characteristics of the seedlings, generating different DQIs. Moreover, Costa et al. (2018) found that the meshes altered the cell elongation of *Butia captata*; however, this did not result in better-quality seedlings. Therefore, it can be observed that different densities influence the characteristics of the seedlings, and the response depends on the species with which one is working.

In high-density conditions, the quality of the seedlings was superior in the environment without a mesh, with the other treatments (red and blue) not differing statistically. This result may be related to competition among the seedlings for solar radiation, especially compared to the medium density without a mesh. The difference observed among the seedlings under the colored meshes can be attributed to a change in the photosynthetic spectrum. Similar results were observed in *Tocoyena formosa* seedlings under different levels of solar radiation, which showed variations in growth. In environments without solar restriction, the seedlings had a higher DQI than seedlings placed on shading meshes (Bonamigo et al., 2016). The higher DQI indicates a higher quality of forest seedlings (Dickson et al., 1960).

According to Sturion et al. (2000), an increase in plant density can directly affect seedling quality, sometimes negatively, as there is greater competition for water, light and nutrients, in addition to greater dissemination of pathogens. However, the use of low densities may result in less use of environmental conditions, with the competition factor being relevant for good seedling development. Massad et al. (2017), when assessing the growth of *Peltophorum dubium* at different densities of seedlings per tray and with different tube volumes, observed that higher density of seedlings per tray resulted in greater aerial part height, larger stem diameter and better DQI.

5. CONCLUSION

The use of different densities of seedlings in the trays, associated with colored meshes, influenced the anatomical characteristics of *Corymbia citriodora*, reducing the thickness of the adaxial cuticle under red mesh. In the adaxial epidermis, seedlings at medium density under red mesh showed increased thickness, while in the abaxial epidermis, the highest value was observed in high-density seedlings under blue mesh. For palisade parenchyma, high-density seedlings under blue mesh showed greater thickness, while in the spongy parenchyma, the treatments did not affect this characteristic.

The main anatomical changes were observed in seedlings arranged at high density under blue mesh, which presented greater leaf thickness. Thus, the study's hypothesis is accepted. However, these anatomical changes observed in seedlings under different meshes do not necessarily indicate better seedling quality, as the highest Dickson Quality Index was recorded in high-density seedlings without the use of meshes.

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AUTHOR CONTRIBUTIONS

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