Universidade Federal do Paraná
Setor de Ciências Agrárias
Pós-graduação em Engenharia Florestal
Revista Floresta

EFFECTS OF DIFFERENT SHADING PERIODS ON THE INITIAL GROWTH OF *Cariniana estrellensis* (Raddi) Kuntze

Rodolfo Soares de Almeida[1*], Gabriel de Resende Baroni[2], Erick Martins Nieri[3], Lucas Amaral de Melo[4]

[1*]Universidade Federal de Lavras, Departamento de Ciências Florestais, Lavras, Minas Gerais, Brasil - * rodolfoflorestal@gmail.com
[2]Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba, São Paulo, Brasil - gabrielbaroni92@gmail.com
[3]Universidade Federal do Sul e Sudeste do Pará, Instituto de Estudos do Xingu, São Félix do Xingu, Pará, Brasil - ericknieri@unifesspa.edu.br
[4]Universidade Federal de Lavras, Departamento de Ciências Florestais, Lavras, Minas Gerais, Brasil - e-mail lucas.amaral@ufla.br

Received for publication: 31/08/2020 – Accepted for publication: 12/05/2022

Resumo

Efeitos de diferentes períodos de sombra no crescimento inicial de Cariniana estrellensis (Raddi) Kuntze. É necessário um melhor entendimento do ciclo de produção e melhores métodos para o cultivo de mudas de espécies brasileiras nativas, a fim de desenvolver ainda mais projetos de restauração ecológica e fechar a lacuna de conhecimento sobre espécies nativas. Este trabalho teve como objetivo avaliar os efeitos de diferentes períodos de sombreamento na produção de mudas de *Cariniana estrellensis*. Os períodos de tratamento foram baseados no número de dias sob sombreamento de 50% (0, 30, 60, 90, 120, 150 e 180 dias de experimento), em delineamento inteiramente casualizado, com quatro repetições e 25 mudas por parcela. Foram mensuradas a altura, diâmetro, biomassa da parte aérea e raízes, número de folhas e qualidade das mudas avaliado através do índice de qualidade de Dickson. Houve uma relação positiva e linear entre todas as variáveis e o período de sombreamento, com um período prolongado na sombra fornecendo os melhores resultados. Em conclusão, mudas de *Cariniana estrellensis* crescem com mais eficiência à sombra.
Palavras-chave: Espécies clímax, Jequitibá-branco, Viveiro, Produção de mudas.

Abstract

A better understanding of the production cycle and best methods for cultivating the seedlings of native Brazilian species are needed to further develop ecological restoration projects and close the knowledge gap on native species. This work aimed to evaluate the effects of different shading periods on the production of nursery seedlings of *Cariniana estrellensis*. The shade periods were based on the number of days under 50% shade (0, 30, 60, 90, 120, 150, and 180 days of experiment), using a completely randomized design, with four replicates, and 25 seedlings per parcel. We measured the height, diameter, biomass of the shoot and roots, number of leaves, and quality of seedlings, using the Dickson quality index assessment. We found a positive and linear relationship between all variables and the shading period, with a prolonged period in shade providing the best results. We concluded that *Cariniana estrellensis* seedlings grow more efficiently in shade.
Keywords: Climax species, Jequitibá-branco, Nursery, Seedlings production.

INTRODUCTION

The cost for producing quality nursery seedlings depends upon the equipment, staff, and techniques used. The quality is closely related to the field survival and initial growth, with it being necessary to include early competition in the growth of seedlings. To achieve good quality seedlings, it is important to consider the ecological traits of the species and modify the production accordingly.

The development of forest seeds and seedling production started near the end of the twentieth century, based on techniques for exotic species, such as *Eucalyptus* and *Pinus* (BUSATO *et al*., 2015). There is a lack of knowledge on the procedures required for producing native Brazilian species. Often the procedures for *Eucalyptus* seedlings are used, even if these conditions are not adequate.

Shading is a process used in nurseries, which aims to cultivate plants in favorable environments, so that the best growth and development is achieved to reduce the production time and increase the resistance to variables encountered in the field. Many trials were carried out with the objective of quantifying the optimum level of shading in native species (REIS *et al*., 1994; OLIVEIRA *et al*., 2011; PORTELA *et al*., 2017), however, few attempts were dedicated to quantifying the necessary period of stay in shade condition for the production of better quality seedlings (FONSECA *et al*., 2002; MARANA *et al*., 2015).

Cariniana estrellensis (Raddi) Kuntze is a native Brazilian species, belonging to the family Lecythidaceae, commonly known as jequitibá-branco. It is characterized as a late successional species. *C. estrellensis* is commonly found in mature and riparian forests of the Atlantic Rainforest (GASPAR *et al*., 2014; NUNES *et al*., 2012). The wood has a high economic value. Among its uses, moldings and internal fittings/structures for furniture are the most important. In construction, its wood can be used in beams, rafters, lining, squares, and when preserved can be used in external applications (CARVALHO, 2003). The economic potential of the plantations is promising, according to Silva *et al*. (2012), as well as the use of the species in projects for the recovery of degraded areas and enrichment plantations. Additionally, increasing the contribution of the forest to sequester atmospheric carbon is recommended (GASPAR *et al*., 2014).

Recent studies have pointed out that as *Cariniana legalis* is classified as a late successional species and is shade tolerant, it is physiologically adapted to shade conditions and therefore, shading is a necessary step to produce its seedlings (REGO and POSSAMAI, 2011, PORTELA *et al*., 2017). The best conditions for the growth and development of *C. legalis* seedlings includes shading at a range of 50% to 30% (REGO and POSSAMAI, 2011). In this context this work aimed to define the shading period necessary to produce *C. estrellensis* seedlings with a high-quality standard.

MATERIALS AND METHODS

The experiment was performed between May/14 and February/15 at a forest nursery, located in Lavras, Minas Gerais, Brazil. The city is at an altitude of 925 m, presenting subtropical characteristics, such as dry winters and wet summers, categorized as Cwa in Köppen's climate classification (DANTAS *et al*., 2007). The climatic features of the region consist of high temperatures and precipitation from October to March and low temperatures and precipitation from March to September.

The seeds of *C. estrellensis* (Mart.) Kuntze were acquired from a private seed company and kept in a cold chamber (8 °C/45% UR) until seeding. The receptacles used were 115 cm^3 cylindrical tubes made of polypropylene. The substrate used was composed of 10% vermiculite, 20% tanned cattle manure, 20% carbonized rice husk, and 50% coconut fiber. The fertilizer was Basacote® mini slow release (three months) with 13% nitrogen, 6% phosphorus, 16% potassium (13-6-16 NPK), with an added 1.4% of magnesium and micronutrients. Additionally, in the fertilizer, Osmocote® plus slow release (8 to 9 moths) was used, with a composition of 15% nitrogen, 9% phosphorus, and 12% potassium (15-9-12 NPK). Both of which were in a concentration of 4 kg m^{-3} of each substrate. The use of both slow release fertilizers, with different release rates, was to reduce fertigation.

The seeding was manually completed during May/14, with two to three seeds of *C. estrellensis* per pot. During the seedling production, the irrigation was performed three times a day using a micro-irrigation system. The plants were maintained in an environment with 50% shade until germination reached 60% in August/14, which marks the beginning of the treatments.

The treatments consisted of the time period that the seedlings were maintained in the shaded environment: 0, 30, 60, 90, 120, 150, and 180 days after the treatments start (days ATS) (Figure 1). After the shading period, the plants were placed in full sun conditions. The shade was provided by a synthetic fabric, black in color, which blocks 50% of the natural light. The experiment was conducted in a completely randomized design, with four replications, and an experimental unit of the mean of 25 plants.

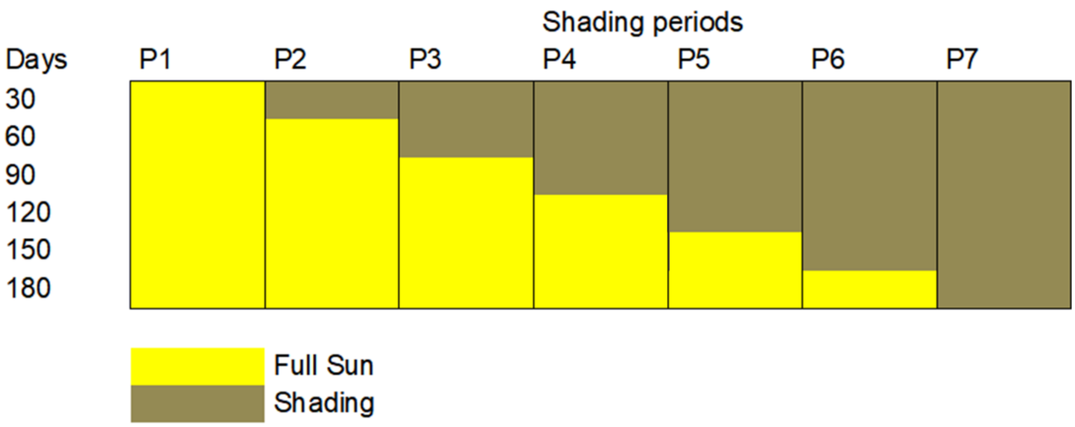

Figure 1. Different shading periods tested during *Cariniana estrellensis* seedling production, where P1, P2, P3, P4, P5, P6, and P7 were the different periods evaluated

Figura 1. Diferentes períodos de sombreamento testados durante a produção de mudas de *Cariniana estrellensis*, onde P1, P2, P3, P4, P5, P6 e P7 foram os diferentes períodos avaliados

Nondestructive measurements (stem height and diameter) were taken monthly, to follow the growth of the seedlings. The height of the plants (H) was measured using a graduated ruler placed at the root collar and measured to the terminal bud. An electronic caliper was used to measure the diameter (D) using the top of the pot as a reference.

Destructive measurements (biomass) were taken at the end of the experiment, during February/15. To assess the biomass, five seedlings with the mean height and diameter, based on the measurements of one hundred seedlings, from each plot of the experiment, randomly selected from each shade period tested, provided the data for the Dickson quality index value. The experimental unit for this analysis, is the mean of ten plants with two replications. The seedlings were cleaned, especially the root system, in running water, then separated into the components of the plant, roots, stems, and leaves. All components were stored separately in paper bags, which contained ten plants in each. They were dried in ovens at 70 °C, until a constant weight was reached. The shoot (SB), leaf (LB), and root biomass (RB) were weighed on an analytical scale and combined to create the total biomass (TB).

The Dickson quality index (DQI) (DICKSON *et al*., 1960) was used to evaluate the seedlings' morphological and physiological conditions, because its formula (1).

$$DQI = \frac{TB\ (g)}{[(H(cm)/D\ (mm))+(SB(g)/RB(g))]} \qquad \text{(Equation 1)}$$

Where: TB = total biomass (g); H = steam height (cm); D = diameter (mm); SB = shoot biomass (g); and RB = root biomass (g).

The measurements were submitted to an analysis of variance (ANOVA) by the F-test at 5% significance, as well as its regressions. Growth curve regressions were based on both the full sun and shading periods. All statistical analyses were conducted using the SISVAR software (FERREIRA, 2014).

RESULTS

All measurements had a positive significance according to the F-test at a 5% probability. There was a positive effect on the stem height of *C. estrellensis* in a shaded environment, verified by the higher average stem height of plants cultivated in shade for 180 days (Figure 2 A).There was a positive effect caused by the shading on the diameter of the seedlings, with the higher diameter values found in seedlings cultivated entirely in the shade (Figure 2 B).

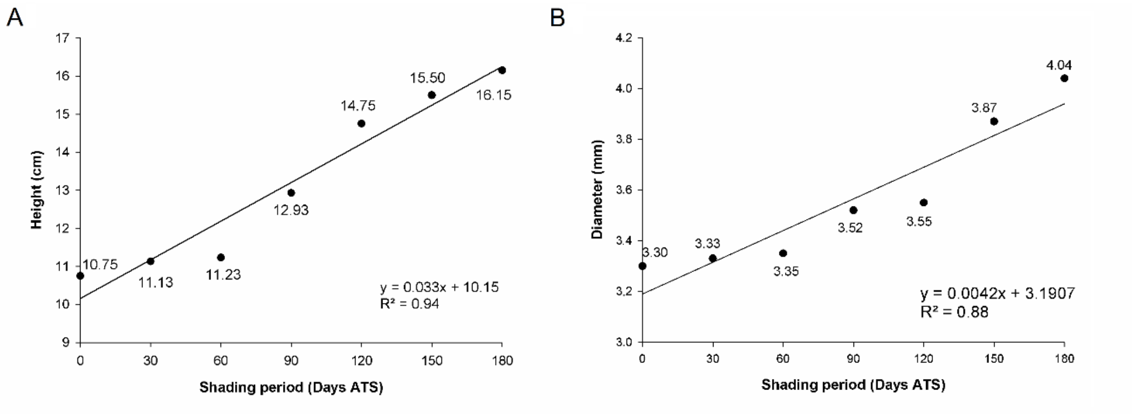

Figure 2. (A): Stem height (cm) of *Cariniana estrellensis* seedlings, under different periods of shading, evaluated at 180 days after the treatments started (ATS); (B): Stem diameter of *Cariniana estrellensis* seedlings, under different periods of shading, evaluated at 180 days after the treatments started (ATS)

Figura 2. (A): Altura do caule (cm) de mudas de *Cariniana estrellensis*, sob diferentes períodos de sombreamento, avaliadas 180 dias após o início do tratamento (ATS); (B): Diâmetro do caule de mudas de *Cariniana estrellensis*, sob diferentes períodos de sombreamento, avaliadas 180 dias após o início do tratamento (ATS)

The growth curve presented in Figure 3 A reflects the effects of shade on the plants' height through time. The early exposure to full sun conditions caused some damage, which reduced the potential growth. Whilst extended periods in the shade had beneficial effects on this species, resulting in a better average height. The effects on the diameter through time can be observed in Figure 3 B. In contrast to the height curve, the diameter growth curve only differentiated at 60 days ATS.

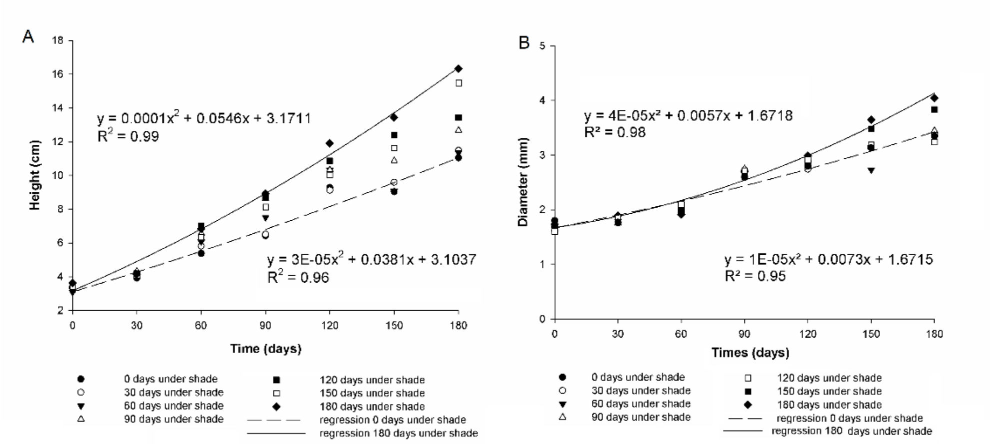

Figure 3. (A): Stem growth curve of *Cariniana estrellensis* seedlings through time, for each shading period tested; (B): Stem diameter growth curve of *Cariniana estrellensis* seedlings through time, for each shading period tested.
Figura 3. (A): Curva de crescimento do caule de mudas de *Cariniana estrellensis* ao longo do tempo, para cada período de sombreamento testado; (B): Curva de crescimento do diâmetro do caule de mudas de *Cariniana estrellensis* ao longo do tempo, para cada período de sombreamento testado.

The mean number of leaves (Figure 4) was highest when *C. estrellensis* was cultivated under the shading structure for a period of 180 days ATS. When the entire production cycle was conducted in the full sun environment, there was a reduction of 27.98% in the number of leaves.

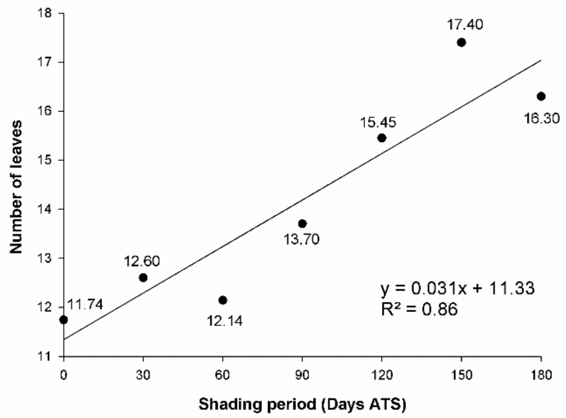

Figure 4. Number of leaves on *Cariniana estrellensis* seedlings, under different periods of shading, evaluated at 180 days after the treatments started (ATS).
Figura 4. Número de folhas de mudas de *Cariniana estrellensis*, sob diferentes períodos de sombreamento, avaliadas 180 dias após o início do tratamento (ATS).

The shading period had a positive effect on the shoot biomass, as shown in Figure 5 A. Seedlings of *C. estrellensis* that were subjected to a longer period under the shade structure, had higher biomass values. Early exposure to full sun conditions proved detrimental to biomass accumulation on the shoot.

The components of the shoot biomass are the leaf and stem biomass. Both had a positive relationship with the shading period (Figure 5 A). In terms of the shoot biomass, there was an increase of 0.51 g to the leaf biomass and 0.17 g to the stem biomass, which symbolize more than 62% and 42% of the extra reserves, respectively.

The root biomass had a positive correlation with the shading period, where the seedlings in the 180 day shade treatment produced and stored more biomass in the roots (Figure 5 B). The early exposure to a full sun environment presented the lowest biomass values, whilst the accumulation of root biomass reserves became higher during the long period in shade.

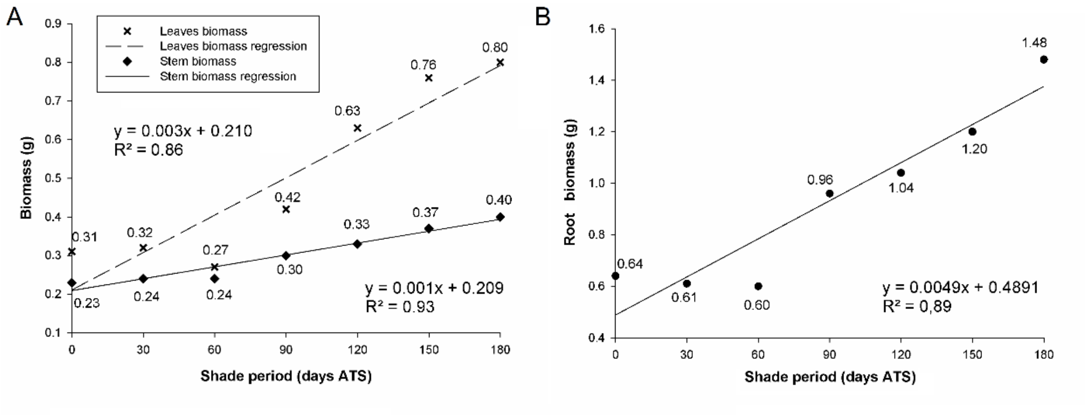

Figure 5. (A): Leaf and stem biomass of *Cariniana estrellensis* seedlings, under different periods of shading, evaluated at 180 days after the treatments started (ATS); (B): Root biomass of *Cariniana estrellensis* seedlings, under different periods of shading, evaluated at 180 days after the treatments started (ATS).

Figura 5. (A): Biomassa foliar e caule de mudas de Cariniana estrellensis, sob diferentes períodos de sombreamento, avaliadas 180 dias após o início do tratamento (ATS); (B): Biomassa radicular de mudas de Cariniana estrellensis, sob diferentes períodos de sombreamento, avaliadas 180 dias após o início do tratamento (ATS).

The Dickson's quality index (DQI) (Figure 6) had a positive relationship with the shading period in the production of *C. estrellensis* seedlings. The higher index values are associated with the seedlings that had longer shading periods, with the lowest values due to the early exposure to full sun conditions.

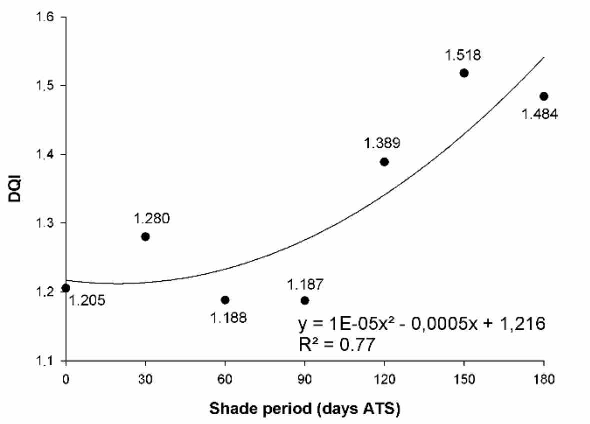

Figure 6. Dickson quality index (DQI) for *Cariniana estrellensis* seedlings, under different periods of shading, evaluated at 180 days after the treatments started (ATS).

Figura 6. Índice de qualidade de Dickson (DQI) para mudas de Cariniana estrellensis, sob diferentes períodos de sombreamento, avaliados aos 180 dias após o início do tratamento (ATS).

DISCUSSION

The stem height is an important measurement as it is associated with field growth and survival, as a higher height represents an advantage during early competition, as the vertical spaces can be occupied to capture the solar radiation. The diameter reflects the accumulation of reserves, which increase the resistance of the stem, thus enhancing the field survival rates (MARANA *et al*., 2015; FARIA *et al*., 2016). The positive and linear effect at height was also observed at *Jacarattia spinosa* in similar experimental conditions (MARANA *et al*., 2015).

The positive effect of shading on the plant height could be explained by two main reasons: positive phototropism and milder leaf temperatures. Firstly, positive phototropism, which is the growth towards a source of electromagnet energy, solar radiation, or others, triggered by a low light intensity environment, promotes a higher plant height, meaning the plant survives for longer in the environment (NERY *et al*., 2016; TAIZ *et al*., 2017). Secondly, a milder leaf temperature could lead to the efficient temperature control of the leaf, resulting in a better hydric status and an optimized temperature for photosynthetic activity (REIS *et al*., 1994; REGO and POSSAMAI, 2011).

According to Rego and Possamai (2006), the reduced growth in a full sun environment reflects the intense radiation, leading to stomata closure, decreasing the internal CO_2 concentration, and damaging the photosynthetic apparatus. A similar response was observed in shade tolerant species, such as *Calophyllum brasiliense* (NERY *et al*., 2016) and *Copaifera langsdorffii* (REIS *et al*., 2016). Portela *et al*. (2017), working with the physiological responses of *C. estrellensis* to increasing solar radiation, found symptoms of photoinhibition in a full solar radiation environment, caused by a drop in the chlorophyll content, resulting in a general growth deficit.

The hypothesis is that the better physiological status of *C. estrellensis* cultivated in the shade could explain the higher values for the diameter and number of leaves. Portela *et al*. (2017) explained that, because of the better hydric status, an optimized temperature for photosynthetic activity, and an elevated number of leaves, the plants in the shade produce more photoassimilates, used in growth and as stock. As the diameter is a function of the reserves and elements of the vessels and cells, such as the parenchyma, xylem, and phloem, it is expected that higher diameter values would be found in more active and physiologically efficient plants (KRAMER, 2012). However, an opposite result was observed at *J. spinosa* in similar experimental conditions (MARANA *et al*., 2015), exposing a different response in different species.

The greater biomass accumulation in the roots, rather than the shoots, of *C. estrellensis*, opposes the trends observed by Meira *et al.* (2012), Marana *et al*. (2015), and Nery *et al.* (2016), where those authors state that there was rapid shoot growth and slower root growth in conditions of lower irradiance for *Melissa officinalis*, *J. spinosa* and *C. brasiliense*, respectively. Usually, tree species tend to allocate more biomass to the root system, instead of the shoot, under intense solar radiation (LIMA *et al*., 2010; OLIVEIRA *et al*., 2011).

In an environment with lower luminosity, plants usually invest in strategies to maximize the photosynthesis, by increasing the leaf area or number of leaves (OLIVEIRA *et al*., 2011; NERY *et al.,* 2016). This strategy can be observed in *C. estrellensis* seedlings produced in the shade, which increase the number of leaves and leaf biomass. In contrast, considering a full sun environment, plants tended to reduce the leaf area and structure as a strategy to avoid the excess loss of water by transpiration (ALMEIDA *et al*., 2005; SANTOS *et al*., 2014). The same behavior is observed in *C. estrellensis* cultivated entirely in a full sun environment, where there was a much lower biomass accumulation and smaller number of leaves.

The DQI is an index that uses morphological traits to predict the seedlings quality, by computing the robustness and biomass distribution while considering several important parameters (FONSECA *et al*., 2002; PEREIRA *et al*., 2017). A common way to interpret the DQI is that a greater index value means a better quality seedling, only within the same species (BUSATO *et al*., 2015; CALDEIRA *et al*., 2012). The high DQI values of seedlings kept in the shade for longer can be explained by the strong correlation between the DQI, steam diameter, and dry matter (BINOTTO *et al*., 2010), which reflects better morphological traits. However, the decrease in the DQI value observed at 180 days ATS, might suggest the need of a hardening phase at the end of the seedling production.

However, as per Dickson *et al*. (1960), the DQI takes into consideration several morphological traits, such as the height and diameter, as well as some physiologically related parameters, like the biomass and its components, resulting in a good quality indicator, the uses a destructive method to assess quality; therefore, it is not appropriate to be a grading technique. The most effective way that DQI can be used in a nursery, is being part of a sampling schedule quality test. Further study is required to discriminate a specific range of values that distinguishes the quality categories of *C. estrellensis* seedlings.

CONCLUSION

- The seedlings of *Cariniana estrellensis* (Raddi) Kuntze expressed positive tendencies for all variables studied in response to prolonged shading.
- For its production in nurseries, we recommend the use of shade structures until reaching the project specifications and a quick hardening phase in a full sun environment.

REFERENCES

ALMEIDA, S. M. Z.; SOARES, A. M.; CASTRO, E. M.; VIEIRA, C. V.; CAJEGO, E. B. Alterações morfológicas e alocação de biomassa em plantas jovens de espécies florestais sob diferentes condições de sombreamento. **Ciência Rural**, Santa Maria, v.35, n.1, p. 62-68, 2005.

BINOTTO, A. F.; LÚCIO, A. D.; LOPES, S. J. Correlations between growth variables and the Dickson quality index in forest seedlings. **Cerne**, Viçosa, v.16, n.4, p. 457-464, 2010

BUSATO, L. C.; JUNIOR, R. C.; VIEIRA, J.; ESPERANÇA, A. A. F.; MARTINS, A. V. Aspectos ecológicos na produção de sementes e mudas para a restauração. In: MARTINS, S. V. **Restauração ecológica de ecossistemas degradados.** Viçosa: Editora UFV; 2015.

CALDEIRA, M. V. W.; DELARMELINA, W. M.; LUBE, S. G.; GOMES, D. R.; GONÇALVES, E. O.; ALVES, A. F. A. Biossólido na composição de substrato para a produção de mudas de *Tectona grandis*. **Floresta**, Curitiba, v.42, n. 1, p. 77-84, 2012.

CARVALHO, P. **Espécies arbóreas brasileiras: recomendações silviculturais de espécies florestais**. Brasília: EMBRAPA Informação Tecnológica; 2003.

DANTAS, A. A. A.; CARVALHO, L. G.; FERREIRA, E. Classificação e tendências climáticas em Lavras, MG. **Ciência e Agrotecnologia**, v.31, n. 6, p. 1862-1866, 2007.

DICKSON, A.; LEAF, A. L.; HOSNER, J. F. Quality appraisal of white spruce and white pine seedling stock in nurseries. **The Forestry Chronicle**, v. 36, n. 1, p. 10-13, 1960.

FARIA, J. C. T.; CALDEIRA, M. V. W.; DELARMELINA, W. M.; ROCHA, R. L. F. Substratos alternativos na produção de mudas de *Mimosa setosa* Benth. **Ciência Florestal**, Santa Maria, v. 26, n. 4, p. 1075-1086, 2016.

FERREIRA, D. F. Sisvar: A guide for its boot strap procedures in multiple comparisons. **Ciência e Agrotecnologia**, Lavras, v. 38, n. 2, p. 109-112, 2014.

FONSECA, É. P.; VALERI, S. V.; MIGLIORANZA, E.; FONSECA, N. A. N.; COUTO, L. Padrão de qualidade de mudas de *Trema micrantha* (l.) blume, produzidas sob diferentes períodos de sombreamento. **Revista Árvore**, Viçosa, v. 26, n. 4, p. 515-523, 2002.

GASPAR, R. O.; CASTRO, R. V. O.; PELOSO, R. V. D.; SOUZA, F. C.; MARTINS, S. V. Análise fitossociológica e do estoque de carbono no estrato arbóreo de um fragmento de Floresta Estacional Semidecidual. **Ciência Florestal**, v. 24, n. 2, p. 313-324, 2014.

KRAMER, P. **Physiology of woody plants**. Elsevier, 2012.

LIMA, M. A. O.; MIELKE, M. S.; LAVINSKY, A. O.; FRANÇA, S.; ALMEIDA, A. A. F.; GOMES, F. P. Crescimento e plasticidade fenotípica de três espécies arbóreas com uso potencial em sistemas agroflorestais. **Scientia Florestalis**, Piracicaba, v. 38, n. 87, p. 527-534, 2010.

MARANA, J. P.; MIGLIORANZA, E.; FONSECA, E. P. Qualidade de mudas de jaracatiá submetidas a diferentes períodos de sombreamento em viveiro. **Revista Árvore**, Viçosa, v. 39, n. 2, p. 275-282, 2015.

NERY, F. C.; PRUDENTE, D. O.; ALVARENGA, A. A.; PAIVA, R.; NERY, M. C. Desenvolvimento de mudas de guanandi (*Calophyllum brasilens* Cambess.) sob diferentes condições de sombreamento. **Revista Brasileira de Biociências**, Porto Alegre, v. 14, n. 3, p. 187-192, 2016.

NUNES, Y. R. F.; PETRERE, J. R. M. Structure and dynamics of a *Cariniana estrellensis* (Lecythidaceae) population in a fragment of Atlantic Forest in Minas Gerais, Brazil. **Rodriguésia**, Rio de Janeiro, v. 63, n. 2, p. 257-267, 2012.

OLIVEIRA, F. D.; ARAÚJO, A. P.; GUERRA, J. G. M. Crescimento e acumulação de nutrientes em plantas de taro sob níveis de sombreamento artificial. **Horticultura Brasileira**, v.29, n. 3, p. 292-298, 2011.

PEREIRA, K. T. O.; OLIVEIRA, F. A.; CAVALCANTE, A. L. G.; DANTAS, R. P.; OLIVEIRA, M. K. T.; COSTA, J. P. B. M. Qualidade de mudas de moringa sob diferentes níveis de nutrientes aplicados via fertirrigação. **Pesquisa Florestal Brasileira**, Colombo, v. 36, n. 88, p. 497-504, 2017.

PORTELA, F.; GAMA, V. N.; ZANETTI, L. V.; MILANEZ, C. R.; SILVA, D. M.; CUZZUOL, G. R. F. How does *Cariniana estrellensis* respond to different irradiance levels? **Journal of Forestry Research**, v. 30, n. 1, p. 31-44, 2019.

REGO, G. M.; POSSAMAI, E. Efeito do sombreamento sobre o teor de clorofila e crescimento inicial do jequitibá-rosa. **Pesquisa Florestal Brasileira**, Colombo, v. 53, n. 1, p. 179-194, 2011.

REIS, G. D.; REIS, M. G. F.; PAULA, R. C.; MAESTRINI, M.; BORGES, E. E. L. Crescimento e ponto de compensação lumínico em mudas de espécies florestais nativas submetidas a diferentes níveis de sombreamento. **Revista Árvore**, Viçosa, v. 18, n. 2, p. 97-106, 1994.

REIS, S. M.; MARIMON-JÚNIOR, B. H.; MORANDI, O. S.; OLIVEIRA-SANTOS, C.; OLIVEIRA, B.; MARIMON, B. S. Desenvolvimento inicial e qualidade de mudas de *Copaifera langsdoffii* Desf. Sob diferentes níveis de sombreamento. **Ciência Florestal**, Santa Maria, v. 26, n. 1, p. 11-20, 2016.

SANTOS, M. S.; FEIJÓ, N. S. A.; SECCO, T. M.; MIELKE, M. S.; GOMES, F. P.; COSTA, L. C. B.; SILVA, D. C. Effects of shading on leaf anatomy of *Gallesia integrifolia* (Spreng) Harms and *Schinnus terebinthifolius* Raddi. **Revista Brasileira de Plantas Medicinais**, Botucatu, v. 16, n. 1, p. 89-96, 2014.

SILVA, L. F.; SILVA, M. L.; CORDEIRO, S. A. Análise econômica de plantios de jequitibá-branco (*Cariniana estrellensis*). **Revista Agrogeoambiental**, v. 4, n. 2, p. 1-10, 2012.

TAIZ, L.; ZEIGER, E.; MOLLER, I. M.; MURPHY, A. **Fisiologia e desenvolvimento vegetal**. Artmed Editora, 2017.