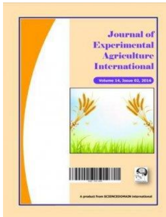

Journal of Experimental Agriculture International

22(5): 1-7, 2018; Article no.JEAI.40396
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Effect of Leaf Sun Protector on Initial Growth of *Khaya senegalensis* under Water Deficiency in Different Microclimatic Conditions

Erilva Machado Costa[1], Talita Miranda Teixeira Xavier[1*], José Eduardo Macedo Pezzopane[1], Siléia Oliveira Guimarães[1], Alcides Pereira Santos Neto[2] and Mariana Duarte Silva Fonseca[1]

[1]Department of Forestry and Wood Science, Federal University of Espírito Santo, Jerônimo Monteiro, ES, Brazil.
[2]Instituto Federal de Educação, Ciência e Tecnologia do Amazonas – IFAM, Maués – AM, Brazil.

Authors' contributions

This work was carried out in collaboration between all authors. Author EMC designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors TMTX and JEMP managed the analyses of the study. Authors SOG, APSN and MDSF helped to conduct the experiment and statistical analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2018/40396
Editor(s):
(1) Suleyman Korkut, Professor, Duzce University, Department of Forest Industrial Engineeering, Division of Wood Mechanic and Technology, Turkey.
Reviewers:
(1) Mustafa Ünlü, Cukurova University, Turkey.
(2) Miguel Aguilar Cortes, Universidad Autónoma del Estado de Morelos, Mexico.
(3) Megahed Amer, Egypt.
(4) Hani Mansour, Egypt.
(5) Mukhtar Ridwanu Bunza, Bayero University, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history/24419

Original Research Article

Received 4th February 2018
Accepted 15th April 2018
Published 2nd May 2018

ABSTRACT

African mahogany (*Khaya senegalensis*) is considered as an alternative for forest implantation due to its fast growth and wood properties. However, in some regions, there have been frequent reports of seedling loss or reduced initial growth as a consequence of water scarcity. An alternative way is the use of leaf sun protector, to modify the energy balance and reduce water deficit impacts. Thus,

**Corresponding author: E-mail: talitamtx@yahoo.com.br;*

the objective of the present study was to assess the effect of applying leaf sun protector on the growth of young *Khaya senegalensis* plants submitted to water deficit soil under two microclimatic conditions: high and low atmospheric demand. The plants were kept under water deficit corresponding to 20% of the available water in the soil and treatments were adopted with and without calcium-based leaf sun protector inside greenhouse acclimatized with controlled temperature and relative humidity. Growth was analyzed based on values of total dry matter, leaf area and specific leaf area, after three months of experimenting. Applying leaf sun protector reduced the impact of water deficit on *Khaya senegalensis* plant growth, especially in the condition of high atmospheric demand, characterized by high vapor pressure deficit and temperature values.

Keywords: African mahogany; vapor pressure deficit; air temperature.

1. INTRODUCTION

Khaya senegalensis is a species of the family Meliaceae, known as African mahogany. This species has silvicultural potential because it is a hardwood resembles the wood of the Brazilian mahogany (*Swietenia macrophylla*) for physical and mechanical properties. It is the most drought tolerant species within the genus *Khaya*, but studies reported severe damage caused by water deficit [1].

Stress caused by water deficiency influences several processes in the plant, such as leaf and root growth, and reduces stomatal conductance, photosynthesis and dry matter [2,3,4,5,6,7]. According to [8] and [9] water restriction for the plant causes a reduction in the net CO_2 assimilation by decreasing stomatal conductance and consequently the transpiration rate. Also, the radiation intercepted by the leaf tends to promote leaf heating that can reach levels harmful to the plant metabolism [10].

African mahogany (*Khaya senegalensis*) is considered as an alternative for forest implantation, because of its fast growth and wood properties. However, in some regions, there have been frequent reports of seedling loss or reduced initial growth, as a consequence of water shortage. An alternative management is the use of leaf sun protector to modify the energy balance and reduce the water deficit impact.

Leaf sun protectors generally consist of calcium, silicate and aluminum, that when sprayed on the adaxial surface of the leaf as a reflective film, reduce the noxious effects of solar radiation, heat and water deficit [11].

Thus, the objective of the present study was to assess the effect of a leaf sun protector on the growth of young African mahogany plants when submitted to water deficiency in two microclimate conditions, characterized by different atmospheric demands.

2. MATERIALS AND METHODS

The study was carried out from October 2013 to to January 2014 in acclimatized greenhouse with controlled temperature and relative humidity, at the Forest Meteorology and Ecophysiology Laboratory at the Federal University of Espírito Santo, located in the municipality of Jerônimo Monteiro - Brazil (latitude 20º47'25″S and longitude 41º23'48″ W, 120 m altitude).

The *Khaya senegalensis* growth was assessed under water deficiency and with leaf sun protector in two different microclimatic conditions. Thus the experiment was monitored following a completely randomized design in a 2 x 2 factorial scheme (two microclimate conditions x two leaf sun protector used conditions, with and without) with six replications.

The microclimatic conditions were established with temperature and relative humidity controlled by automatic sensors, and the data were collected by automatic meteorological stations consisting of temperature and relative humidity probes (Vaisala, model CS500) installed inside the greenhouses. The data were collected by a *data logger* (Campbell Scientific Inc, model CR-10x) with data reading in every 10 seconds and storage in every five minutes. The vapor pressure deficit data (VPD) were obtained from the difference between the water vaporsaturation pressure values and vapor partial pressure (ea), [12].

Two microclimatic schedules were established, one with low and one with high atmospheric demand, in different greenhouses in the same locality. The control was performed automatically and triggered exhausters and water curtains when necessary. Throughout the study period, the microclimate with low atmospheric demand presented 24ºC mean temperature, 0.21 KPa mean VPD and 5.6ºC average daily heat amplitude. The microclimate with high atmospheric demand had 28.9ºC mean temperature, 1.41 KPa mean VPD and 10.6ºC daily mean heat amplitude (Fig. 1).

Seventy days old African mahogany plants were used in the initial phase at expedition stage. The seedlings were transplanted to 12.5L polyethylene pots, filled with about 15kg substrate consisting of Red-Yellow Latossol, coffee hulls and cattle manure.

Water retention points were used to determine the water sheet in the soil, at 0.010 MPa tension for field capacity (FC) and 1.5 MPa for wilt point (WP) [13]. The available water (AW) was calculated from the retention curve data, given by the expression AW=FC-WP proposed by [14].

After 30 days of acclimatization in the greenhouse, the seedlings were submitted to water restriction, through irrigation cutting, until the soil reached 20% total water available, which remained at this level until the end of the experiment. The water replenishment of the treatment without water deficit was controlled by weighing the pots every day using 10 g precision scales.

A leaf sun protector, basically consisting of 22.5% Ca (37.5 gml^{-1}), was applied at 60 ml concentration of the product diluted in two liters water and 5 ml fixer were added to give greater adherence to the leaf. It was applied on the adaxial surface of the leaf, using a container with spray nozzle promoting total leaf coverage, applied whenever new leaves were emitted.

Plant growth was assessed at the end of the experimental period by quantifying the total dry matter, the leaf area (LA) and specific leaf area (SLA), when the plants were 160 days old. The total dry matter was determined by drying the plant material (leaves, stems and roots) in a forced air circulation chamber at 75ºC for 72 hours. The LA was determined with an area integrator (LI-COR, model LI 3100), and the SLA was determined from the total leaf area and leaf dry matter ratio.

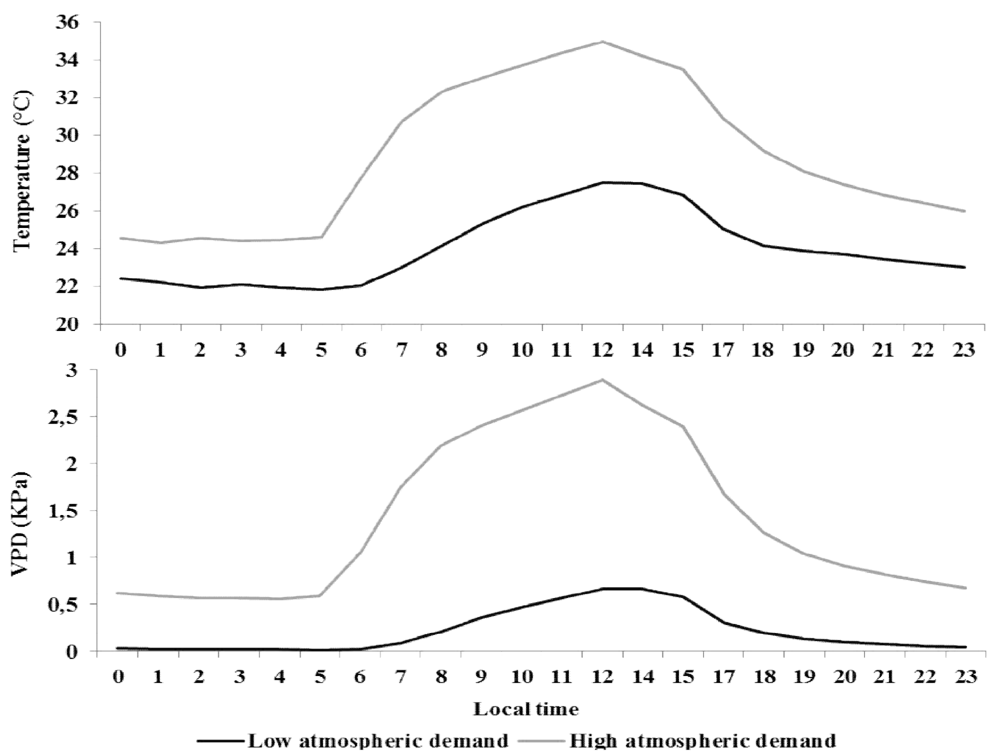

Fig. 1. Hourly means throughout the day of air temperature and vapor pressure deficit (VPD) recorded during the experimental period, October to January, inside acclimatized greenhouses in Jerônimo Monteiro, ES, Brazil

The data obtained between the treatments were submitted to analysis of variance, and when significant were submitted to the Tukey test to compare the means at the level of 5% significance, using the Sisvar 5.3 software [15].

3. RESULTS

The microclimate and leaf sun protector interaction were significant when the plants were assessed within the microclimate, and the highest values were found in the plants with leaf sun protector (Fig. 2A). Thus, the protective film acted to benefit the plants submitted to high atmospheric demand, reducing the harmful effects of high temperature and low humidity. The use of the leaf sun protector on the plants, regardless of the microclimatic condition, decreased the damage caused by water deficit, providing significant increase in the total plant dry matter, resulting in an increase of 36.6% and 53.4% for the low and high atmospheric demand microclimates, respectively (Fig. 2A).

In the plants without leaf sun protector, the total dry matter did not differ statistically between the microclimates, but leaf sun protector application resulted in a significant increase in the high atmospheric demand conditions, showing reducing effects on the damage caused by water deficit under high temperature and vapor pressure deficit conditions (Fig. 2B).

The total LA of the plants with leaf sun protector application, in the two microclimates studied, increased significantly by 12% and 8.7%, for the low atmospheric demand and high atmospheric demand conditions, respectively (Fig. 3A). The highest total LA values were observed under high atmospheric demand, but only the means of the plants without leaf sun protector were significantly bigger (Fig. 3B).

The SLA presented results contrary to those observed in the total LA since the leaf sun protector reduced the SLA in both microclimates (Fig. 3C). It was observed between the microclimates that without leaf sun protector and in high atmospheric demand, the SLA increased whereas with leaf sun protector the plants maintained values that were statistically the same (Fig. 3D).

4. DISCUSSION

Higher total dry matter means for plants treated with leaf sun protector were also observed by [16] in apple trees (*Malus domestica*) and [17] in vines (*Vitis vinífera*), who reported increase in fruit yield and quality when calcium-based leaf sun protector was applied by spraying.

[16] observed in apple trees that the use of calcium-based leaf sun protector was beneficial in transpiration when the plants were exposed to high temperatures, reducing leaf

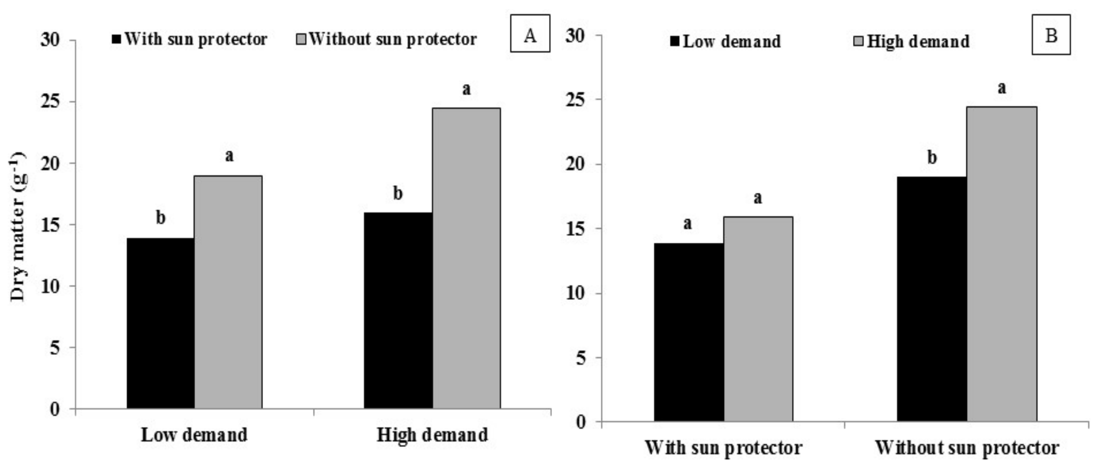

Fig. 2. Mean values of total *Khaya senegalensis* (African mahogany) dry matter submitted to water deficit of 20% of the available water in the soil, with and without leaf sun protector, in two microclimate conditions (low atmospheric demand and high atmospheric demand) in Jerônimo Monteiro, ES, Brazil, between October and January. (A) Effect of sun protector and (B) effect of microclimatic conditions. Means followed by the same letter do not differ statistically by the Tukey test (p>0.05)

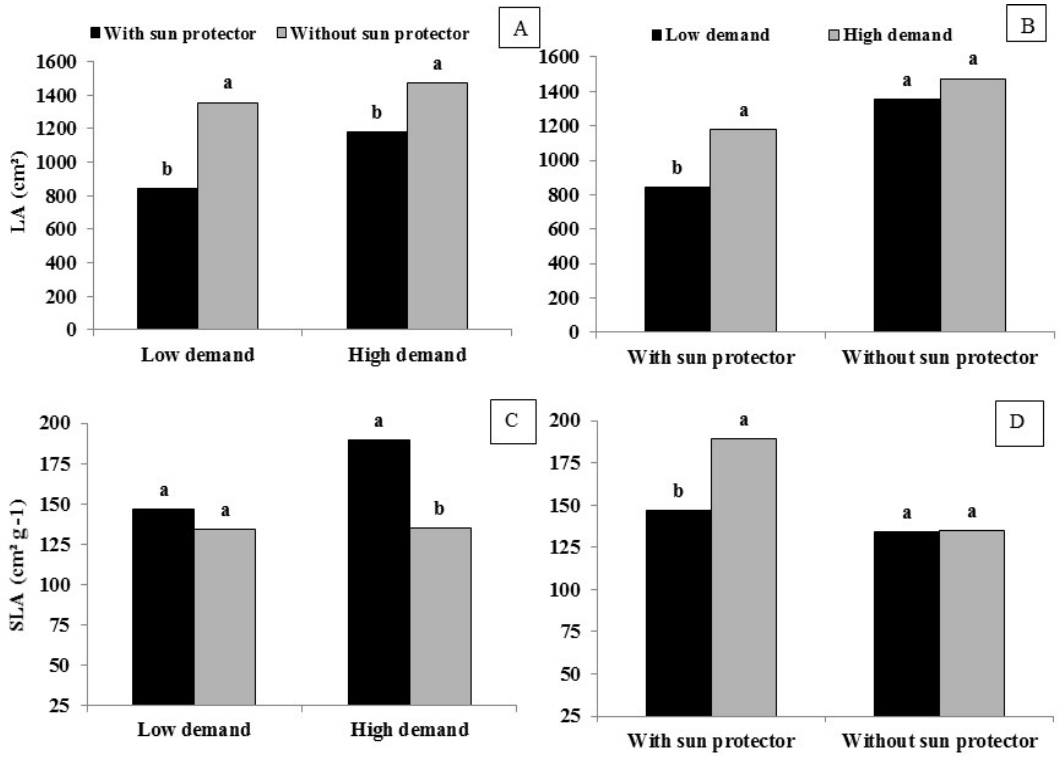

Fig. 3. Mean values of the leaf area (LA) and specific leaf area (SLA) of *Khaya senegalensis* (African mahogany) submitted to water deficit of 20% of the water available in the soil, with and without leaf sun protector, in two microclimate conditions (low atmospheric demand and high atmospheric demand) in Jerônimo Monteiro, ES, Brazil, between October and January. Effect of sun protector (A, C) and effect of microclimatic conditions (B, D). Means followed by the same letter do not differ statistically by the Tukey test (p>0.05)

transpiration and consequently raising water use efficiency. [18] observed that leaf sun protector application acted to decrease leaf temperature of *Rose* ssp. plants by 2.5ºC in the midday period, thus there was higher growth in the plant compared to the plants that were not sprayed.

Regarding leaf elongation, the total mean LA values were greater with the use of leaf sun protector, regardless of the atmospheric demand, but it was observed that the effect was largest under low atmospheric demand, and there was 12% increase in the total LA of the plants with leaf sun protector. The specific LA increased significantly with the leaf sun protector, regardless of the atmospheric condition, suggesting a direct effect on leaf cell lengthening, because the protective film functions as shading on the leaf, reducing the temperature and possibly increasing water use when water availability in the soil and atmosphere are reduced.

In this sense [19] reported that cell lengthening was more sensitive to water deficiency than cell division. This response is derived from a drastic reduction in biomass accumulation in the leaves rather than leaf expansion [20]. [21] reported that plants under water deficit conditions in the soil tended to increase the leaf temperature because of decreased transpiration rates in the plant, and thus its draining condition was affected, modifying its photosynthetic activities and later the plant yield.

Low water availability to the plant may restrict growth, and potentially, increase photoinhibition in microclimate conditions with high air evaporative demand conditions [22,23]. Thus, it is evident that the use of leaf sun protector can be an efficacious tool in regions with marked water deficiency in the soil and high air evaporative demands, because it aims to improve the acclimatization of the plants to these stressful environments [18].

5. CONCLUSIONS

It can be revealed from the above study that

- Using the leaf sun protector reduced the effects of water deficit on African mahogany plant growth, mainly in microclimatic conditions with high atmospheric demand.
- Findings of the study increase understanding of the effect of leaf sun protectors on African mahogany, under the condition of water deficiency as the planting is practised to regions susceptible to water deficit in the soil and high atmospheric demand.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Pinheiro AL, Couto L, Pinheiro DT, Brunetta JMF. Ecologia, silvicultura e tecnologia de utilização dos mognos-africanos (*Khaya* spp.). Viçosa MG: Sociedade Brasileira de Agrossilvicultura. 2011;102.
2. Pinheiro HA, Damatta FM, Chaves ARM, Loureiro ME, Ducatti C. Drought tolerance is associated with rooting depth and stomatal control of water use in clones of *Coffea canephora*. Annals of Botany. 2005; 96:101‑108.
3. Colom MR, Vazzana C. Drought stress effects on three cultivars of *Eragrostis curvula*: Photosynthesis and water relations. Plant Growth Regulation. 2001; 34:195‑202.
4. Liberato MAR, Gonçalves JF de C, Chevreuil LR, Nina Junior A da R, Fernandes AV, Santos Junior UM dos. Leaf water potential, gas exchange and chlorophyll a fluorescence in acariquara seedlings (*Minquartia guianensis* Aubl.) under water stress and recovery. Brazilian Journal of Plant Physiology. 2006;18:315‑323.
5. Martins MDO, Nogueira RJMC, Azevedo Neto ADD, Santos MGD. Crescimento de plantas jovens de nim-indiano (*Azadirachta Indica A. Juss. - Meliaceae*) sob diferentes regimes hídricos. Revista Árvore, Viçosa-Mg. 2010;34(5):771-779.
6. Balducci L, Destauriers A, Giovannelli A, Rossi S, Rathgeber CBK. Effects of temperature and water deficit on cambial activity and woody ring features. Tree Physiology, Oxford. 2013;33:1006–1017.
7. Albuquerque MPF, Moraes FKC, Santos RIN, De Castro GLS, Ramos EMLS, Pinheiro HA. Ecofisiologia de plantas jovens de mogno africano submetidas a déficit hídrico e reidratação. Pesquisa Agropecuária Brasileira. 2013;48(1):9-16.
8. Marenco RA, Lopes NF. Fisiologia vegetal: Fotossíntese, respiração, relações hídricas. Nutrição Mineral, 3 ed., UFV, Viçosa. 2009;486.
9. Chaves MM, Flexas J, Pinheiro C. Photosynthesis under drought and salt stress: regulation mechanisms from whole plant to cell. Annals of Botany. 2009; 103(4):551-560.
10. Taiz L, Zeiger E. Fisiologia Vegetal. 5. ed. Porto Alegre: ARTMED. 2013;918.
11. Ahmed FF, Shaaban MM, Abd El-Aal AMK. Protecting crimson seedless grapevines growing in hot climates from Sunburn. Research Journal of Agriculture and Biological Sciences. 2011;7(1):135-141.
12. Pereira AR, Angelocci LR, Sentelhas PC. Agrometeorologia: Fundamentos e aplicações práticas. Guaíba: ed. Agropecuária. 2002;487.
13. EMBRAPA - Empresa Brasileira de Pesquisa Agropecuária. Centro Nacional de Pesquisas de Solos. Manual de métodos de análise de solos. 2ed. Rio de Janeiro. 1997;212.
14. Centurion JF, Andreoli I. Regime hídrico de alguns solos de Jaboticabal. Revista Brasileira de Ciência do Solo. Viçosa. 2000;24:701.
15. Ferreira DF. Sisvar - Sistema de análise de variância. Versão 5.3. Lavras - MG: UFLA; 2010.
16. Aly M, El-Megeed NA, Awad RM. Reflective particle films effect on sunburn, yield, mineral composition and fruit maturity of ‘Anna ‘apple (*Malus domestic*) trees. Research Journal of Agriculture and Biological Sciences. 2010;6:84-92.
17. Ahmed FF, Abdel Aal AMK, El-Sayed MA, Sayed HR. Protecting red roomy grapevines growing under minia region conditions from sunburn damage. Stem Cell. 2013;4(2):15-20.
18. Sotelo-Cuitiva YM, Restrepo-Díaz H, García-Castro A, Ramírez-Godoy A,

Flórez-Roncancio VJ. Effect of kaolin film particle applications (surround wp®) and water deficit on physiological characteristics in rose cut plants (*Rose* spp l.). American Journal of Plant Sciences. 2011;2(3):354.

19. Hsiao TC. Plant response to water stress. Annual Review of Plant Physiology. 1973; 4:519-70.
20. Paz V, Vera A, Páez A. Distribución de biomasa de *Barleria lupulina* Lindl. Em respuesta a tres regímenes de riego. Revista de la Faculdade de Agronomía (LUZ). 2003;20:273-281.
21. Larcher W. Ecofisiologia vegetal. Tradução: Prado CHBA. e Franco. A.C. São Carlos, Rima. 2006;533.
22. Valladares F, Pearcy RW. Interactions between water stress, sun-shade acclimation, heat tolerance and photoinhibition in the sclerophyll *Heteromeles arbutifolia*. Plant, Cell and Environment. 1997;20:25-36.
23. Jaleel CA, Manivannan PARAMASIVAM, Wahid A, Farooq M, Al-Juburi HJ, Somasundaram RAMAMURTHY, Panneerselvam R. Drought stress in plants: A review on morphological characteristics and pigments composition. International Journal Agriculture and Biology. 2009;11(1):100-105.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/24419