

EFFECT OF LEAF SUN PROTECTOR ON INITIAL GROWTH *KHAYA SENEGALENSIS* UNDER WATER DEFICIT IN DIFFERENT MICROCLIMATIC CONDITIONS

Abstract

African mahogany (*Khaya senegalensis*) has been presented 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. A management alternative is the use of leaf sun protector, to modify the energy balance and reduce water deficit impacts. Thus, 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 in the 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 greenhouses 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

INTRODUCTION

Khaya senegalensis Desris 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 have reported severe damage caused by water deficit (PINHEIRO et al., 2011).

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 (PINHEIRO et al., 2005; COLOM E VAZZANA, 2001; LIBERATO et al., 2006; MARTINS et al., 2010; BALDUCCI et al., 2013; ALBUQUERQUE et al., 2013). According to Marengo and Lopes (2009), water restriction for the plant causes reduction in the net CO₂ assimilation by decreasing stomatal conductance and consequently the transpiration rate. In addition, the radiation intercepted by the leaf tends to promote leaf heating that can reach levels harmful to the plant metabolism (TAIZ; ZEIGER, 2013).

African mahogany (*Khaya senegalensis*) has been presented as 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. A management alternative 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 (AHMED; SHAABAN; AHMED, 2011).

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 deficit in two microclimate conditions, characterized by different atmospheric demands.

MATERIAL AND METHODS

The study was carried out from October to January in acclimatized greenhouse with control of temperature and relative humidity of the air, at the Forest Meteorology and Ecophysiology Laboratory at the

Federal University of Espírito Santo, located in the municipality of Jerônimo Monteiro - Brazil (latitude 20°47'25" S and longitude 41°23'48" W, 120m altitude).

The *Khaya senegalensis* growth was assessed under water deficit 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 use conditions, with and without) with six replications.

The microclimatic conditions were established with temperature and relative humidity controlled by automatic sensors, and the datas 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 *datalogger* (Campbell Scientific Inc, model CR-10x) with data reading every 10 seconds and storage 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), according to Pereira; Angelocci; Sentelhas, (2002).

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 24 °C mean temperature, 0.21 KPa mean VPD and 5.6° C average daily heat amplitude. The microclimate with high atmospheric demand had 28.9°Cmean temperature, 1.41 KPa mean VPD and 10.6°C daily mean heat amplitude (Figure 1).

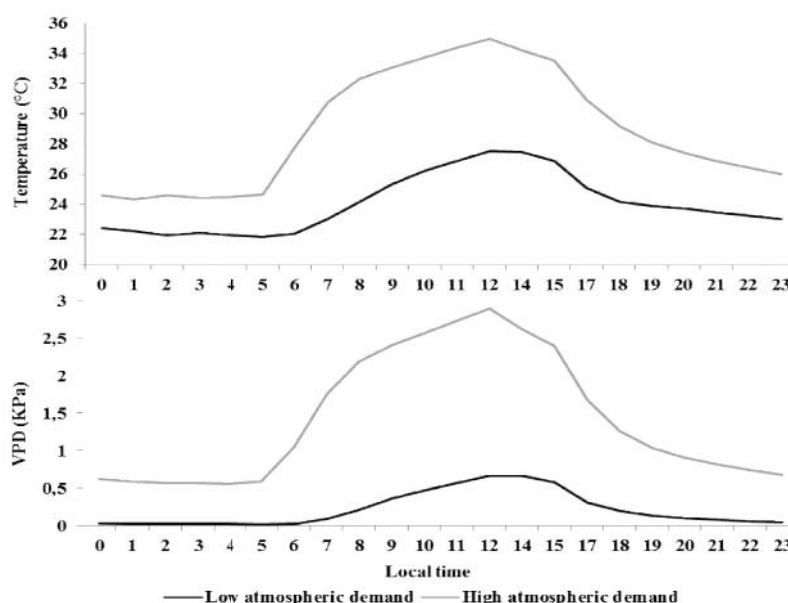


Figure 1. Hourly means throughout the day of air temperature and vapor pressure deficit (VPD) recorded during the experimental period October to January, inside acclimatized greenhouses in Jerônimo Monteiro, ES, Brazil.

Plants of African mahogany were used in the initial phase at expedition stage with 70 days. The seedlings were transplanted to 12.5 L polyethylene pots, filled with about 15 kg substrate consisting of Red-Yellow Latossol, coffee hulls and cattle manure.

Water retention points were used to determine the water sheet in the soil, according to EMBRAPA (1997) at 0.010 MPa tension for field capacity (FC) and 1.5 MPa for wilt point (WP). The available water (AW) was calculated from the retention curve data, given by the expression $AW = FC - WP$ proposed by Centurion; Andreoli, (2000).

After 30 days of acclimatization in greenhouse, the seedlings were submitted to water restriction, by means of 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 was used consisting basically of 22.5% Ca (37.5 g ml⁻¹), 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 75°C 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.

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 (FERREIRA, 2010).

RESULTS

The microclimate and leaf sun protector interaction was significant when the plants were assessed within the microclimate, and the highest values were found in the plants with leaf sun protector. 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, reduced the damage caused by water deficit, providing significant increases 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 (Figure 2A).

In the plants without leaf sun protector application, 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 (Figure 2B).

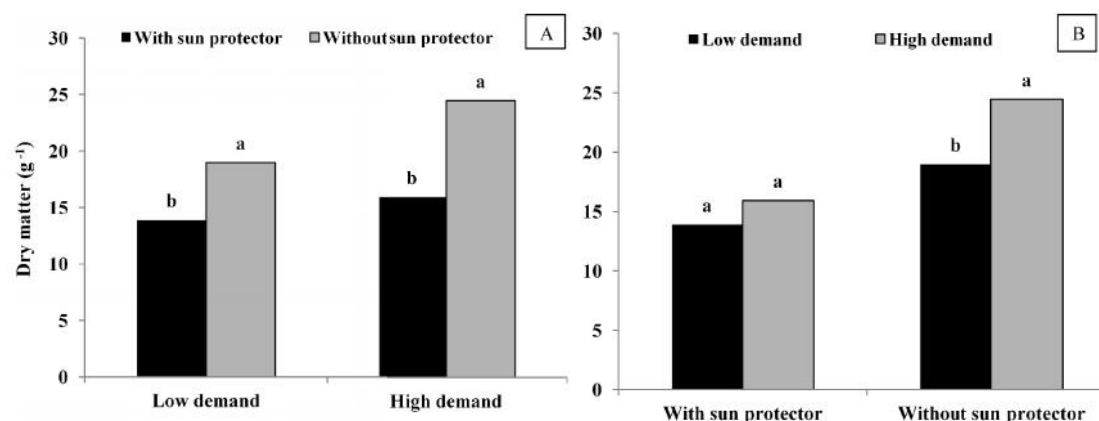


Figure 2. Mean values of total *Khaya senegalensis* (African mahogany) dry matter submitted to water deficit of 20% of the available water in the soil, with and without leaf sun protector application, into two microclimate conditions (low atmospheric demand and high atmospheric demand) in Jerônimo Monteiro,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

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 (Figure 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 (Figure 3B).

The SLA presented results contrary to those observed in the total LA since the leaf sun protector reduced the SLA in both microclimates (Figure 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 (Figure 3D).

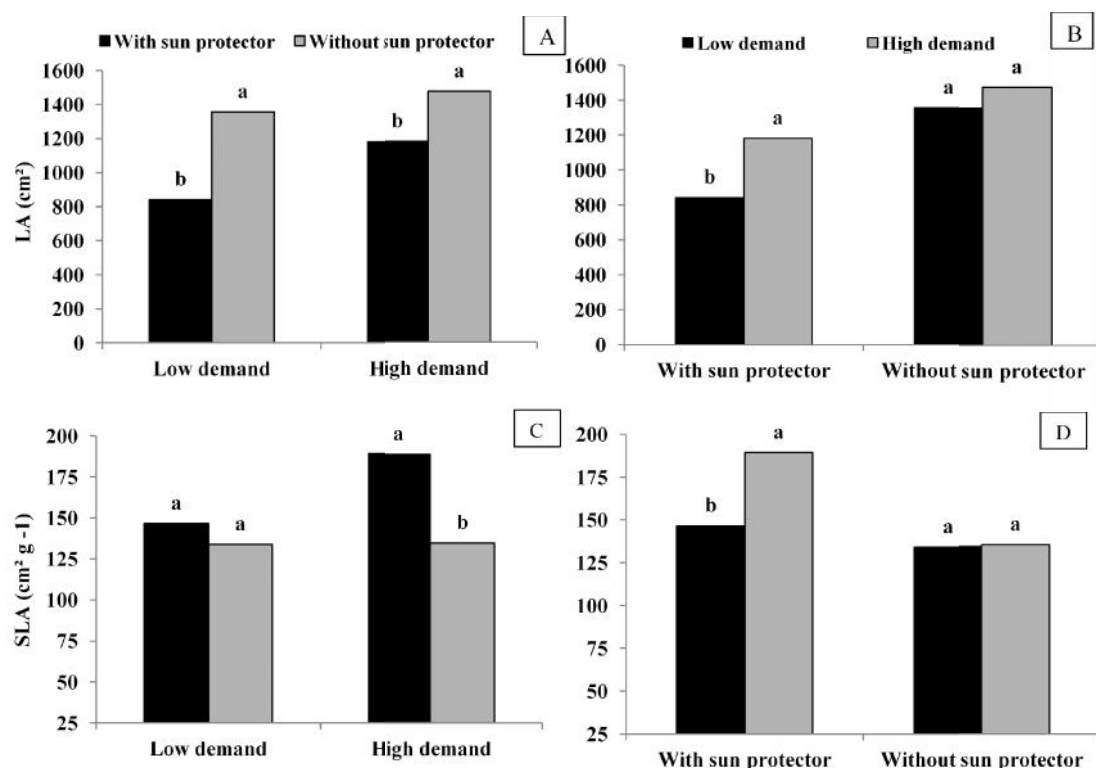


Figure 3. Mean values of the leaf area (LA) and specific leaf area (SLA) of *Khaya senegalensis* (African mahogany) submitted to water deficit of 20% of the water available in the soil, with and without leaf sun protector application, into two microclimate conditions (low atmospheric demand and high atmospheric demand) in Jerônimo Monteiro, ES, Brazil, between October and January. Effect of application 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 ($p > 0.05$)

DISCUSSION

Higher total dry matter means for plants treated with leaf sun protector were also observed by Aly et al. (2010) in apple trees (*Malus domestica*) and Ahmed et al. (2013) in vines (*Vitis vinifera*), who reported increase in fruit yield and quality when calcium-based leaf sun protector was applied by spraying.

Aly et al. (2010) observed in apple trees (*Malus domestica*) that the use of calcium-based leaf sun protector has been beneficial in transpiration when the plants were exposed to high temperatures, reducing leaf transpiration and consequently raising water use efficiency. Sotelo-Cuitiva et al. (2011) observed that leaf sun protector application acted to decrease leaf temperature of *Rose* ssp. plants by 2.5°C in the midday period, thus there was bigger growth in the plant compared to the plants that were not sprayed.

Regarding leaf elongation, the total LA means were bigger with the use of the 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, Hsiao (1973) reported that cell lengthening was more sensitive to water deficiency than cell division. This response is derived from drastic reduction in biomass accumulation in the leaves rather than leaf expansion (PAZ et al., 2003). Larcher (2006) reported that plants under water deficit conditions in the soil tended to increase the leaf temperature because transpiration rates decreased 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 (VALLADARES; PEARCY, 1997; JALEEL et al., 2009). 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 (SOTELO-CULTIVA et al., 2011).

CONCLUSIONS

Using the leaf sun protector reduced the effects of water deficit on African mahogany plant growth, mainly in microclimatic conditions with high atmospheric demand.

This study presents useful results that increase understanding of the effect of leaf sun protectors on African mahogany, under the condition of water deficiency as the planting is advanced to regions susceptible to water deficit in the soil and high atmospheric demand.

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