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# AFRICAN MAHOGANY SUBMITTED TO DRIP IRRIGATION AND FERTILIZATION<sup>1</sup>

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**ABSTRACT** – African mahogany (*Khaya ivorensis* A. Chev.) is a tree species that has been increasing in Brazilian commercial planting. However, the lack of water and nutrition are great obstacles for crop production. The aim of this study was to evaluate the growth of young mahogany plants submitted to drip irrigation and topdressing. The experimental design was of randomized blocks, with three repetitions in subdivided plots. Treatments consisted of drippers: 1, 2 and 3pl<sup>t</sup>l<sup>-1</sup>; flows: 2, 4 and 8L h<sup>-1</sup>, and a treatment without irrigation. For topdressing, subplots levels were, as follows: 1) 17.5 and 25.2; 2) 35.1 and 50.1; 3) 52.5 and 75.0; 4) 70.0 and 100.2; and 5) 87.5 and 125.1 g plant<sup>-1</sup> N and K<sub>2</sub>O, respectively, divided into five bimonthly applications, which started in the 4<sup>th</sup> month after planting. Plant height, diameter at root collar and at breast height (DBH), and stem height were evaluated. Results showed statistically significant differences (P>0.05) between irrigated and non-irrigated plants. Mean plant height ranged (from 2 to 20 months in field) from 0.33 to 3.25 and 2.67m for irrigated and non-irrigated plants, respectively. Mean stem height ranged from 0.23m to 0.87 and 0.71m for irrigated and non-irrigated plants, respectively. Thus, irrigation with 1 dripper per tree and flow of 2L h<sup>-1</sup> was able to supply mahogany water requirements in the first two years in field. Trees have not responded to N and K topdressing at the beginning of the cycle.

**Keywords:** Water stress; Hardwoods; Nitrogen.

## MOGNO AFRICANO SUBMETIDO À IRRIGAÇÃO POR GOTEJAMENTO E ADUBAÇÃO

**RESUMO** – O mogno africano (*Khaya ivorensis* A. Chev.) é uma das espécies arbóreas que vem se destacando no Brasil em plantios comerciais. Os déficits hídrico e nutricional são grandes entraves para a produção vegetal. O objetivo deste estudo foi avaliar o crescimento de plantas jovens de mogno submetidas à irrigação por gotejamento e adubação de cobertura. O delineamento experimental foi blocos casualizados - DBC, com três repetições em parcelas subdivididas. Os tratamentos foram: gotejadores: 1, 2 e 3pl<sup>t</sup>l<sup>-1</sup>; vazões: 2, 4 e 8Lh<sup>-1</sup>; e sem irrigação; e as subparcelas, adubação de cobertura: 1) 17,5 e 25,2; 2) 35,1 e 50,1; 3) 52,5 e 75,0; 4) 70,0 e 100,2; 5) 87,5 e 125,1g planta<sup>-1</sup> de N e K<sub>2</sub>O, respectivamente, parceladas em cinco aplicações bimestrais iniciadas no 4º mês após o plantio. Avaliaram-se: altura de planta, diâmetro de caule no colo e na altura do peito (DAP), e altura de fuste. Os resultados mostraram que houve diferença estatística significativa (P>0,05) entre as plantas irrigadas e não irrigadas. A altura média das plantas variaram (dos 2 aos 20 meses de idade) de 0,33m a 3,25 e 2,67m irrigadas e não irrigadas, respectivamente. Variaram de 0,23

*m a 0,87 e 0,71 m em altura de fuste, com e sem irrigação. Assim, a irrigação com um gotejador por planta, de vazão 2L h<sup>-1</sup> foi suficiente para atender as demandas de água do mogno nos primeiros dois anos de cultivo. As plantas não responderam a adubação de N e K.*

*Palavras-chave: Déficit hídrico; Madeira nobre; Nitrogênio.*

## 1. INTRODUCTION

The use of forest products currently faces the problem of raw material decrease in the sector, both due to ecological pressures, aimed at reducing exploitation of native forests, as well as due to the scarcity of forest products, which are increasingly distant from consumer areas. Among the affected sectors, sawmills and laminations are highlighted, which, in Brazil, survive from native forest extraction regarding “hardwood”.

In order for planted forests to serve the consumer market, there is the need to choose the appropriate species and silvicultural techniques to be employed. In addition, forests must produce timber in quality and quantity compatible with market expectations. Among hardwood exotic species introduced in Brazil, the African mahogany (*Khaya ivorensis* A. Chev.) stands out. The species aforementioned had its origin in countries from the west coast of the African continent, which has similar edaphoclimatic characteristics to some Brazilian regions, explaining the rapid adaptation of the species in Brazil. For Brito et al. (2013), a large part of the territory of Goiás State has edaphoclimatic aptitude for African mahogany cultivation, which may represent the addition of one more crop with good economic profitability for the State and perhaps for other places with similar characteristics.

Among factors limiting plant production, water deficit is highlighted, which occurs in large cultivable areas, affecting plant-water relations and plant metabolism (Nogueira et al., 2000). Additional water supply through irrigation allows species cultivation outside their natural environments, ensuring good growth and plant development, which is observed in their yield. Studies have demonstrated the positive effect of irrigation on arboreal species growth and yield for guava (Silva, 2012), citrus (Alves Júnior et al., 2011), and eucalyptus (Lopes et al., 2007). On the other hand, some plants do not respond to irrigation or fertilization, as is the case of pequi (Alves Junior et al., 2013). In addition, tree species have nutrient demand variation depending

on the species, development stage and climatic conditions (Fernandes et al., 2000).

Due to the limited water resources in many regions, localized drip irrigation is a great alternative, because it has high water application efficiency.

Many studies have argued that water and nutritional availability are the most limiting factors for plant development in the *Cerrado* biome. Thus, the objective of this study was to evaluate the growth of African mahogany plants submitted to irrigation and fertilization, considering the potential for exploitation of African mahogany and the lack of information on this forest species in Brazil.

## 2. MATERIAL AND METHODS

The experiment was conducted in an experimental area in Bonfinópolis, GO (16°35'49" S; 49°16'39" W, elevation of 780 m), with annual mean temperature of 23 °C, relative humidity of 71% and accumulated rainfall of 1487 mm. The study location has well-defined dry (May-September) and rainy (October-April) seasons. According to Köppen, climate was defined as Aw, tropical savannah, megathermal. Mean annual evaporation (Class A pan) is 1915 mm. The strongest winds are recorded in September (Silva et al., 2007). In the region, a dystroferic Red Latosol (Oxisol), clay texture, *Cerradão* subperennial stage and flat relief predominates (Silva et al., 2007). Soil analysis was performed before preparation of the area for two depths, 0-20 and 20-40 cm, and the following chemical characteristics were found: pH (CaCl<sub>2</sub>) = 5.1 and 5.0; OM = 2.1 and 1.2 %; P (Mehlich) = 4.2 and 1.4 mg dm<sup>-3</sup>; Al = 0.0 and 0.0 mmol<sub>c</sub> dm<sup>-3</sup>; H+Al = 2.8 and 2.8 mmol<sub>c</sub> dm<sup>-3</sup>; K = 45.0 and 26.0 mg dm<sup>-3</sup>; Ca = 0.9 and 0.5 mmol<sub>c</sub> dm<sup>-3</sup>; Mg = 0.3 and 0.2 mmol<sub>c</sub> dm<sup>-3</sup>; CEC = 4.1 and 3.6 mmol<sub>c</sub> dm<sup>-3</sup>; V(%) = 32.0 and 21.5%. Moreover, the following physical characteristics were found: Sand = 38.0 and 47.0%; Silt = 24.0 and 23.0% and Clay = 38.0 and 30.0% (clay loam texture) with water retention estimated at 1.5 mm cm<sup>-1</sup>.

The experiment was carried out in the field (March/2012), containing 450 African mahogany plants (*Khaya ivorensis* A. Chev.) with approximately 30 days old (mean diameter: 0.8 cm; mean height: 32 cm; stem height 7.5 cm) and 5 x 5 m spacing. Area preparation was carried out in August 2011 (3 months before planting) with disk plowing and two harrows, in which dolomitic limestone was added, increasing the base saturation to 70%. The irrigation system was installed in April 2012. At planting, holes were fertilized with 100 g P<sub>2</sub>O<sub>5</sub> (single superphosphate). Immediately after planting, 5 L of water was placed per plant, including the non-irrigated treatment, in order to guarantee survival. Rainfall equal to 2216.2 mm was recorded during the experiment period (March/2012 to November/2013).

A Randomized Complete Block (RCB) experimental design was used, with three repetitions in subdivided plots and 50 treatments. Ten irrigation plots (Table 1) were subdivided into 5 topdressing doses (Table 1). Each experimental plot consisted of 15 plants, with 3 plants for each subplot, totaling 150 plants per block and 450 plants in the experiment. In addition to border

plants, the experimental area had 600 plants (totaling an area of 1.5 ha). Irrigation started in May 2012 (dry period) using the drip system, with 1, 2 and 3 drippers per plant and 2, 4 and 8 L h<sup>-1</sup> (self-compensating) flows, plus the control, without irrigation. Netafim brand drippers, PCJ-CNL model, were used. Plot 6, containing two drippers per plant and a flow rate of 4 L h<sup>-1</sup>, was used to apply the standard water volume, i.e., the volume calculated to restore 100% of plant water requirements. In addition, four plots (2 to 5) were irrigated below the standard volume, and four plots (7 to 10 plots) were irrigated above the standard. Fertilization began in July 2012, with the conduction of the first topdressing. The fertilization dose used in the control was recommended by silviculturists of the region (subplot 3), 52.5 g N and 75 g (K<sub>2</sub>O) per plant, annually. From the standard dose, smaller and larger doses were applied to the subplots (Table 1). In addition, the total dose value was divided equally and distributed bimonthly, manually and circularly in the subplots, at 0.30 m from the plant. Plants that received fertilization treatments were marked with colored ribbons, where each color corresponded to a fertilization dose.

**Table 1** – Plot descriptions: number of drippers per tree, individual dripper flow (L h<sup>-1</sup>), wet area per tree (A, m<sup>2</sup>), water volume applied at 20 months in field (Vol, m<sup>3</sup> plant<sup>-1</sup>); and experimental subplots description: ammonium sulfate (NH<sub>4</sub>SO<sub>4</sub>) and potassium chloride (KCl) leaves used in the five fertilization subplots, bimonthly and annually, for African mahogany trees in Bonfinópolis, GO, Brazil.

**Tabela 1** – Descrição das parcelas experimentais: número de gotejadores por planta, Vazão individual do gotejador (L h<sup>-1</sup>), Área molhada por planta (A, m<sup>2</sup>), Volume de água aplicado no período de 20 meses de avaliação, por planta (Vol, m<sup>3</sup> planta<sup>-1</sup>); e descrição das subparcelas experimentais: Dosagens de sulfato de amônio (NH<sub>4</sub>SO<sub>4</sub>) e cloreto de potássio (KCl) utilizadas nas cinco subparcelas de adubação, bimestral e anual, por planta de Mogno Africano, em Bonfinópolis-GO.

Plot	No. of drippers	Per plant	Flow rate (L h <sup>-1</sup> )	Wet area(m <sup>2</sup> )	Vol(m <sup>3</sup> plant <sup>-1</sup> )
1	0		-	0.44	13.44
2	1		2	0.29	8.96
3	2		2	0.15	4.48
4	3		2	0.27	6.72
5	1		4	0.18	4.48
6	2		4	0.09	2.24
7	3		4	0.22	3.36
8	1		8	0.10	2.24
9	2		8	0.05	1.12
10	3		8	-	-
Subplot	Bimestral		Annual		
	N	K <sub>2</sub> O	N	K <sub>2</sub> O	
	.....g plant <sup>-1</sup> .....				
1	3.5	5.0	17.5	25.2	
2	7.0	10.0	35.1	50.1	
3	10.5	15.0	52.5	75.0	
4	14.0	20.0	70.0	100.2	
5	17.5	25.0	87.5	125.1	

For the first year, irrigation was performed during the period from May to October 2012, and in the second year, irrigation was carried out from June to September 2013. In irrigated treatments, irrigations were performed daily, and the applied water amount was estimated from crop evapotranspiration (ETc), which is the product of reference evapotranspiration (ETo) and crop coefficient (Kc). ETo was estimated by Penman-Monteith equation and the adopted Kc was 0.5 for the first year and 0.7 for the second. Kc data was obtained from fruit plant studies due to lack of information on African mahogany.

The meteorological variables of the experimental area (minimum and maximum air temperatures, solar radiation, relative air humidity, wind speed and rainfall) were collected with the aid of an automated weather station (Davis Vantage PRO2).

Gross irrigation volume was calculated in relation to the wet area in each treatment. The wet area (WA) was determined from the diameter wetted by the bulb, estimated by the model proposed by Schwartzman; Zur (1986). Irrigation application efficiency was 90%.

The volume of water applied per plant (*Vol*, m<sup>3</sup>) and the irrigation time (*IT*, h) were obtained by equations [1] and [2], respectively:

$$Vol = ETo \cdot Kc \cdot Kloc \cdot AP$$

$$IT = \frac{(q/ef)}{Vol}$$

Where:

Kc is the crop coefficient (0.5 for the first year and 0.7 for the second),  $K_{loc}$  is the evapotranspiration reduction coefficient for localized irrigation, AP is the useful area of each plant (m<sup>2</sup>), q is the dripper flow rate (L h<sup>-1</sup>), and ef is the water application efficiency (90%). For  $K_{loc}$  calculation with wet area percentage of less than 20% (Feres, 1981, apud Mantovani et al., 2009), equation 3 was used:

$$K_{loc} = 1.94PM + 0.1$$

Where PM is the wet area percentage, in absolute value.

The wet diameter (D, m) was obtained from the model proposed by Schwartzman & Zur (1986):

$$D = 1.82 \cdot Vol^{0.22} \left( \frac{Ks}{q} \right)^{-0.17}$$

Where Ks is the saturated soil hydraulic conductivity (m s<sup>-1</sup>) and q is the dripper flow rate, given in m<sup>3</sup> s<sup>-1</sup>.

Plant growth assessments were conducted every two months (May, July, September and November 2012, and January, March, May 2013) by measuring the following phenometric variables: plant height - measured from the upper end of the orthotropic branch to ground level, using a millimeter precision ruler; stem height - measured from ground level to the first leaf insertion; and trunk diameter - carried out five centimeters from the ground, with the aid of a pachymeter.

For data statistical analysis, the SISVAR software - Variance Analysis System, was used. For irrigation treatments, analysis was qualitative between treatments and in time, and mean comparison was conducted by Tukey's test at 5% error probability. For fertilization treatments, data quantitative analysis was made through regression analysis.

### 3. RESULTS

Plant growth in both height and diameter was influenced by irrigation, showing statistical differences (Table 2) between irrigated and non-irrigated treatments ( $p > 0.05$ ). Height growth rate was 25% higher in irrigated treatments compared to the non-irrigated treatment. Mean plant height at the beginning of the study was of 0.33 m (2 months of age). In the last evaluation, plants reached 3.25 m and 2.67 m (20 months of age) when irrigated and not irrigated, respectively. Stem height growth rate was 33% higher, starting with a mean of 0.23 m, at 2 months of age, and reaching 0.87 m and 0.71 m at 20 months of age, when irrigated and not irrigated, respectively. Diameter at root collar growth rate was 19% higher, starting with a mean of 0.79 cm (2 months of age), reaching 5.9 cm and 5.1 cm at 16 months of age in irrigated and non-irrigated plants, respectively. The diameter at breast height (DBH) growth rate was 24% higher, reaching 20 months 4.6 cm and 3.7 cm a 20 months of age for irrigated and non-irrigated plants, respectively.

Plant heights in irrigated treatments differed from the non-irrigated treatment from July 2013 (Table 2), the 4<sup>th</sup> month after planting (full drought season).

It is noteworthy that, even with the beginning of rainfall in October, non-irrigated plants failed to obtain enough growth rates to match irrigated plant means (Table 2). For stem height, this effect was only observed from the beginning of the drought period

**Table 2** – Mean total height, stem height, stem diameter and DBH data evaluations subjected to irrigated and non-irrigated treatments in Bonfinópolis, GO, Brazil.**Tabela 2** – Médias dos dados das avaliações de: altura total, altura de fuste, diâmetro de caule e DAP em metros, submetidas aos tratamentos de irrigação e sem irrigação, Bonfinópolis-Go.

	Plant Height										Stem Height				
	2012					2013					2012				2013
	May	Jul	Sep	Nov	Jan	Mar	May	Jul	Sep	Nov	May	Jul	Sep	Nov	Jan
	60	120	180	240	380	440	500	560	620	680	60	120	180	240	380
8L/h	0.32	0.38	0.49	0.64	0.81	1.49	2.14	2.33	2.82	3.28	0.22	0.28	0.30	0.29	0.32
3got/pl	aF	aF	aEF	aEF	aE	aD	aC	abC	aB	aA	aE	aE	aE	aE	aE
8L/h	0.29	0.35	0.46	0.58	0.79	1.39	2.06	2.27	2.74	3.17	0.21	0.26	0.29	0.28	0.29
2got/pl	aF	aF	aEF	aEF	aE	aD	aC	abC	aB	aA	aE	aE	aE	aE	aE
8L/h	0.33	0.38	0.47	0.63	0.82	1.52	2.13	2.38	2.78	3.25	0.24	0.26	0.29	0.27	0.28
1got/pl	aF	aF	aEF	aEF	aE	aD	aC	abC	aB	aA	aE	aE	aE	aE	aE
4L/h	0.33	0.38	0.50	0.66	0.85	1.50	2.04	2.23	2.61	3.15	0.22	0.25	0.29	0.28	0.32
3got/pl	aF	aF	aEF	aEF	aE	aD	aC	abBC	abB	aA	aD	aD	aD	aD	aD
4L/h	0.32	0.37	0.47	0.61	0.79	1.44	2.09	2.27	2.77	3.27	0.22	0.26	0.27	0.27	0.30
2got/pl	aF	aF	aEF	aEF	aE	aD	aC	abC	aB	aA	aE	aE	aE	aE	aE
4L/h	0.31	0.35	0.47	0.60	0.79	1.43	2.01	2.27	2.74	3.26	0.22	0.24	0.27	0.27	0.28
1got/pl	aF	aF	aEF	aEF	aE	aD	aC	abC	abC	aA	aE	aE	aE	aE	aE
2L/h	0.33	0.38	0.49	0.65	0.80	1.42	1.93	2.25	2.71	3.15	0.22	0.24	0.28	0.28	0.30
3got/pl	aF	aF	aEE	aEF	aE	aD	aC	abC	abB	aA	aE	aE	aE	aE	aE
2L/h	0.35	0.41	0.50	0.62	0.80	1.50	2.18	2.47	2.95	3.43	0.24	0.27	0.30	0.30	0.31
2got/pl	aF	aF	aEF	aEF	aE	aD	aD	aC	aB	aA	aE	aE	aE	aE	aE
2L/h	0.36	0.40	0.51	0.66	0.80	1.50	2.10	2.38	2.83	3.34	0.26	0.28	0.31	0.33	0.33
1got/pl	aF	aF	aEF	aEF	aE	aD	aC	aC	aB	aA	aD	aD	aD	aD	aD
Sem	0.33	0.38	0.39	0.43	0.64	1.19	1.82	1.93	2.31	2.67	0.28	0.26	0.26	0.27	0.29
Irrig.	aF	aF	aF	aE	aE	aD	aC	bBC	bAB	bA	aE	aE	aE	aE	aE

	Diameter at root collar					Diameter at breast height					Stem height				
	2012					2013					2013				
	May	Jul	Sep	Nov	Jan	Mar	May	Jul	Sep	Nov	Mar	May	Jul	Sep	Nov
	60	120	180	240	380	440	500	560	620	680	440	500	560	620	680
8L/h	0.0078	0.01	0.015	0.019	0.026	0.045	0.058	0.037	0.043	0.048	0.51	0.64	0.68	0.76	0.87
3got/pl	aA	aB	aC	aD	aDE	aEF	aF	aB	aAB	aA	aD	aC	aBC	aB	aA
8L/h	0.0076	0.009	0.014	0.017	0.025	0.042	0.058	0.034	0.039	0.044	0.49	0.59	0.62	0.70	0.87
2got/pl	aA	aB	aC	aD	aDE	aEF	aF	abB	abAB	abA	abD	aCD	abBC	abB	aA
8L/h	0.0078	0.01	0.015	0.019	0.027	0.044	0.058	0.037	0.041	0.046	0.51	0.61	0.63	0.72	0.86
1got/pl	aA	aB	aC	aCD	aDE	aDE	aE	aB	abAB	abA	abA	aCD	abBC	abB	aA
4L/h	0.008	0.01	0.015	0.019	0.027	0.044	0.059	0.035	0.040	0.044	0.54	0.62	0.64	0.72	0.86
3got/pl	aA	aB	aC	aD	aDE	aDE	aDE	abB	abAB	abA	aC	aBC	abBC	abB	aA
4L/h	0.0076	0.009	0.015	0.018	0.025	0.044	0.057	0.035	0.039	0.045	0.51	0.59	0.63	0.74	0.87
2got/pl	aA	aB	aC	aD	aD	aE	aE	abB	abAB	abA	aD	aCD	abC	aB	aA
4L/h	0.0072	0.009	0.015	0.018	0.025	0.044	0.059	0.036	0.041	0.046	0.48	0.58	0.63	0.74	0.87
1got/pl	aA	aB	aC	aD	aD	aE	aE	abB	abAB	abA	abD	aCD	abC	aB	aA
2L/h	0.0076	0.01	0.016	0.019	0.026	0.043	0.057	0.034	0.040	0.045	0.52	0.59	0.69	0.77	0.87
3got/pl	aA	aB	aC	aC	aD	aE	aE	abB	abB	abA	aD	aCD	aBC	aAB	aA
2L/h	0.0083	0.011	0.016	0.019	0.027	0.046	0.061	0.038	0.042	0.048	0.50	0.59	0.67	0.77	0.86
2got/pl	aA	aB	aC	aD	aD	aE	aE	aB	aB	aA	aD	aCD	aBC	aAB	aA
2L/h	0.0085	0.01	0.016	0.019	0.027	0.046	0.060	0.036	0.040	0.046	0.54	0.62	0.66	0.77	0.87
1got/pl	aA	aB	aC	aD	aE	aF	aG	abB	abAB	abA	aC	aBC	aBC	aA	aA
Sem	0.0086	0.01	0.01	0.014	0.019	0.036	0.051	0.026	0.031	0.037	0.40	0.45	0.54	0.64	0.71
Irrig.	aA	aB	bC	bD	bDE	bDE	bE	bB	bAB	bA	bD	bCD	bBC	bAB	bA

\* Means followed by the same lowercase letter in the column and uppercase letter in the row do not differ statistically by Tukey's test at 5% error probability level.

of the following year (March 2013), in plants with one year of planting.

Topdressing effect (Table 3) was verified on biometric variable growth rates by multiple regression, and no statistical significance was observed.

#### 4. DISCUSSION

Young Brazilian mahogany (*Swietenia macrophylla*) plants tolerate periods of 15 to 30 days of water deficiency (Cordeiro et al., 2009). This species also belongs to the Meliaceae family, as well as the

**Table 3** – Regression analysis summary with the mean square for plant height, stem height and Diameter at breast height (DBH) of African mahogany in response to topdressing (N and K).

**Tabela 3** – Resumo da análise de regressão com o quadrado médio, para altura de planta, altura de fuste e diâmetro à altura do peito de mogno africano, em resposta a adubação de cobertura (N e K).

Source of Variation	Degrees of freedom	Plant height	Stem height	DBH
		Mean Square	Mean Square	Mean Square
Linear regression	1	86.83 <sup>ns</sup>	10.87 <sup>ns</sup>	0.005 <sup>ns</sup>
Quadratic regression	1	86.80 <sup>ns</sup>	7.34 <sup>ns</sup>	0.0006 <sup>ns</sup>

African Mahogany, although the first one is native to the Amazon biome.

*Eucalyptus grandis* and *Pinus elliotti* plants cultivated in the *Triângulo Mineiro Cerrado* had a higher growth when submitted to irrigation, corroborating with the results found in this study (Fernandes, 2009).

Although plants survived (95% survival) to the water deficit period in the experimental area (Figure 1A), typical of the *cerrado* biome (dry season = 6 months), this was reflected in non-irrigated plants growth, since some woody species under water deficit conditions limit stomatal opening, resulting in CO<sub>2</sub> assimilation

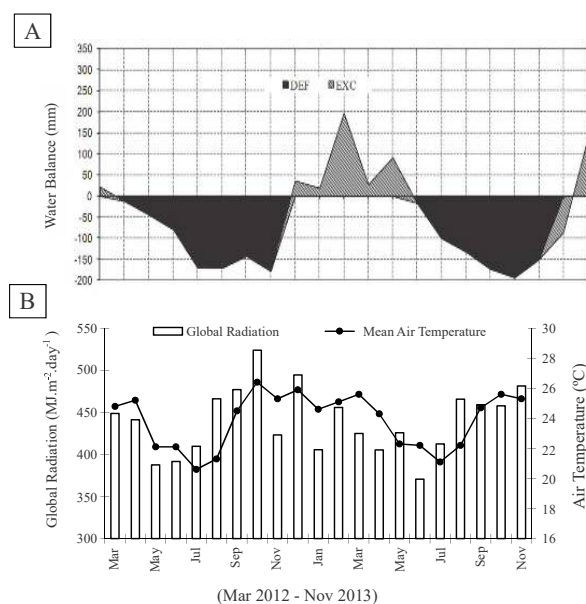
rate reduction and lower plant growth (Franco, 1998; Mattos et al., 2002; Silva et al., 2005; Albuquerque et al., 2013).

Lower non-irrigated plant growth can be explained by the planting season (March/2012), which coincided with the end of rainfall in the region. Afterwards, a drought period advanced until October/2012 (Figure 1A), which may have impaired both plant adaptation and plant growth.

Considering that the mahogany is a large species, which can reach 70 m height and 3.5 m DBH (Carvalho, 2007), plants evaluated in this study are young. In addition, the radius explored by young mahogany plant roots was only 0.50 m until 6 months of age, and 1.0 m until 1 year of age. Because of this, a single dripper with a flow rate of 2 L h<sup>-1</sup> was enough to supply plant water requirements. In treatments with 2 and 3 drippers, regardless of flow rate, drippers were arranged in a way that, in the treatment with 2 drippers, the plant was in a median region between emitters. Moreover, in the treatment with 3 drippers, the water provided by border emitters was outside the young mahogany root system water absorption zone. The distance between emitters was 60 cm, and based on the treatment with 8 L h<sup>-1</sup> and 3 drippers, operating 1 hour per day, a wet radius of 0.38 cm was obtained. That is, all the water that was expelled by border emitters was probably lost in that crop stage.

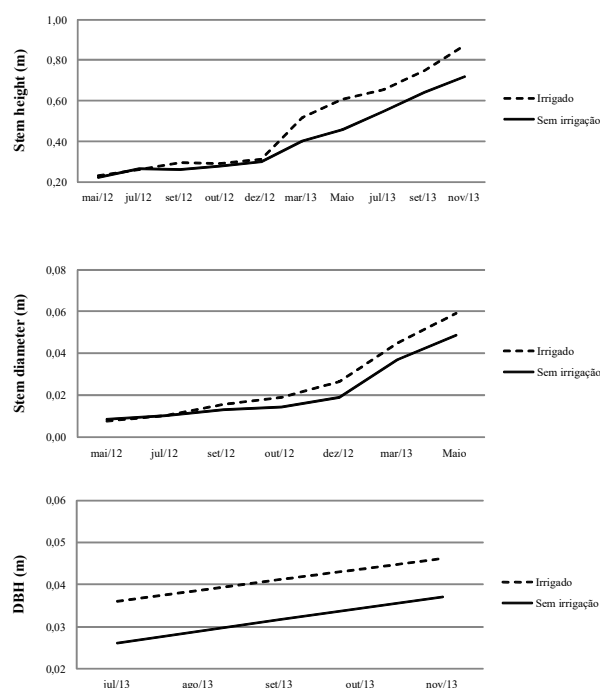
Although plant growth increased during the first months, plant growth rates intensified in the summer (December - March), probably as an influence of maximum water availability (Figure 1A) in the soil and photoperiod effect, with higher energy availability (Figure 1B).

In general, irrigated and non-irrigated treatments showed lower growth rates up to 160 days after planting (Figure 2), which may have occurred due to seedlings ripening stage and low energy availability. This effect was more accentuated in the non-irrigated treatment, since there was water restriction (Figure 1A). From



**Figure 1** – A: Water balance by Thornthwaite & Matter method (Pereira et al., 2002); and B: Temperature and global radiation for the period from March/2012 to November/2013), Bonfinópolis, GO, Brazil.

**Figura 1** – A: Balanço hídrico pelo método de Thornthwaite & Matter (Pereira et al., 2002), e B: Temperatura média do ar e radiação solar para o período de Março/2012 a Novembro/2013), Bonfinópolis-GO.



**Figure 2** – Mean growth data of African mahogany trees (total height, stem height, diameter and DBH) from 2 to 20 months in the field, Bonfinópolis, GO, Brazil.

**Figura 2** – Dados médios de crescimento de plantas de mogno africano (altura total, altura de fuste, diâmetro e DAP) dos 2 aos 20 meses no campo, Bonfinópolis - Go.

November/2012, higher growth rates were observed in both irrigated and non-irrigated treatments ( $p < 0.05$ ) for all variables analyzed, decreasing again in the dry period of the following year (2013), with effect in irrigated treatments (Figure 2). Thus, the importance of irrigation for African mahogany plant growth in the first two years of forest implantation was noticed.

It was observed that, in the first reading, conducted in May 2012 (2 months of age), plants obtained mean values of 0.008 m diameter, 0.32 m total height and 0.23 m stem height. As of November 2013 (20 months of age), in the last evaluation, DBH, total height and stem height mean data were, respectively: 0.045; 3.25 and 0.87 m for irrigated plants and 0.037, 2.67 and 0.71 m for non-irrigated plants. In general, it was observed that mahogany plants developed slightly less than expected, including irrigated ones. The literature shows that Brazilian Mahogany plants transplanted with 0.60

m height, that is, approximately the double of the initial height of plants in this study (0.32 m), obtained a mean total height of 3.40 m during a period of 14 months (Cordeiro, 2012). The value aforementioned corresponds to a growth rate of  $0.24 \text{ m month}^{-1}$ , which was higher than the rate obtained by plants of the present study,  $0.15 \text{ m month}^{-1}$  when irrigated and  $0.12 \text{ m month}^{-1}$  when not irrigated. This may be due to transplanted seedling size, or due to species and region differences. The mahogany (*Swietenia macrophylla*) is known as the Brazilian mahogany and is a species native to the Amazon region, where the study was conducted. Therefore, the plant is already adapted to the environment conditions.

Differences were not detected for variables that expressed plant growth in relation to the different fertilization rates (Table 3). In studies with Brazilian mahogany and its nutritional needs, it was verified that the order of necessity follows  $P > S > K > N$  (Souza et al., 2010), which may explain the absence of a significant African mahogany response to potassium (K) and nitrogen (N), as these elements are not the most necessary in the initial growth of this plant. Increasing N doses of 0, 20, 40, 60, 80, 100 and 120  $\text{g N ton}^{-1}$  of substrate increased Brazilian Mahogany (*Swietenia macrophylla* King) seedlings growth in terms of stem and root dry matter and plant height, up to the optimal dose of  $61.5 \text{ g N Mg}^{-1}$ . The maximum dose used in this study ( $120 \text{ g N Mg}^{-1}$ ) caused negative effect, impairing seedling quality (Tucci et al., 2009). Rosa (2014), in a study on African mahogany (*Khaya ivorensis*) seedlings in pots (90 days), reported that nitrogen fertilization only improved plant leaf area, while the other variables (height, stem and diameter) did not show significant differences between treatments (0, 00, 0, 12, 0, 24, 0, 36, 0, 48, 0, 60 grams of N per plant). Other researches with perennial species showed that N omission did not affect locust (Duboc et al., 1994) and aroeira-do-sertão (*Myracrodruon urundeuva* Fr, All) growth (Mendonça et al., 1999).

Moreover, considering that Cerrado soils are naturally low in phosphorus (Souza et al., 2004), which was confirmed in this study ( $4.2$  and  $1.4 \text{ mg dm}^{-3}$  for 0-20cm and 0-40 layers, respectively) (Fig. 1), the lack of P application may have caused lower growth, as it is known that phosphorus is a plant growth limiting factor for many plants, such as *Cedrella fissilis* (Silva and Muniz, 1995), *Acacia mangium*, *Tibouchina*



*granulosa* and *Aspidosperma polyneurom* (Braga et al., 1995).

In addition, African mahogany can adapt to poor soils. In Indonesia, mahogany of *Swietenia macrophylla* King. species is developed in very poor soils (Soemianegara and Lemmens, 1993). For Carvalho (2007), there are several tolerable soil conditions for mahogany (*Swietenia macrophylla*), ranging from deep and poorly drained soils, acidic and swampy clay soils, to well-drained alkaline soils, including soils derived from igneous and metamorphic rocks. Due to *Swietenia macrophylla* and *Khaya ivorensis* species proximity, it can be inferred that the African mahogany is adapted to *Cerrado* environmental conditions. According to Sallenave (1959), who studied mahogany special characteristics and properties, this species originated in African west coast countries, mainly in Ivory Coast, Ghana, Togo, Nigeria, Cameroon, Congo and Angola. In general, the predominant soils found in these countries are classified as Oxisols, Ultisols and Entisols (Soil Survey Staff, 2006), which, according to the Brazilian classification (Embrapa, 2006), represent, respectively: Latosols, Argisols and Neosols, which are in the *Cerrado* of Goiás.

## 5. CONCLUSIONS

Young African mahogany plants, up to two years of age, respond positively to drip irrigation.

Irrigation with one drip per plant and flow rate of 2 L h<sup>-1</sup> is enough to meet the water demands of African mahogany in the first two years of cultivation.

Plants did not respond to the different Nitrogen and Phosphorus topdressing doses, applied every 2 months, at the beginning of the cycle.

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