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Indolebutyric acid and light quality in the rooting of african mahogany minicuttings

Ácido indulbutírico e qualidade de luz no enraizamento de miniestacas de mogno africano

Ácido indolbutírico y calidad ligera en el enraizamiento de miniesquejes de caoba africana

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Abstract
The vegetative propagation of african mahogany allows the formation of more uniform seedlings, at a lower cost and with greater productive potential. The objective of this study was to evaluate the effects of indolebutyric acid (iba) and light quality on the rooting of african mahogany minicuttings. The experiment was conducted in a greenhouse, using an experimental design in randomized blocks, in a 3x4 factorial scheme and 4 replications, totaling 48 experimental units. The treatments consisted of light supplementation (period between 7 and 9 p.m.), with 2 luminous spectra (white and red), one control (kept in the dark) and 4 concentrations of iba (absence, 1500, 3000 and 4500 mg l^{-1}). Each experimental unit consisted of 8 minicuttings, and the experiment was conducted for 80 days. The combination of iba (4500 mg l^{-1}) and light supplementation in the red spectrum yields a greater root system growth of african mahogany minicuttings.
Keywords: *Khaya senegalensis*; Auxin; Vegetative propagation.

Resumo
A propagação vegetativa de mogno africano possibilita a formação de mudas mais uniformes, de menor custo e com maior potencial produtivo. Objetivou-se avaliar os efeitos de concentrações de ácido indolbutírico (AIB) e da qualidade de luz no enraizamento de miniestacas de mogno africano. O experimento foi conduzido em casa de vegetação, em delineamento experimental em blocos casualizados, em esquema fatorial 3x4 e 4 repetições, totalizando 48 unidades experimentais. Os tratamentos foram constituídos por suplementação luminosa (período entre 19 às 21h) com 2 espectros luminosos (branco e vermelho) e um controle (mantido no escuro) e 4 concentrações de AIB (ausência, 1500, 3000 e 4500 mg L^{-1}). Cada unidade experimental foi composta por 8 miniestacas, e o experimento foi conduzido por 80 dias. A combinação de AIB (4500 mg L^{-1}) e suplementação luminosa no espectro do vermelho proporcionam maior crescimento do sistema radicular das miniestacas de mogno africano.
Palavras-chave: *Khaya senegalensis*; Auxinas; Propagação vegetativa.

Resumen
La propagación vegetativa de la caoba africana permite la formación de plántulas más uniformes, a menor costo y con mayor potencial productivo. El objetivo fue evaluar los efectos de las concentraciones de ácido indolbutírico (IBA) y la calidad de la luz sobre el enraizamiento de miniesquejes de caoba africana. El experimento se realizó en invernadero, en un diseño de bloques al azar, en esquema factorial 3x4 y 4 repeticiones, totalizando 48 unidades experimentales. Los tratamientos consistieron en suplementación lumínica (periodo de 7pm a 9pm) con 2 espectros de luz (blanco y rojo) y un testigo (mantenido en oscuridad) y 4 concentraciones de IBA (ausencia, 1500, 3000 y 4500 mg L^{-1}). Cada unidad experimental constó de 8 miniesquejes, y el experimento se llevó a cabo durante 80 días. La combinación de IBA (4500 mg L^{-1}) y la suplementación liviana en el espectro rojo proporciona un mayor crecimiento del sistema radicular de los miniesquejes de caoba africana.
Palabras clave: *Khaya senegalensis*; Auxinas; Propagación vegetativa.

1. Introduction

Mahogany (*Swietenia macrophyla* King) is one of the most valuable wood species in the world. This species has been extracted in its natural occurrence areas in America, from Mexico to Brazil (Grogan et al., 2002), which has been causing the ecological vulnerability of the species. Commercial mahogany cultivation has presented problems due to damage caused by *Hypsipyla grandella* (Zeller), which makes its sustainable exploitation difficult (Corcioli et al., 2016). The species *Khaya senegalensis* (African mahogany), belonging to the family Meliaceae, appears as an alternative to substitute Brazilian mahogany due to its great phenotypic similarity, especially regarding the physical characteristics of wood.

Ribeiro et al. (2017) described that, in Brazil, the species had its first plantations installed in the Northern region in the year 1976 and the growing demand for tropical wood is leading to new investments in commercial plantations, heating the forest market around the species. Several plantations have already been set in Australia, Asia and tropical America, but few studies have been published discussing results from adopted silvicultural systems, growth and yield, economic analysis, and others that provide forest managers and investors with more information for decision making. in conducting the species.

The first step to the success of planting a particular species is to obtain seedlings of high genetic and phytosanitary quality. The vegetative or clonal propagation can be advantageous to maintain the genetic characteristics of the propagated plants, generating clones that can show high yield and plasticity for the nurserymen. Another factor capable of forcing the option for cloned seedlings is when the seed supply is limited (Xavier et al., 2003).

Minicutting is a clonal propagation technique that has been used in the production of seedlings of forest species. This technique consists in pruning the apices of the plants cultivated in clonal hedges, aiming to stimulate the release of new shoots, which are collected and taken for rooting in a greenhouse (Alfenas, 2009; Mcmahow et al., 2014; Stuepp et al., 2016). The clonal hedge is a semi-hydroponic system where a sand-containing channel supports the planting and cultivation of the parent plants, generally using drip irrigation to supply water and nutrients (Assis and Mafia, 2007). Borges et al. (2011) studied the effect of indolebutyric acid (IBA) on the rooting of minicuttings of different *Eucalyptus* species in two conduction systems (conventional and hedge) and verified that the plants kept in the hedge, conducted in a sand bed, presented greater rooting, independent of auxin concentration.

It is important to know the factors that affect root formation, since they are related to the success of seedling production through vegetative propagation (Cunha et al., 2009; Oliveira et al., 2016). Fachinello et al. (2005) reported that several factors influence cutting rooting: intrinsic, or linked to the plant itself; and extrinsic, linked to environmental conditions. The plant hormones that cause rooting (auxins) stand out among the intrinsic factors and depend on the species and the development stage of the parent plant, in addition to being influenced by extrinsic factors. Among the synthetic auxins for exogenous use in rooting induction, indolebutyric acid (IBA) is the most widely used substance (Brondani *et al*., 2008). It is also known that, in order to make the use of minicuttings feasible, it is important to know the need for exogenous auxin necessary for rooting, as well as the rooting potential of the species (Oliveira et al., 2015).

Erig and Schuch (2011) stated that light quality is an environmental factor that emerges as an important tool for the induction of physiological balances (auxin/cytokine), which may favor specific responses such as rooting (Damiani et al., 2009; Pasa et al., 2012). Rossal (2006) studied the effect of light quality and growth regulators on the rooting of guava and peach stem cuttings.

In this context, the objective of this study was to evaluate the effects of IBA concentrations and light quality on the rooting of African mahogany minicuttings.

2. Methodology

The experiment was carried out in a greenhouse (PADFAN model) covered with polypropylene plastic (150 μm) and Sombrite® (50% shading), equipped with intermittent misting, triggered for 20 seconds every 7 minutes in the daytime period, located in Bambui – MG, at the following geographic coordinates: 20°02’22.64”S and 46°00’19.40”W, average altitude of 690m. During the whole conduction of the experiment, in the greenhouse, the average temperature was 27 ºC and the relative humidity was around 80-90%.

The plant material consisted of African mahogany (*Khaya senegalensis*) minicuttings, which were approximately 8 cm long with a pair of leaves. The parent plants were grown in a clonal hedge (bed system), maintained in nutrient solution containing: calcium nitrate (0.920 g L^{-1}), potassium chloride (0.240 g L^{-1}), potassium nitrate (0.140 g L^{-1}), monoammonium phosphate (0.096 g L^{-1}), magnesium sulfate (0.364 g L^{-1}), hydroiron (0.040 g L^{-1}), boric acid (2.8 mg L^{-1}), zinc sulfate (0.480 mg L^{-1}), manganese sulfate (1.120 mg L^{-1}), copper sulfate (0.100 mg L^{-1}) and sodium molybdate (0.040 mg L^{-1}), according to Borges et al. (2011).

The treatments consisted of light supplementation, performed from 7 to 9 p.m. in different light spectra (red and white) and a control maintained in the dark combined with different concentrations of IBA (0, 1500, 3000 and 4500 mg L^{-1}). The experimental design was in randomized blocks (RBD) in a 3x4 factorial scheme, totaling 12 treatments, with 4 replications. Each experimental plot consisted of 8 minicuttings. IBA was applied in the minicutting base by immersing the minicuttings for 7 seconds in trays containing the different concentrations of the phytoregulator (Vasconcelos, 2012), according to the treatments.

After the application of the IBA concentrations, the minicuttings were transplanted into 110-cm^3 tubes containing commercial substrate (bioplant), and were maintained under different light conditions, according to the treatments.

For the treatments with light, a wooden structure divided into boxes was built, which was embedded in benches to allow the passage of sunlight during the day and, at the same time, to isolate the light in the different spectra (red and white) of the compartments at night. The boxes were 70 cm long, 60 cm wide and 38 cm high, and one lamp was placed per compartment. The tray, with dimensions of 60 x 38 cm, was located in the center of the compartment. Leds (Superled Ouro) of 7 watts were used in the experiment, with red and white irradiance of 2,8 $w.m^{-2}$ e 4,3 $w.m^{-2}$, respectively.

The evaluations were carried out 80 days after cutting planting, and the following characteristics were evaluated: survival, rooting rate, root number and length, root and shoot dry matter. The data were submitted to analysis of variance (ANOVA), using the statistical software Sisvar (Ferreira, 2011), and the means were compared by the Scott-knott test at 5% probability.

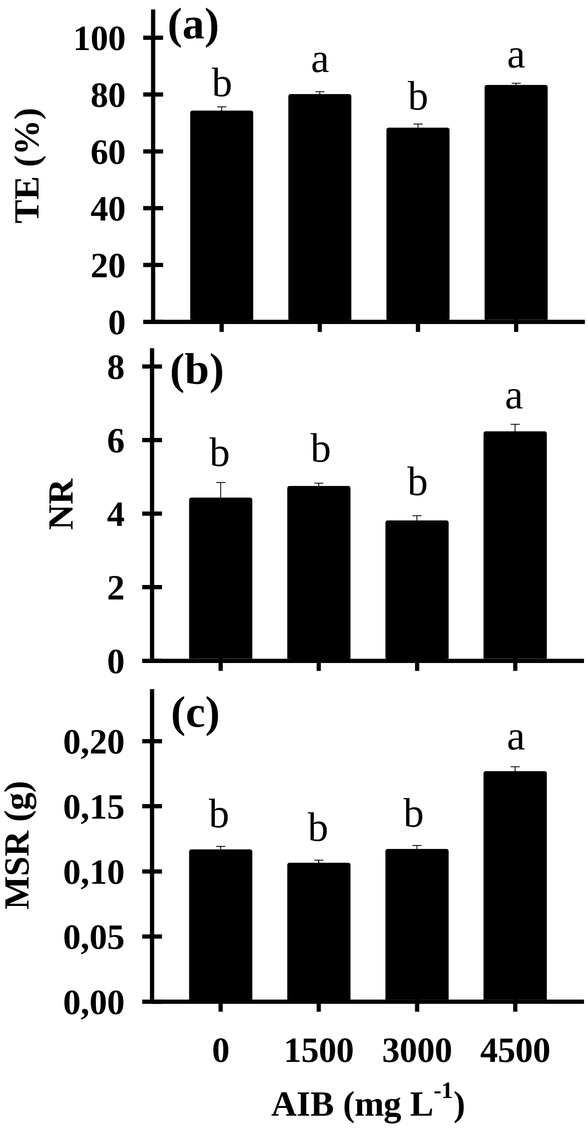
3. Results and Discussion

The analysis of variance (ANOVA) showed significance ($p \leq 0.05$) for the variables: root ratio (RR), root number (RN), root dry matter (RDM), only for IBA. There were interactions between the studied factors (IBA and luminous spectra) only for the variable root system length (RSL).

The survival index had no significant effect on the factors under study ($p \geq 0.05$). The survival of minicuttings was close to 100% for all the treatments tested. Shoot dry matter was not significant ($p \geq 0.05$) and the plants presented accumulation of 0.897g on average in the different treatments.

Higher rooting rates (RR) were observed with the use of IBA concentrations (1500 and 4500 mg L^{-1}) (Figure 1a). The use of IBA (4500 mg L^{-1}) resulted in a higher root number (RN), reaching 6.13 roots on average, being 45% superior to the control treatment in the absence of IBA (Figure 1b). Root dry matter (RDM) of the plants presented greater accumulation at a concentration of 4500 mg L^{-1} (Figure 1c).

Figure 1. Rooting rate (RR) (a); Root number (RN) (b); Root dry matter (RDM) (c).



Means followed by the same letter do not differ by the Scott-Knott test at 5% probability. Source: Authors.

The high survival rate of the cuttings demonstrates that environmental conditions (temperature and relative humidity) were conducive to the growth of African mahogany. In general, forest species have shown high survival levels in greenhouses, even if rooting is low (Brondani *et al*., 2010). The high survival rate of minicuttings must be associated with the environmental conditions, which are controlled to ensure it (Wendling & Xavier, 2005).

The vegetative propagules or cuttings have certain internal amounts of hormones that promote or inhibit rooting, and an ideal balance between them is necessary for rooting (Hartman *et al*., 2011). According to Fachinelo *et al*. (2005), cuttings removed from young matrices root more easily, since age is directly related to a greater number of rooting cofactors and lower presence of inhibitors. The use of IBA resulted in the increase in RR, RN and RDM (Figure 1), and the interaction between the use of IBA (4500 mg L^{-1}) and auxins present endogenously in African mahogany cuttings probably contributed positively to rooting.

Vasconcelos (2012) reported that the use of 400 mg L^{-1} IBA provided higher root number and length of the root system in *Khaya senegalensis*, reaching 9 roots per cutting and length of 65 cm, respectively. Similarly, Pinto and Franco (2009) observed that *Lippia alba* treated with (500 – 1000 mg L^{-1} IBA), yielded a greater root number. Vale *et al*. (2008) studied IBA concentrations of 0, 100, 200 and 300 mg L^{-1} in guava cuttings ('Paluma'), and found that the increase in IBA doses favored a linear increase in root number.

Tonietto, Fortes and Silva (2001) studied minicuttings of two plum cultivars (Reubennel and Puma 7), concluded that IBA increases rooting, number and root length of the two cultivars. It is possible, according to the authors, that with the induction and probable anticipation of root formation with the use of IBA, there was a longer period for root growth within the substrate; thus IBA has an indirect effect on root length.

The plants maintained in the control treatment had a good rooting rate, around 70% (Figure 1A). The results of this study agree in parts with those obtained by Vasconcelos (2012), who concluded that it is possible to produce seedlings by *Khaya senegalensis* cuttings without the use of the exogenous hormone IBA. However, in this study, the use of IBA at a concentration of 4500 mg L^{-1} increases the rooting rate of African mahogany by around 10% (Figure 1A).

Hernández et al. (2012) found results contrary to those observed in this study and obtained better rooting results (above 90%) in the apical cuttings of *Piptadenia gonoacantha*, independent of the IBA doses tested (0, 2000 and 6000 mg L^{-1}). Oliveira *et al*. (2016) stated that the vegetative propagation by minicutting of ministrain showed potential for production of purple ipe seedlings, independently of the position of the propagule and the application of IBA.

The combination of IBA concentration (4500 mg L^{-1}) and light supplementation in the red spectrum led to a longer root system length (RSL), reaching 53.37 cm (Table 1). In the absence of light, better results for RSL were observed in the absence of IBA or in the presence of 3000 mg L^{-1} of this growth regulator. IBA concentrations (1500 and 4500 mg L^{-1}) in the presence of light supplementation at white wavelength positively benefited the RSL of African mahogany plants, being superior to the control (absence of IBA) (Table 1). For Xavier *et al*. (2009), light quality, photoperiod, and irradiance should be adequately offered to achieve a photosynthetic rate that provides carbohydrates for root initiation and to keep minicuttings alive. In addition, they report that the above factors vary as a function of species.

Table 1. Root length (cm) of African mahogany seedlings submitted to different luminous spectra and IBA doses.

	Root system length (cm)			
	IBA (mg L^{-1})			
Luminous spectra	0	1500	3000	4500
Absence of light	43.20Aa	22.96 Bb	46.39 Aa	36.69 Bb
White light	23.67 Bb	38.38 Aa	23.05 Bb	36.05 Ba
Red light	18.82 Bc	42.45 Ab	22.262 Bc	53.37 Aa

Means followed by the same vertical uppercase letter or horizontal lowercase letter do not differ by the Scott-Knott test at 5% probability. Source: Authors.

In the study conducted by Rossal (2006) with supplementation of two hours daily, using red, yellow, white and blue lights and growth regulators in the rooting of guava and peach stem cuttings, it was concluded that light quality influences rooting, and there is an interaction between exogenously applied hormones and light quality and the rooting responses to light quality and IBA for both species. These results agree with those obtained in this study, where higher growth of the root growth system was promoted with supplementation of the red light spectrum in combination with high IBA concentration (Table 1). This behavior may be related to the interaction between the radiation and the system of light receptors consisting of phytochromes, which activate genes that lead to plant development and differentiation, allowing that most of the resources are allocated for the growth of the root system (Li *et al*., 2015).

4. Conclusion

The vegetative propagation of African mahogany is possible by minicutting, using IBA for rooting.

The combination of IBA at a concentration of 4500 mg L^{-1} and light supplementation in the red spectrum provides greater growth of the root system of African mahogany minicuttings.

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