Scientific Article

VEGETATIVE PROPAGATION OF *HYMENAEA COURBARIL* L. AND *APULEIA LEIOCARPA (*VOGEL*)* J. F. MACBR. BY MINI-CUTTING

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ABSTRACT – The objective of this work was to evaluate the vegetative propagation of *Hymenaea courbaril* (*jatobá*) and *Apuleia leiocarpa* (*garapa*) using the mini-cutting technique with the use of indolebutyric acid (IBA) growth regulator in different types of mini-cuttings. Two experiments were set up: the first involving the two species and three mini-cutting techniques (basal, intermediate and apical) in the presence and absence of IBA (4000 mg kg^{-1}). In the second experiment, only the *garapa* species was evaluated by testing the same three mini-cutting techniques at four IBA concentrations: 0, 1000, 2000 and 4000 mg kg^{-1}. The mini-cuttings were obtained from 6-month-old seedlings produced from seeds in a nursery. A randomized block design was used in a 3 x 2 x 3 factorial scheme (three mini-cutting techniques, two IBA concentration levels and three evaluation dates) in the first experiment, and a 3 x 4 x 3 factorial scheme (three mini-cutting techniques, four IBA concentrations and three evaluation dates) in the second experiment. At 90 days, *jatobá* had an average survival of 54%, with less than 5% of total rooting, without significant influence of the mini-cutting technique or IBA use. *Garapa* presented higher survival for the basal mini-cuttings in both experiments, which were the only ones that took root. IBA did not influence survival or rooting percentage of *garapa* mini-cuttings, but negatively influenced the root number, length and dry mass. We concluded that the basal mini-cutting is a viable technique for vegetative propagation of garapa, presenting 40% of rooting, but the propagation by mini-cutting for *jatobá* was not successful under the conditions of this study.

Keywords: Rooting; auxin; Fabaceae.

PROPAGAÇÃO VEGETATIVA DE HYMENAEA COURBARIL *L. E* APULEIA LEIOCARPA *(*VOGEL*)* *J. F.* MACBR*. POR MEIO DA MINIESTAQUIA*

RESUMO – O trabalho teve como objetivo avaliar a propagação vegetativa de ***Hymenaea courbaril*** (jatobá) e ***Apuleia leiocarpa*** (garapa) por meio da técnica de miniestaquia com o uso do regulador de crescimento, ácido indolbutírico (AIB), em diferentes tipos de miniestacas. Foram montados dois experimentos, o primeiro envolvendo as duas espécies, três tipos de miniestacas (basais, intermediárias e apicais), na presença e ausência de AIB (4000 mg kg^{-1}). No segundo experimento, avaliou-se apenas a espécie garapa testando-se os mesmos três tipos de miniestacas em quatro concentrações de AIB: 0, 1000, 2000 e 4000 mg kg^{-1}. As miniestacas foram obtidas a partir de mudas de 6 meses de idade, produzidas em viveiro a partir de sementes. Utilizou-se delineamento em blocos casualizados no esquema fatorial 3 x 2 x 3 (três tipos de miniestacas, dois níveis de AIB e três datas de avaliação) no primeiro experimento, e 3 x 4 x 3 (três tipos de miniestacas, quatro concentrações de AIB e três datas de avaliação) no segundo experimento. Aos 90 dias, o jatobá apresentou sobrevivência média de 54%, com menos de 5% de enraizamento total, sem influência significativa do tipo de miniestaca ou do uso do AIB. Em ambos os experimentos a garapa apresentou maior sobrevivência para as miniestacas basais, que foram as únicas que enraizaram. O AIB não influenciou a sobrevivência e o percentual de enraizamento de miniestacas da garapa, porém influenciou de forma negativa o número, comprimento e massa seca de raiz. Conclui-se para garapa que a miniestaquia, a partir das miniestacas basais se mostrou uma técnica viável, com 40% de enraizamento, porém para jatobá, nas condições do estudo, a propagação por miniestaquia não teve sucesso.

Palavras-Chave: Enraizamento; Auxina; Fabaceae.

1. INTRODUCTION

Hymenaea courbaril L., popularly known as *jatobá*, has a wide geographical distribution, naturally occurring in the Amazon, Caatinga, Cerrado, Atlantic Forest, and Pantanal biomes in several states and regions of Brazil (Lima and Pinto, 2015). *Jatobá* belongs to the Fabaceae family, and has food, timber, landscape and medicinal potential. Its wood is highly valued for having high density, hardness and mechanical resistance, and therefore it is highly recommended for use in the furniture and construction industries (Lorenzi, 1992).

Apuleia leiocarpa (Vogel) J. F. Macbr., popularly known as *garapa*, *grápia*, or *amarelão*, belongs to the Fabaceae family, and has natural distribution in the Amazon, Caatinga, Cerrado, and Atlantic Forest biomes (Lima, 2015). It is a deciduous tree that reaches up to 35 m and 100 cm in diameter at breast height (Carvalho, 2003). Its wood has a high economic value with several uses. Due to the intense logging and fragmentation of its habitat, it is suspected that the population has suffered a reduction of at least 30% in the last 100 years and is considered endangered (CNC Flora, 2012). In addition, the species has irregular fruiting and a large size, making it difficult to collect its fruit (Carvalho, 2003).

Vegetative propagation techniques, including cutting and mini-cutting, are an alternative to overcome the difficulties in propagating native species and can be used for commercial purposes, as well as assisting in the rescue and conservation of genetic forest resources (Dias et al., 2012). Cutting is a method of asexual propagation, which consists in removing and using parts of the mother plant to be multiplied. Mini-cutting is a newer technique with the principle being to harness the juvenile potential of the propagules for rooting induction (Ferriani et al., 2010). As this technique involves juvenile rather than woody material, mini-cuttings may provide greater rhizogenic potential, larger number of propagules and reduced seedling formation time in the nursery (Menezes et al., 2018).

The rooting of cuttings and mini-cuttings varies among species and between clones/progenies of the same species (Neubert et al., 2017), and may be influenced by intrinsic plant-related factors and extrinsic factors related to environmental conditions. Intrinsic factors include the genetic constitution of the plant, the endogenous level of inhibitors, cutting techniques, plant age and nutritional and water conditions of the parent plant (Cavalcante et al., 2019; Guimarães et al., 2019). Among the relevant extrinsic factors are the time of year of collection, use of growth regulators, substrate quality, and the environmental conditions (temperature, light and humidity) (Hartmann et al., 2011; Peralta et al., 2017; Freitas et al., 2017b; Marchi et al., 2018).

For species with difficulty in rooting, an alternative is the use of plant growth regulators which can promote, inhibit or modify plant morphological and physiological processes at low concentrations (Lacerda et al., 2007). Among these regulators are auxins, among which in turn are indole-3-acetic acid (IAA), indolebutyric acid (IBA) and α-naphthalenoacetic acid (NAA).

Several native species have already shown positive responses to auxin application, such as *Paubrasilia echinata* Lam (Endres et al., 2007), *Trichilia catigua* A. Juss. (Valmorbida et al., 2008), *Cariniana estrellensis* (Raddi) Kuntze, *Piptadenia gonoacantha* (Mart.) J.F.Macbr. (Hernández et al., 2012), *Schizolobium parahyba* var. *amazonicum* (Huber ex Ducke) Barneby (Lima et al., 2018), and *Ilex paraguariensis* St. Hil (Bisognin et al., 2017).

However, IBA may present quite a variable response according to species, cutting technique, concentration, or application mode, among others (Lima et al., 2018; Emer et al., 2016; Yamamoto et al., 2010).

In view of the above, the objective of this work was to evaluate the potential of vegetatively propagating *Apuleia leiocarpa* (*garapa*) and *Hymenaea courbaril* (*jatobá*) by testing different concentrations of IBA growth regulator and mini-cutting techniques.

2. MATERIAL AND METHODS

Two experiments were carried out in the “Luiz Fernando de Oliveira Capellão” forest nursery of the Department of Forestry, Forest Institute of the Federal Rural University of Rio de Janeiro, located in Seropédica/RJ (latitude 22°45'S and longitude 43º41'W). The climate of the region is Aw according to the Köppen classification (Ramos et al., 1973), and the maximum average annual temperature is 29.0ºC and the minimum average is 19.8ºC in the last 10 years, according to the average data from the Agricultural Ecology Meteorological Station Km 47 - Seropédica/PESAGRO - RIO. In addition, the average rainfall is 1,152 mm per year, concentrated between December and March, with the lowest rainfall in July and August.

Indolebutyric acid (IBA) powder was used at a concentration of 4,000 mg kg^{-1} in the first experiment carried out from March to June 2017 using *Apuleia leiocarpa* (*garapa*) and *Hymenaea courbaril* (*jatobá*) species. The influence of the presence or absence of the hormone without varying the concentration, three mini-cutting techniques (basal, intermediate and apical) were evaluated at 30, 60 and 90 days after planting (DAP). The experimental design was a randomized block design in a 3 x 2 x 3 factorial scheme with three mini-cutting techniques, two levels of growth regulator (with or without IBA) and the three evaluation dates. In the first rooting evaluation, 50% of the cuttings of each repetition were sampled and then the others in the second. Plots of ten mini-cuttings were repeated five times.

The second experiment was conducted from February to May 2018 only with the *garapa*, in which different IBA powder concentrations (0, 1000, 2000 and 4000 mg kg^{-1}) were evaluated in three mini-cutting techniques (basal, intermediate and apical) and evaluated on three dates at 30, 60 and 90 days after planting (DAP). The experimental design was a randomized block design in a 3 x 4 x 3 factorial scheme with the three mini-cutting techniques, the four IBA concentrations and the three evaluation dates. There were five repetitions of eight mini-cuttings per plot for each treatment.

Garapa seeds were collected from a forest fragment located in Paracambi/RJ, while *jatobá* seeds were collected from parent plants located at the UFRRJ campus in Seropédica/RJ. The seedlings of both species were produced in the nursery of UFRRJ, using polyethylene bags with 2.0 liters of volumetric capacity as plastic containers. The substrate was composed of a mixture of subsoil soil, cattle manure and sand in a ratio of 5:4:1. This substrate received basic fertilization as recommended by Gonçalves et al. (2000), with the following doses per m^3 of substrate: 150 g of N, using ammonium sulfate; 300 g of P_2O_5, through the use of simple superphosphate; 100 g of K_2O by the use of potassium chloride; and 150 g of FTE Br12 (1.8% B, 0.8% Cu, 3.0% Fe, 2.0% Mn and 0.1% Mo) for micronutrient supply. Coverage fertilization was performed according to the recommendation of Gonçalves et al. (2000), being composed of 200 g of N by ammonium sulfate and 180 g of K_2O by potassium chloride to 100 liters of nutrient solution, applying 5 ml per seedling. The first cover fertilization occurred after 30 days of sowing, repeating every 15 days for nitrogen fertilization, and every 30 days for potassium fertilization. During the seedling production, the containers remained in beds under full sun on the ground covered with gravel, and daily irrigations were performed two to three times in a daily volume of 15 mm by sprinkler system.

Jatobá and *garapa* mini-cuttings were obtained from seedlings approximately six months old, and 100 cm and 45 cm high, respectively. Basal, intermediate and apical mini-cuttings of each seedling were performed in both species, approximately 12 cm long, with the leaf area being reduced to 25% of the initial size. The mini-cuttings were collected using pruning shears, placed in containers with water to prevent dehydration and taken to a covered area of the nursery, until its staking in the substrate. No pest disinfestation treatment was performed.

For preparing the IBA in talc, 0.1 to 0.4 g of IBA (depending on the treatment) was mixed in industrial talc until completing 100g. Sufficient alcohol was added to form a paste for better homogenization, then transferred to a greenhouse at 40 °C, where the mixture remained until complete evaporation of the solvent (Yamamoto et al., 2010). Growth regulator application was performed by introducing the moistened mini-cut base into the powder container approximately 1 cm from the base, and then the mini-cut was planted on the substrate at a depth of 2 to 3 cm.

The culture vessels in experiment 1 were 280 cm^3 volume polypropylene tubes with eight longitudinal striations, while 50 cm^3 volume polypropylene tubes with six longitudinal striations were used in experiment 2. The containers were supported on polypropylene box trays. The substrate used in both experiments was composed of peat and vermiculite.

After planting the mini-cuttings in the substrate, they were kept in a greenhouse on benches suspended for 90 days with a temperature between 25 to 30 ºC and relative humidity above 60%. Irrigation was performed daily by nebulization. The temperature control in the greenhouse was done through a temperature sensor which triggered the misting system when the air temperature reached 30 °C and turned off when the temperature dropped to 25 °C. At night the system was shut down and resumed from 06 to 18 hours.

Three survival evaluations were performed at 30, 60 and 90 days after planting, and two rooting evaluations at 60 and 90 days. In the first rooting evaluation, 50% of the mini-cuttings of each repetition were sampled, and then the others in the second. We observed the formation of roots and calluses, as well as the absence of roots and calluses in these evaluations.

When the presence of a root was observed in the second experiment, they were counted, measured with a graduated ruler and placed in an oven at 70 ºC for two days to determine the dry mass in a digital analytical scale.

The results were submitted to tests to verify compliance with the assumptions for the analysis of variance. The variance analyzes were performed once the assumptions were met, the Scott-Knott clustering method was applied at 5% probability if there were differences by the F-test between factor levels for the mini-cutting technique, and regression adjustments were performed for the different IBA concentrations or evaluation dates. Statistical analysis was performed using the R program (R Core Team, 2018).

3. RESULTS

3.1 Experiment 1

Only the isolated evaluation date factor was significant from the results of the analysis of variance for *jatobá*. The average survival of *jatobá* cuttings was 90% at 30 days, and reduced up to 90 days (Table 1). Regardless of the evaluation date, there was no significance between survival averages in comparing cutting techniques and between the general averages obtained with or without the use of IBA.

The average survival for *garapa* was 85% at 30 days, decreasing to 12% at 90 days (Table 1). The basal mini-cuttings had better survival than the other mini-cuttings ($P<0.05$) in all evaluations, regardless of the addition of the IBA (Table 1). The intermediate and apical mini-cuttings had total mortality at 90 days. Regardless of the cutting technique, the application of IBA reduced the survival percentage of mini-cuttings at 30 days. Only 5% (n = 15) of the 300 *jatobá* mini-cuttings took root in the experiment, 3% of apical mini-cuttings, 1.6% intermediate and 0.3% basal. There were 17.3% (n = 52) with callus formation, with 9.6% (n = 29)

Table 1 – Average survival of apical, intermediate and basal mini-cuttings of *Hymenaea courbaril* (jatobá) and *Apuleia leiocarpa* (*garapa*) at 30, 60 and 90 days after planting (DAP) with (+) and without (-) indolebutyric acid (IBA) at the concentration of 4000 mg kg^{-1}.

Tabela 1 – *Sobrevivência média de miniestacas apicais, intermediárias e basais de **Hymenaea courbaril (jatobá)** e **Apuleia leiocarpa (garapa)** aos 30, 60 e 90 dias após o plantio (DAP) com (+) e sem (-) aplicação de ácido indolbutírico (AIB) na concentração 4,000 mg kg^{-1}.*

Hymenaea courbaril (jatobá)										
	30 DAP			60 DAP			90 DAP			Overall mean
Mini-cutting/IBA	-	+	mean	-	+	mean	-	+	mean	
apical	82^{aA}	84^{aA}	83^{A}	74^{aA}	80^{aA}	77^{A}	60^{aA}	61^{aA}	61^{A}	74^{A}
intermediate	100^{aA}	84^{aA}	92^{A}	90^{aA}	76^{aA}	83^{A}	69^{aA}	56^{aA}	63^{A}	79^{A}
basal	96^{aA}	94^{aA}	95^{A}	76^{aA}	76^{aA}	76^{B}	51^{aA}	29^{aB}	40^{B}	70^{A}
Overall mean	93^{a}	87^{a}	90	80^{a}	77^{a}	79	60^{a}	49^{a}	54	74
Apuleia leiocarpa (garapa)										
	30 DAP			60 DAP			90 DAP			Overall mean
Mini-cutting/IBA	-	+	mean	-	+	mean	-	+	mean	
apical	74^{aB}	60^{bC}	67^{B}	10^{bB}	29^{aB}	19^{B}	0^{aB}	0^{aB}	0^{B}	29^{B}
intermediate	94^{aA}	82^{aB}	88^{A}	9^{aB}	$8,0^{aC}$	8.3^{B}	0^{aB}	0^{aB}	0^{B}	32^{B}
basal	98^{aA}	100^{aA}	99^{A}	60^{aA}	62^{aA}	61^{A}	34^{aA}	40^{aA}	37^{A}	66^{A}
mean	89^{a}	81b	85	26^{a}	33^{a}	30	11^{a}	13^{a}	12	42

Means followed by equal letters, lowercase letters (between IBA levels on each date) and uppercase letters (between mini-cutting for each IBA x date combination) do not differ from each other by the F-test and the Scott-Knott clustering method at 5% probability, respectively.

Médias seguidas de letras iguais, minúsculas na linha (entre níveis de AIB em cada data) e maiúsculas na coluna (entre miniestacas para cada combinação entre AIB x data), não diferem entre si pelo teste F e método de agrupamento de Scott-Knott a 5% de probabilidade, respectivamente.

apical mini-cuttings, and 7.6% (n = 23) of intermediate mini-cuttings.

3.2 Experiment 2

The basal mini-cuttings were higher than the others at 30, 60 and 90 days after planting (Table 2). Intermediate mini-cuttings had significantly higher survival than apical 30 days, regardless of IBA concentration. However, the survival of the intermediate cuttings at 60 and 90 days was equal to the apical mini-cuttings. Survival behavior of mini-cuttings decreased over time for apical,basal and intermediate mini-cuttings (Figure 1a).

The rooting percentage showed the same behavior as the survival percentage, with only a significant double interaction between cuttings and time at 5% probability. There was no significant adjustment of the regression model between the different IBA concentrations for each mini-cut x time combination, nor in the overall mean for survival and rooting (%).

Regardless of IBA concentration (on average), only basal mini-cuttings emitted roots at 60 and 90 days after planting, statistically differing from the apical and intermediate cuttings, in which rooting was null (Table 2).

There was a significant interaction of the mini-cut type x IBA and mini-cut type x time regarding the number and length of roots in *garapa* mini-cuttings. Only the basal *garapa* mini-cuts had roots. The average number of roots for this mini-cutting technique was 1.2 at 60 days and 2.9 at 90 days (Table 3). The other types of mini-cuttings did not take root, regardless of IBA doses. The quadratic regression model for basal mini-cuttings was adjusted between IBA concentrations with minimum point inflection on the average of the evaluation dates, with the minimum number of roots (0.6) estimated at the dosage 2142 mg kg^{-1} IBA (Figure 1b).

The mean root length of the basal mini-cuttings was 1.4 cm at 60 days and 5.6 cm at 90 days, regardless of the IBA concentration (Table 3). Considering the mean dates for the basal mini-cut, there was an adjustment in the quadratic regression model between IBA concentrations, with minimum root length (2.3 cm) estimated at 2700 mg kg^{-1} IBA (Figure 1c).

The root dry mass followed the same behavior as the number and length of roots, with the mini-cut type x IBA and mini-cut type x time interactions being significant. The root dry mass for the basal mini-cuttings was 5.4 mg and 17.9 mg at 60 and 90 days, respectively (Table 3). The root dry mass of the basal mini-cuttings fit in the mean quadratic regression model of the evaluation dates. The lowest root dry mass value (0.92 mg) was estimated at 2833 mg kg^{-1} IBA (Figure 1d).

Table 2 – Average survival percentage of apical, intermediate and basal *Apuleia leiocarpa* (*garapa*) minicuttings at 30, 60 and 90 days after planting (DAP) with indolebutyric acid (IBA) application at concentrations of 0, 1,000, 2,000 and 4,000mg kg^{-1}.
Tabela 2 *– Porcentagem de sobrevivência média de miniestacas apicais, intermediárias e basais de **Apuleia leiocarpa (garapa)** aos 30, 60 e 90 dias após o plantio (DAP) com aplicação de ácido indolbutírico (AIB) nas concentrações de 0, 1,000, 2,000 e 4,000mg kg^{-1}.*

	IBA concentration (mg kg^{-1})				
Mini-cutting	0	1000	2000	4000	Mean
		30 DAP			
apical	45.0^c	45.0^c	65.0^b	45.0^c	50.0^c
intermediate	65.0^b	77.5^b	87.5^a	80.0^b	77.5^b
basal	100.0^a	97.5^a	100.0^a	100.0^a	99.4^a
		60 DAP			
apical	2.5^b	0.0^b	2.5^b	2.5^b	1.9^b
intermediate	2.5^b	2.5^b	17.5^b	15^b	9.4^b
basal	95.0^a	90.0^a	87.5^a	97.5^a	92.5^a
		90 DAP			
apical	0.0^b	0.0^b	0.0^b	0.0^b	0.0^b
intermediate	0.0^b	0.0^b	5.3^b	0.0^b	1.3^b
basal	77.3^a	73.9^a	69.6^a	77.3^a	74.5^a
Overall mean	25.8	24.6	24.9	25.8	25.3

Averages followed by equal letters in the column do not differ from each other by the Scott-Knott clustering method at 5% probability.
Médias seguidas por letras iguais na coluna, não diferem entre si pelo método de agrupamento de Scott-Knott a 5% de probabilidade.

Table 3 – Rooting, number, length and root mass of *Apuleia leiocarpa* (*garapa*) apical, intermediate and basal mini-cuttings evaluated 60 and 90 days after planting (DAP) with application of different IBA concentrations.
Tabela 3 *– Enraizamento, número, comprimento e massa de raízes de miniestacas apicais, intermediárias e basais de* ***Apuleia leiocarpa (garapa)*** *avaliadas 60 e 90 dias após o plantio (DAP) com aplicação de diferentes concentrações de AIB.*

Rooting (%)						
IBA	Apical	Intermediate	Basal	Apical	Intermediate	Basal
	60 DAP			90 DAP		
0	0^b	0^b	20^a	0^b	0^b	40^a
1000	0^a	0^a	5^a	0^b	0^b	25^a
2000	0^a	0^a	0^a	0^b	0^b	25^a
4000	0^a	0^a	10^a	0^b	0^b	35^a
Mean	0^b	0^b	8.8^a	0^b	0^b	31.3^a
Number of roots (n)						
IBA	Apical	Intermediate	Basal	Apical	Intermediate	Basal
	60 DAP			90 DAP		
0	0^b	0^b	3.6^a	0^b	0^b	4.2^a
1000	0^b	0^b	0.4^a	0^b	0^b	2.0^a
2000	0^a	0^a	0^a	0^a	0^a	1.3^a
4000	0^a	0^a	0.8^a	0^b	0^b	4.1^a
Mean	0^b	0^b	1.2^a	0^b	0^b	2.9^a
Root length (cm)						
IBA	Apical	Intermediate	Basal	Apical	Intermediate	Basal
	60 DAP			90 DAP		
0	0^b	0^b	3.7^a	0^b	0^b	8.1^a
1000	0^a	0^a	1.4^a	0^b	0^b	6.0^a
2000	0^a	0^a	0^a	0^b	0^b	4.5^a
4000	0^a	0^a	0.6^a	0^b	0^b	3.9^a
Mean	0^b	0^b	1.4^a	0^b	0^b	5.6^a
Root mass (mg)						
AIB	Apical	Intermediate	Basal	Apical	Intermediate	Basal
	60 DAP			90 DAP		
0	0^b	0^b	18.6^a	0^b	0^b	31.2^a
1000	0^a	0^a	2.3^a	0^b	0^b	20.4^a
2000	0^a	0^a	0^a	0^a	0^a	6.6^a
4000	0^a	0^a	0.8^a	0^b	0^b	13.3^a
Mean	0^b	0^b	5.4^a	0^b	0^b	17.9^a

Means followed by equal letters on the line do not differ from each other by the Scott-Knott clustering method at 5% probability.
Médias seguidas de letras iguais na linha, não diferem entre si pelo método de agrupamento de Scott-Knott a 5% de probabilidade.

4. DISCUSSION

Jatobá did not show vegetative propagation viability by mini-cutting technique due to the low rooting. Some species such as *Combretum leprosum* Mart (Oliveira et al., 2014) and *Plathymenia reticulata* Benth (Pessanha et al., 2018) have also shown difficulty in vegetative propagation. Several factors can influence the survival of the mini-cutting, such as the occurrence of injuries, hormonal balance, the genetic constitution of the mother plant, the endogenous level of inhibitors, climatic, nutritional and health factors (Xavier et al., 2009).

IBA had no significant influence on rooting success and survival of *garapa* mini-cuttings, and the concentrations used reduced the number, length and dry mass of roots. According to Botin and Carvalho (2015), auxins are growth regulators which induce root formation in cuttings, but in some cases have little or no effect on species with difficult rooting, and may even have toxicity. Other already studied species have also shown no response to IBA in relation to cutting survival or rooting, among which we can highlight *Eucalyptus grandis* Hill ex Maiden (Titon et al., 2003), *Campomanesia aurea* O. Berg (Emer et al., 2016) and *Buxus sempervirens* L. (Vieira et al., 2018).

The lack of response to auxin in some species may be due to the high degree of lignification of mini-cuttings, thereby making IBA action difficult (Hartmann et al., 2011). Another hypothesis may be the need for high

*** Significant at 0.01% by Regression Analysis.
**** Significativo a 0,01 pela Análise de Regressão.*

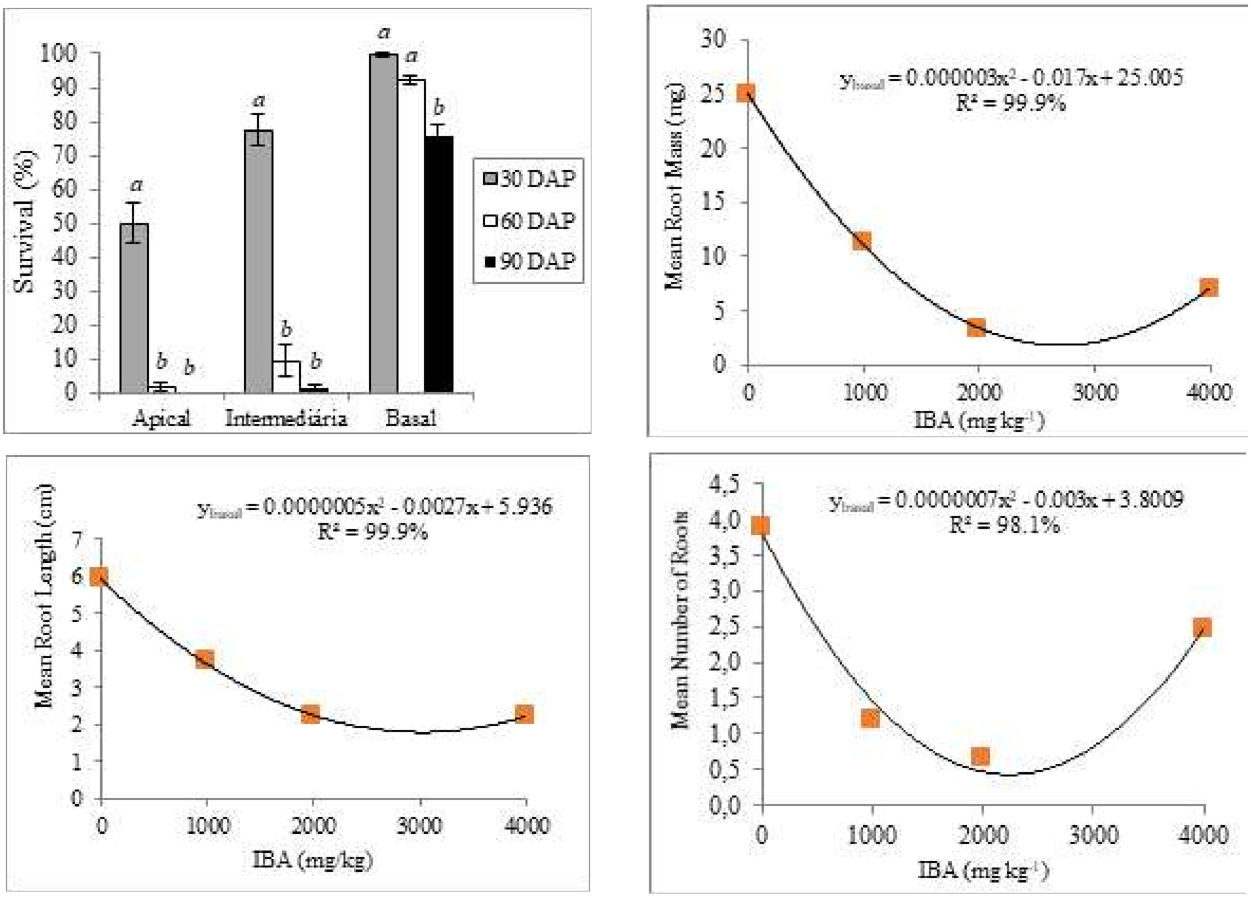

Figure 1 – Survival of *Apuleia leiocarpa* mini-cuttings up to 90 days after planting (DAP) (a); Average number of roots (b); average length of roots (c); root dry matter mass (d) of *Apuleia leiocarpa* basal mini-cuttings 90 days after planting as a result of IBA application.
Figura 1 – *Sobrevivência de miniestacas de* ***Apuleia leiocarpa*** *até 90 dias após o plantio (DAP) (a); Número médio de raízes (b); comprimento médio de raízes (c); massa de matéria seca de raízes (d) de* ***miniestacas basais*** *de* ***Apuleia leiocarpa*** *após 90 dias*

doses of IBA to express its effect, as reported by Dias et al. (2015), using doses of 0, 8,000, 16,000 and 32,000 mg L^{-1} of IBA in *Schizolobium amazonicum* Herb. mini-cuttings, obtaining better rooting results in the highest dose. Oliveira et al. (2015) also only found adventitious root response in *Handroanthus heptaphyllus* Mattos apical mini-cuttings at a dose of 8,000 mg L^{-1} after testing lower concentrations (0, 2,000, 4,000, 6,000 mg L^{-1} of IBA).

It is important to highlight that cuttings may have sufficient endogenous auxin levels in their tissues to promote root formation (Hartmann et al., 2011). Thus, the exogenous application of growth regulators to vegetative propagules, especially auxins, can sometimes damage cuttings. Mantovani et al. (2017) observed that the application of IBA, as well as the increase in concentrations, caused a reduction in the survival percentage of *Peltophorum dubium* Spreg. Taub. apical and basal mini-cuttings. For Nachtigal et al. (1994), increasing IBA concentrations up to 400 mg L^{-1} using slow immersion of the base of herbaceous cuttings of araçá for 16 hours increased leaf fall and cutting death; they correlated this fact with the phytotoxic effect of the IBA.

The basal *garapa* mini-cutting had the best performance in relation to the intermediate and apical mini-cuttings, while there was no difference between the mini-cutting techniques used for *jatobá*. According to Hartmann et al. (2011), less lignified (herbaceous) cuttings are more sensitive to dehydration and death, which may justify the mortality of apical and intermediate cuttings. For Druege et al. (2004), cutting survival may be limited by their initial reserve, which varies between cutting technique and their lignification degree. In a study conducted with *Acca sellowiana*, Berg.Franzon et al. (2004) found that cuttings of the apical portion of the branches did not survive the 60-day period in a greenhouse. On the other hand, Mantovani et al. (2017) observed a higher survival (100%) and rooting percentage of apical mini-cuttings when compared to basal (60%) mini-cuttings in *Peltophorum dubium*.

The 40% rooting found for basal garapa mini-cuttings at 90 days can be considered median. In species such as *Plinia cauliflora* (DC.) Kausel apical herbaceous cuttings reached a maximum of 10% rooting when submitted to IBA concentrations ranging from 2000 to 4000 mg L^{-1} (Sasso et al., 2010). The best result for *Campomanesia adamantium* (Cambess.) O. Berg was 57% rooting without the use of exogenous auxin collected from hardwood cuttings obtained in May (Martins et al., 2015). In addition, the best result for *Campomanesia aurea* (O. Berg) was 30% for rooting of semi-wood cuttings without positive response to IBA application (Emer et al., 2016). Freitas et al. (2017a) found 53% rooting for *Enterolobium contortisiliquum* (Vell.) Morong produced in mini-greenhouse PET bottles. Pessanha et al. (2018) obtained an average of 16% rooting in *Plathymenia reticulata* without an influence of IBA use.

The effects of IBA on higher dry matter yield, length and/or root number have already been reported by Sampaio et al. (2010) in the rooting of *preciosa* cuttings (*Aniba canelilla* (Kunth) Mez), by Mantovani et al. (2017) in *Peltophorum dubium* mini-cuttings, and by Oliveira et al. (2015) for *Handroanthus heptaphyllus* Mattos mini-cuttings. However, these effects were not verified in the concentrations used in this work.

5. CONCLUSIONS

- The use of mini-cuttings proved to be technically viable for the vegetative propagation of *Apuleia leiocarpa*, with the use of basal cuttings as vegetative propagules being more effective, without the need for IBA.

- IBA was detrimental to the *Apuleia leiocarpa* rooting at the concentrations used, which was reflected in the lower dry matter yield, number and length of mini-cut roots.

- *Hymenaea courbaril* did not adapt to the propagation process via mini-cutting in the conditions under which the experiment was carried out, and further studies with vegetative propagation of this species are necessary.

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