

PROPAGATION THROUGH CUTTING TECHNIQUE OF SPECIES OCCURRING IN THE LOWER SÃO FRANCISCO RIVER IN SERGIPE STATE WITH DIFFERENT CONCENTRATIONS OF INDOLBUTIRIC ACID¹

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ABSTRACT – The objective of this work was to evaluate the feasibility of vegetative propagation through cutting technique of seven tree species with strong occurrence in the riparian forest of the Lower São Francisco River in Sergipe State, under different concentrations of indolbutiric acid at 0, 2500, and 5000 mg.L⁻¹, for potentialization of its use in soil bioengineering technique. It was used a complete random block design with three replicates, and a total of twenty-one treatments. The evaluation period was 120 days for each species, and the data collection was made in intervals of fifteen days, in a total of eight evaluations for each species. The evaluated parameters were: Survival Rate, *callus* formation, and Root Dry matter Weight. Among the studied species, *Schinus terebinthifolius* Raddi presented the best results related to cutting technique mainly under the indolbutiric acid concentration of 2500 mg.L⁻¹.

Keywords: Native species, IBA and Phyto regulators.

PROPAGAÇÃO POR ESTAQUIA DE ESPÉCIES DE OCORRÊNCIA NO BAIXO CURSO DO RIO SÃO FRANCISCO, SOB DIFERENTES CONCENTRAÇÕES DE ÁCIDO INDOLBUTÍRICO

RESUMO – O objetivo deste estudo foi avaliar a viabilidade da propagação vegetativa por meio do método de estaquia de sete espécies arbóreas de grande ocorrência na zona ripária do Baixo Curso do Rio São Francisco sergipano, submetidas a diferentes concentrações do fitorregulador AIB (ácido indolbutírico): 0, 2500 e 5000 mg.L⁻¹, para potencialização de seu uso na composição da técnica de bioengenharia de solos. O delineamento experimental utilizado foi o Inteiramente Casualizado (DIC) com três repetições, totalizando 21 tratamentos. O período de avaliação foi de 120 dias para cada espécie, sendo realizada coleta de dados quinzenalmente, totalizando oito avaliações por espécie. Os parâmetros avaliados foram: Taxa de sobrevivência, Taxa de enraizamento, Número de raízes formadas, Formação de calos e Peso de matéria seca de raízes. Entre as espécies estudadas, *Schinus terebinthifolius* Raddi apresentou os melhores resultados com esse método de propagação, com destaque para a concentração de 2500 mg.L⁻¹.

Palavras-Chave: Espécies nativas, Propagação vegetativa e Fitorreguladores

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1. INTRODUCTION

Due to its length and complexity, the São Francisco River basin is divided into four sections: Upper, Middle, Sub-Middle, and Lower São Francisco. These sections are autonomous allowing a decentralized and Basin-wide management model (ANA/GEF/PNUMA/OEA, 2003). With the implementation of the cascade of dams and other public policies, especially in the sub-middle and lower São Francisco, impacts have been identified, such as the removal of riparian vegetation and accelerated erosion of the banks, causes and effects of changes in the dynamics of the river which gradually reduce productive land area (HOLANDA et al., 2005).

Control of bank erosion can be accomplished in several ways, such as the use of rockfill, which, though efficient, is quite expensive, precluding its use extensively throughout the river banks. In an attempt to solve the problem of the riverine population, many empirical solutions have been made, which do not produce the desired effect, cause problems for the recovery of riparian vegetation in addition to degrading the landscape (HOLANDA et al., 2009).

As an alternative to the empirical practices of the riverines and to the expensive bordering and rockfill biotechniques, the use of abundant raw material has been tested through experimental trials in the lower São Francisco through bioengineering techniques, providing a way of mitigating the problem that can be economically viable and has shown technical efficiency (HOLANDA et al., 2008).

Soil bioengineering is a biotechnology that consists in the use of living materials or inert plant substances, biotextiles, associated or not with rocks, concrete, or metals, presenting themselves to be environmentally sustainable for containment of erosion of embankments at various conditions of slope and soil grain size on the banks of water bodies like reservoirs, irrigation canals, and rivers (DURLO; SUTILI, 2005). According to Gray and Sotir (1996), the vegetation component which has great importance in these biotechnologies has been recognized not only for its aesthetic qualities, but also for its beneficial hydromechanical effects and protection against soil erosion.

Unlike other technologies in which plants are merely an aesthetic component of design, in soil bioengineering they assume an important ecological, economic, and especially structural contribution (ARAUJO et al., 2005).

Currently, with regards to vegetative propagation, taking live cuttings from a matrix plant to grow new plants is one of the most widespread propagation methods of forest species. Cutting is the aseptic culture of shoot tips in nutrient media, with appropriate concentrations of auxin and cytokinin hormones used to promote the induction of growth, proliferation, and rooting (JONES; HATFIELD, 1976; VAZ; NEGUEROLLES, 1979; JAMES; THURBON, 1981; SIMMONDS, 1983; WELANDER, 1983). Cutting presents some advantages such as: fast emergence of a reasonable quantity of seedlings from a single plant matrix; simple technique; absence of common problems found in other processes of vegetative propagation (eg. incompatibility between grafts and rootstock), and low cost (MÉSEN et al., 1997; LANA et al., 2008; ALCANTARA et al., 2008).

The application of phytohormones on species with rooting difficulty can compensate for low levels or even lack of endogenous auxin (WAGNER et al., 1989; PIO et al., 2004). Auxin induces rooting in many species thus providing a higher rate and speed of root formation, and greater quality, uniformity and survival of the root system. (BARBOSA et al., 1985; DUNN et al., 1996; TONIETTO et al., 1997; DIAS et al., 1999).

Little is known about cutting as a technique for vegetative propagation in application with native forest species, both at the experimental and commercial level (XAVIER et al., 2003). Initial results indicate the technical feasibility of vegetative propagation to produce seedlings of *Schinus terebinthifolius* (BAGGIO et al., 1989) and *Mimosa caesalpiniaefolia* Benth (LINS et al., 2006). However there is incipient information about the development of forest species regenerated through this form of propagation.

The objective of this work was to evaluate the feasibility of vegetative propagation through cutting technique of seven woody species with strong occurrence in the riparian forest of the Lower São Francisco River in Sergipe State, under different concentrations of Indolbutiric Acid at 0, 2500, and 5000 mg.L⁻¹, in order to be used as part of the soil bioengineering technique.

2. MATERIAL AND METHODS

Cuttings from seven forest species of wide occurrence in the sedimentary section of the riparian zone of the Lower São Francisco River at Sergipe state located in northeastern Brazil were evaluated, with experimental tests conducted at the greenhouse of the

Universidade Federal de Sergipe. The species were *Schinus terebinthifolius* Raddi (aroeira), *Spondias lutea* L. (cajá), *Inga marginata* Wild (ingá), *Tapirira guianensis* Aubl (pau-pombo), *Lonchocarpus sericeus* (Poir.) D.C. (falso-ingá), *Mimosa caesalpiniaefolia* Benth (sabiá) and *Genipa americana* L. (genipapo).

For the collection of vegetative material, three vigorous trees from each species were selected based on their healthy appearance and built. The material was taken from the basal portion of the individuals, basal cuttings being prepared without leaves, which were taken in the preparation and with lengths between 15 and 20 cm and a diameter between 0.5 and 1.5 cm. After collection, the cuttings were placed in a bucket of water in order not to lose moisture, and then all cuttings were straight cut at the apex and at an angle at the base.

Before planting, the cuttings were immersed in sodium hypochlorite 1%, remaining immersed for one minute, in a black plastic bag recipient of 750 ml. The planting was done on the same day as the collection. Irrigation was done twice daily, in the early morning and late afternoon. The substrate used was black soil, washed sand and coconut coir (2:1:1), which allows for greater moisture retention, nutrient availability, good aeration, allowing for future removal of roots. The base of the cuttings was immersed for 15 seconds at different concentrations of IBA (indolbutiric acid) phytohormone: 0, 2500, and 5000 mg.L⁻¹. There were 30 cuttings in each plot, of which twenty-four were evaluated. Six additional cuttings were kept to replace eventual losses.

The evaluation period lasted for 100 days for each species. Data collection was carried out fortnightly, totaling eight assessments for each species. The evaluated parameters, which considered the total number of cuttings (live and dead), were: Survival Rate, Rooting Rate, Number of Roots Formed, Number of *Calli* Formed, and Root Dry Weight.

The Survival Rate is the number of live cuttings in relation to the total number of cuttings per treatment, given in percentage; Rooting Rate is the percentage number of cuttings that rooted in relation to total cuttings; Number of Roots Formed is determined by counting the number of roots that a cutting produce; Root Dry Weight is determined by collecting and drying the roots in an oven at 60°C for 24 hours, and weighed on a balance accurate to 0.01g; Number of *Calli* Formed is determined by counting the Number of *Calli* that a cutting produced.

The experimental design was completely randomized with three replicates, totaling twenty-one treatments. Treatment effects and their interactions were tested using analysis of variance and significant differences between the means were carried out by using the Tukey test at 95% probability. Cuttings were selected for destructive evaluations, as was the randomized arrangement of treatments.

3. RESULTS

3.1 Survival Rate and Rooting Rate

Cuttings of *S. terebinthifolius* were the only ones to show significant reduced percentage at higher concentrations of IBA, suggesting phytotoxicity between the concentrations of 2500 and 5000 mg.L⁻¹ (Table 1).

The total percentage of rooted cuttings, treated with IBA, varied from 0 to 66.8% (Table 2), showing a wide range, with a development less than desirable for the studied species, since rooting is closely linked to the survival rate. Comparing the concentrations of 2500 and 5000 mg.L⁻¹, there was significant rooting difference for the cuttings of *S. terebinthifolius*. This *species*, in the absence or presence of the hormone, showed different responses in relation to the others, at $p \leq 0.05$, presenting root emissions from the first evaluation. With the application of the hormone, a higher level of rooting was observed, with significant differences between the doses and a clear advantage at the concentration of 2500 mg.L⁻¹, which showed itself to be the most recommended for this parameter.

3.2 Number of Roots Formed and Number of *Calli* Formed

The most significant results for this parameter, as well as also for rooting, were shown by cuttings of *S. terebinthifolius*, showing that the application of indolbutiric acid (IBA) had a positive effect on the formation and root number (Table 3). The number of roots formed for cutting of *S. terebinthifolius* was significantly higher at a dose of 2500 mg.L⁻¹ IBA ($p \leq 0.05$) to that observed in the other species.

S. terebinthifolius also presented better development regarding to the Number of *Calli* Formed, when compared with the other species, in all the treatments, reaching its greatest level at the dose of 2500 mg.L⁻¹ (Table 4).

Table 1 – Survival rate of plant species exposed to different concentrations of indolbutiric acid (IBA).**Tabela 1** – Taxa de sobrevivência das espécies vegetais submetidas a diferentes concentrações de ácido indolbutírico (AIB).

Species	Survival Rate (%)		
	Concentration of IBA (mg.L ⁻¹)		
	0	2500	5000
<i>Schinus terebinthifolius</i>	73.8 aAB*	86.2 aA	68.0 aB
<i>Spondias lutea</i>	69.3 aA	80.7 aA	59.6 aA
<i>Inga marginata</i>	11.1 cA	15.2 cA	12.5 bA
<i>Tapirira guianensis</i>	45.7 bA	41.6 cA	38.7 bA
<i>Lonchocarpus sericeus</i>	40.2 bA	38.7 bA	26.3 bA
<i>Mimosa caesalpiniaefolia</i>	73.8 aA	66.7 bA	65.2 aA
<i>Genipa Americana</i>	47.1 bA	48.2 bA	52.6 aA
C.V. (%)		29.3	

*Means followed by the same lower case letters in a column and capital letters on the lines do not differ significantly by the Tukey test ($p \leq 0.05$). C.V. = coefficient of variation.

Table 2 – Rooting rate of plant species exposed to different concentrations of indolbutiric acid (IBA).**Tabela 2** – Taxa de enraizamento das espécies vegetais submetidas a diferentes concentrações de ácido indolbutírico (AIB).

Species	Rooting Rate (%)		
	Concentration of IBA (mg.L ⁻¹)		
	0	2500	5000
<i>Schinus terebinthifolius</i>	47.1 aB*	66.8 aA	48.6 aB
<i>Spondias lutea</i>	0 aA	1.3 aA	2.7 aA
<i>Inga marginata</i>	0 aA	0 aA	0 aA
<i>Tapirira guianensis</i>	0 bA	0 bA	0 bA
<i>Lonchocarpus sericeus</i>	0 aA	0 aA	0 aA
<i>Mimosa caesalpiniaefolia</i>	2.7 bA	2.7 bA	4.1 aA
<i>Genipa americana</i>	0 aA	0 aA	0 aA
C.V. (%)		69.5	

*Means followed by the same lower case letters in a column and capital letters on the lines do not differ significantly by the Tukey test ($p \leq 0.05$). CV = coefficient of variation.

Table 3 – Number of roots formed for the plant species exposed to different concentrations of indolbutiric acid (IBA).**Tabela 3** – Número de raízes formadas das espécies vegetais submetidas a diferentes concentrações de ácido indolbutírico (AIB).

Species	Number of Roots Formed		
	Concentration of IBA (mg.L ⁻¹)		
	0	2500	5000
<i>Schinus terebinthifolius</i>	49.7 aB*	75.5 aA	43.2 aB
<i>Spondias lutea</i>	0 aA	1.1 aA	1.7 aA
<i>Mimosa caesalpiniaefolia</i>	6.1 bA	2.5 bA	1.2 bA aB
C.V. (%)		53.5	

*Means followed by the same lower case letters in a column and capital letters on the lines do not differ significantly to the level of 5% probability. CV = coefficient of variation.

In the absence of IBA, rooting of *S. lutea* and *M. caesalpiniaefolia* were similar for both, and very different when compared to the *S. terebinthifolius* which presented an increase of 12%.

3.3 Root Dry Weight

Root Dry Weight is associated to Rooting Rate and Number of Roots Formed. By determining the weight of dried roots, it is possible to estimate the

Table 4 – Number of *Calli* formed in plant species exposed to different concentrations of indolbutiric acid (IBA).**Tabela 4** – Número de calos formados nas espécies vegetais submetidas a diferentes concentrações de ácido indolbutírico (AIB).

Species	Number of Calli Formed		
	Concentration of IBA (mg.L ⁻¹)		
	0	2500	5000
<i>Schinus terebinthifolius</i>	5.6 bA *	9.2 bA	4.1 bA
<i>Spondias lutea</i>	14.3 bA	10.1 bA	6.3 bA
<i>Mimosa caesalpiniaefolia</i>	55.0 aB	80.3 aA	48.0 aB
C.V. (%)	36.17		

*Means followed by the same lower case letters in a column and capital letters on the lines do not differ significantly to the level of 5% probability. CV = coefficient of variation.

Table 5 – Root dry matter weight for plant species exposed to different concentrations of indolbutiric acid (IBA).**Tabela 5** – Peso de matéria seca da raiz de espécies vegetais submetidas a diferentes concentrações de AIB (ácido indolbutírico).

Species	Root Dry Weight		
	Concentration of IBA (mg.L ⁻¹)		
	0	2500	5000
<i>Schinus terebinthifolius</i>	1.1 aB*	1.9 aA	1.2 aB
<i>Spondias lutea</i>	0 aB	0.1 aAB	0.4 aA
<i>Mimosa caesalpiniaefolia</i>	0.2 bA	0.3 bA	0.09 bA
C.V. (%)	75.3		

*Means followed by the lower case letters in a column and capital letters on the lines do not differ significantly to the level of 5% probability. CV = coefficient of variation.

quality of the root system produced by the cutting. *S. terebinthifolius* was the species that had the highest mean dry weight (Table 5), as a result of higher rates of rooting and the greater number of roots produced by cuttings (Table 3). These results are in agreement with the results by Nicoloso et al. (1999) for *Platanus acerifolia* Ait., who observed that larger diameter cuttings presented a higher number of roots per cutting, therefore, presenting higher root dry matter.

4. DISCUSSION

When assessing the behavior of species in the absence of IBA (control), it was possible to observe the actual genetic potential of rooting. *M. caesalpiniaefolia* that showed less dependency on the use of this phytohormone when compared to other species, as also observed by Inoue and Putton (2007), who found that the behavior of the Survival Rate of cuttings of a species varies with the concentration of a plant growth regulator.

The use of different concentrations of IBA in the cuttings of the species *S. lutea* and *M. caesalpiniaefolia* did not promote a good *callus* formation, with no significant difference among the data. Fachinello et

al. (2005) reported that *callus* formation is observed as a result of a trauma during the preparation of the cutting, however Hartman et al. (1997) asserts that rooting-inhibiting substances contained in adult plants may be the reason for no *callus* formation. Phytotoxicity by growth regulators is generally due to the fact that auxins, besides being promoters of rooting, also induce hormonal disruption of cuttings in higher concentrations, inhibiting rooting (FRANZON et al., 2004; HERRERA et al., 2004; FOCHESSATO et al., 2006).

The species *S. lutea*, *T. guianensis*, *L. sericeus*, *M. caesalpiniaefolia*, and *G. americana*.) showed differences in Survival Rate, however, the use of hormone in the tested concentrations does not seem to be recommended, since there was no significant differences between treatments ($p > 0.05$).

In the comparison of doses of IBA in each species *S. terebinthifolius* at the dose of 2500 mg.L⁻¹ resulted in an increased level of rooting, but at the maximum dose of IBA a reduction of approximately 37% was observed when compared with the non-application of this hormone. Lima Filho and Santos (2009) emphasize that characteristics of the species and between species, such as vigor, rooting capacity, and survival under

adverse conditions, are determinants for the high values of roots numbers. There was a greater level of rooting in absolute values for *M. caesalpiniaefolia* than in *S. lutea* species, but these were not significant at $p \leq 0.05$. Souza and Lima (2005) demonstrated that the application of IBA in cuttings of *S. lutea* tree reveals no significant effects on rooting.

The cuttings of the species *I. marginata*, *T. guianensis*, *L. sericeus* and *G. americana* showed no root formation under any of the treatments, leading to the dismissal of these cuttings from further evaluation. It is possible that the lack of roots in these species may have occurred due to the type of cutting used, since they were taken from the basal portion of the stem. The works of Couvillon (1988), Alvarenga and Carvalho (1983), and Hartmann and Kester (1990) conclude that the degree of lignification increases from the apex to the base of the stems, where the tissues present a higher degree of differentiation, hindering the resumption of the meristematic condition, essential for root initiation.

The use of different concentrations of IBA in the cuttings of the species *S. lutea* and *M. caesalpiniaefolia* did not promote a good callus formation, both showing a similar development, with no significant difference between the data. In agreement with Fachinello et al. (2005), callus formation is observed as a result of a trauma during the preparation of the cutting, however, the rooting-inhibiting substances contained in adult plants may be the reason for no callus formation (HARTMANN et al., 1997).

When comparing the variation of the hormonal doses in each species a greater rooting was verified in the presence of IBA, with a better performance of the *S. terebinthifolius* statistically significant at the 5% level, in disagreement with the rooting of the species *S. lutea* and *M. caesalpiniaefolia*. These results are in agreement with the observations by Nicoloso et al. (1999) who working with *Platanus acerifolia* Ait. verified that the cuttings of larger diameter presented a higher number of roots per cutting, than those of smaller diameter, therefore, presenting higher root dry matter.

The similarity in the absence of IBA to the dose of 5000 mg.L⁻¹, showed no significant results for the species *M. caesalpiniaefolia* and *S. lutea* in the number of roots formed, probably due to the interaction between

IBA and substrate that influences the moisture content at the base of the cutting as mentioned by Lima et al. (2007). The absorption of water by the cutting is directly related to the degree of contact between it and the water film around the particles in the substrate, with higher absorption occurring with greater volume of water retained by the substrate (DAVIS et al., 1986).

Considering that the capacity of a cutting to emit roots is a function of endogenous factors and environmental conditions, maybe the pH of the substrate (6.2) may have positively influenced the production of roots of *S. terebinthifolius*. Depending on the plant species, pH between 5.5 and 6.5 is considered ideal for rooting cuttings (FACHINELLO et al., 1994). Coconut coir may also have contributed to improving the porosity of the substrate, allowing better gas exchange with the environment, and, consequently, contributing for a better performance of the cuttings of the species *S. terebinthifolius*.

S. terebinthifolius also developed well and had greater values of Root Dry Weight at a 2500 mg.L⁻¹ IBA concentration (Table 5), without significant difference between the control and the highest tested concentration. *S. terebinthifolius* and *M. caesalpiniaefolia* showed that increasing concentrations of this growth regulator caused a stimulation effect on the roots up to a certain value, from which, larger increases showed an inhibitory effect.

One factor that may have contributed to the low values of Root Dry Weight in the *S. lutea* species was the absence of leaves, which were taken in the preparation, as mostly recommended. Nevertheless, Bacarin et al. (1994) concluded that the greater dry weight material of roots from cuttings of Guava tree (*Psidium guajava*, L) is due to the increased use of photosynthetic material stored in the leaves, providing the survival and development of the cuttings.

5. CONCLUSIONS

The application of IBA allowed a direct relationship between Survival Rate and Rooting Rate, although the development of the species for the evaluated parameters presented differences on the concentrations of the hormone applied to the cutting. The species *S. terebinthifolius* showed the best results with the application of the hormone, especially at the concentration of 2500 mg.L⁻¹. The species *M. caesalpiniaefolia*

presented a greater degree of dependence on the application of the hormone in relation to the other species, providing significant results only with its presence.

Under the tested conditions and among the studied species, *S. terebinthifolius* seems to be the most suitable species for this method of propagation, enabling its use as part of the soil bioengineering techniques.

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