Australian Journal of Crop Science AJCS

AJCS 17(8):631-638 (2023) ISSN:1835-2707
doi: 10.21475/ajcs.23.17.08.p3892

Mini-cutting as a technique to propagate *Tabebuia aurea*, an important tree found in tropical dry forests

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Abstract

Tabebuia aurea is a hardwood species from Brazil. This species yields high-quality wood for diverse applications and has a high value in phytosociological importance, but little has been done regarding an effective propagation method for large-scale production in nurseries. Alternatively, vegetative propagation techniques such as mini-cutting technology (an evolution of the cuttings technique) can be used, which has the potential to facilitate mini-stumps (stock plants), productive capacity, and vigour of the propagules (mini-cuttings). Therefore, this paper aimed to establish a protocol for vegetative propagation using the mini-cutting technique for *Tabebuia aurea*. For this, four independent experiments were conducted: the first evaluated the survival and production of mini-stumps between four harvests; the second tested the interaction between mini-cutting types (apical and intermediate) and different concentrations of indole-3-butyric acid (IBA; 0, 2.000, 4.000, and 6.000 mg.L^{-1}) on adventitious rooting; the third analysed the effect of leaf area reduction (0%, 50%, 75%, and 100%) on mini-cuttings; and the fourth verified the substrate effect (100% coconut fibre, 50% coconut fibre + 50% commercial organic compost, and 100% commercial organic compost) on mini-cuttings rooting. The survival; percentage of rooted mini-cuttings; number of roots; length of the largest root; aerial dry mass; and root system dry mass were measured as response variables. The results indicated that all mini-stumps survived four harvests, remained productive, and produced propagules responsive to adventitious rooting. Rooting and mini-cutting survival rates were high, up to 80% without IBA, and the maximum mean setting value of 90% for apical mini-cuttings in the IBA concentration of 2000 mg.L^{-1} and 4000 mg.L^{-1} to intermediate mini-cuttings. Treatments without leaf reduction and with a reduction of 50% promoted better results concerning rooting and plant development. The substrate influences adventitious rooting; coconut fibre + organic compost (1:1) are indicated for the species propagation. For the highest system productivity, apical mini-cuttings with 2000 mg.L^{-1} of IBA, no leaf reduction, and coconut fibre + organic compost (1:1) are recommended as substrates.

Keywords: adventitious rooting; auxins; leaf area; plant propagation; substrate; vegetative propagation.

Introduction

Tropical dry forests, such as Caatinga (Brazilian savannah), are at great risk extremely threatened due to the disorderly use of their plant resources, consequently having their original composition gradually phased out. It is vital to recover the degraded areas of the Caatinga region to mitigate the environmental impacts caused by high deforestation. Therefore, it is essential to understand the species traits and propagation processes to be used in this system to help this recovery.

Tabebuia aurea (Silva Manso), Benth. & Hook. f. ex. S. Moore (Bignoniaceae), native in Brazil and present in the Caatinga and Cerrado biomes, can be used in reforestation stages. It is a tall tree, able to reach 12 to 20 m in height (Nonato et al., 2021), and is used widely in the revegetation of degraded areas, afforestation, for medicinal purposes and the manufacture of furniture (Leite et al., 2021). The species propagates mainly in a seminiferous way: the fruit is of the siliqua type, containing approximately 80 seeds, winged and flat, dispersed by the wind and without dormancy. Some limitations, such as seed dispersal, seed unavailability, and seedlings with high vigour and low quality, hinder species production on a large scale (Freire et al., 2015; Ramos et al., 2021; dos Santos et al., 2021). In general, Caatinga species show irregularity in seed production, which vary according to the rainy season and the duration of the dry season (Oliveira et al., 2011).

Faced with the difficulties encountered in its sexual propagation, the use of vegetative propagation is an alternative for this species' seedling production. The mini-cutting technique has been successfully used in some Caatinga native forest species, and studies have been made with *Sarcomphalus joazeiro* (Mart.) Hauenshild (basionym: *Ziziphus joazeiro* Mart.) (dos Santos et al., 2021) and *Enterolobium contortisiliquum* (Vell.) Morong (Freitas et al., 2018), *Mimosa caesalpiniifolia* Benth (Silva et al., 2022), *Myracrodruon urundeuva* Allemão (Da luz et al., 2020), and *Poincianella pyramidalis* (Freitas et al., 2018).

However, there are no studies underlying the use of vegetative propagation techniques for the seedling production of *Tabebuia aurea*. Considering this aspect, the challenge arises in obtaining information that will help in adapting methodologies for species vegetative propagation, such as the use of rooting means, growth regulators, type, and position of propagule collection, substrate, among others (Aghdaei et al., 2019).

The use of plant growth regulators such as auxins favours adventitious rooting in many forest species, such as *Mimosa caesalpiniifolia* Benth (Silva et al., 2022) and *Khaya grandifoliola* C. DC. (Azevedo, 2021). The application of indole-3-butyric acid (IBA) has been shown to be the most effective regulator in most experiments, especially for forest species (Araújo et al., 2019). The vegetative propagule also influences the emission of adventitious roots, varying according to type, position, and size (Aghdaei et al., 2019; Pimentel et al., 2021).

The leaf area also affects the mini-cutting rooting, the reason why it is necessary to carry out a partial or a total reduction of the leaf on some occasions to reduce excessive transpiration and the umbrella effect of the plant material during the rooting stage (Almeida et al., 2020; Fernandes et al., 2018; Silva et al., 2022). The substrate is also among the factors that influence vegetative propagation and must present traits such as efficiency in the plant's physical support, ability to store water and nutrients, gas exchange, and efficient drainage (Aghdaei et al., 2019; Leite et al., 2021).

For this purpose, the following hypotheses were analysed: (a) *Tabebuia aurea* is suitable for vegetative propagation using the mini-cutting technique, as this technique retains juvenility and produces propagules with better nutritional, water, and physiological conditions that increase rooting; (b) indole-3-butyric acid (IBA) emphasize greater induction of adventitious roots in apical and intermediate mini-cuttings, due to the formation of adventitious roots, being a regenerative process of high complexity and influenced by numerous internal and external factors, including the auxin level; (c) apical mini-cuttings of *Tabebuia aurea* have a higher rooting rate than the intermediate ones, since there is greater production of endogenous auxin, and most transport vessels are functional and have low lignification, which increases the transport of hormones and carbohydrates; and (d) the leaf area influences the rooting and survival of *Tabebuia aurea* mini-cuttings, since the leaves support photosynthesis and carbohydrate accumulation, which are related to the success of adventitious rooting.

Considering the need for studies related to vegetative propagation for Caatinga native species and the absence of this type of study for the *Tabebuia aurea*, this paper aimed to establish a protocol for vegetative propagation for this species using a mini-cutting technique.

Results

Survival and production of mini-stumps in the mini-garden

Initially, it was verified whether the *Tabebuia aurea* mini-stumps would produce shoots and survive the successive cuts. The *Tabebuia aurea* mini-stumps responded with 100% survival in successive prunings and producing buds; the highest number of mini-cuttings (four) were verified on the third harvest, and, consequently, produced 191 mini-cuttings/m^2/40 days, the highest yield (Fig. 1).

Influence of the IBA and the mini-cutting type on Tabebuia aurea adventitious rooting

Subsequently, the influence of the IBA and the mini-cutting type on the adventitious rooting of the produced propagules was verified. In the survival, rooting, and root system dry mass traits, there was a significant interaction ($p<0.05$) among the mini-cutting type factors (apical and intermediate) and IBA concentrations. However, there was no interaction among the factors, and there was no significance of the independent factors ($p>0.05$) for the other traits. The data presented in Fig 2A, Fig 2B, and Fig 2C illustrate that the apical and intermediate mini-cuttings do not differ in terms of survival, rooting, and root dry mass compared to the control treatment without IBA addition. However, at IBA concentrations of 2000 and 4000 mg.L^{-1}, the apical mini-cuttings stand out over the intermediate ones for survival, rooting, and root system dry mass, as expected. However, the intermediate mini-cuttings at the IBA concentration of 6000 mg.L^{-1} present a higher average than apical ones. IBA increases survival, rooting, and root dry mass in apical mini-cuttings at 2000 mg.L^{-1} and 4000 mg.L^{-1} doses, with a reduction in these traits at 6000 mg.L^{-1} doses. On the other hand, in the intermediate mini-cuttings, the IBA concentration of 4000 mg.L^{-1} promoted the highest response to adventitious rooting and survival, but there was no difference in the IBA application on the root system dry mass.

Influence of leaf area on Tabebuia aurea adventitious rooting

Subsequently, a significant influence ($p<0.05$) of leaf area on traits related to rooting and survival of *Tabebuia aurea* mini-cuttings was verified (Table 1). As expected, in the survival and rooting, the best results were verified for the averages of the treatments without leaf reduction and with a reduction of 50% of the foliar area. When we analysed root system dry mass, aerial part dry mass, number of roots, and length of the largest root traits, the best results were verified for the averages of the treatments without leaf reduction, with a reduction of 50% and 75% of the foliar area, while leafless mini-cuttings (100%) were not able to survive and root.

Substrate influence on the rooting of Tabebuia aurea mini-cuttings

Finally, it was verified that the *Tabebuia aurea* mini-cuttings interfered with the means of survival, rooting, root system dry mass, and aerial dry mass, depending on the different types of substrate ($p<0.05$). However, there was no significance ($p>0.05$) for the number of roots and length of the largest root. The highest averages were found for survival, rooting, and aerial dry mass for the substrate composed of coconut fibre + organic compost (1:1) and the organic composite substrate (Table 2). The mini-cuttings cultivated on coconut fibre showed the lowest averages, except for the number of roots and the size of the largest root (Table 3).

Discussion

The first hypothesis tested was validated; that is, *Tabebuia aurea* can be propagated vegetatively by the mini-cutting technique with satisfactory survival and rooting percentages, determinant variables for the success of this technique.

The survival rates of *Tabebuia aurea* mini-stumps were not affected by the four consecutive harvest, considering that there was no mortality during the first experimental period. This process ensures the adjustment of the mini-garden system used in this research, in which the mini-stumps showed a positive performance in the shoot emergence. The

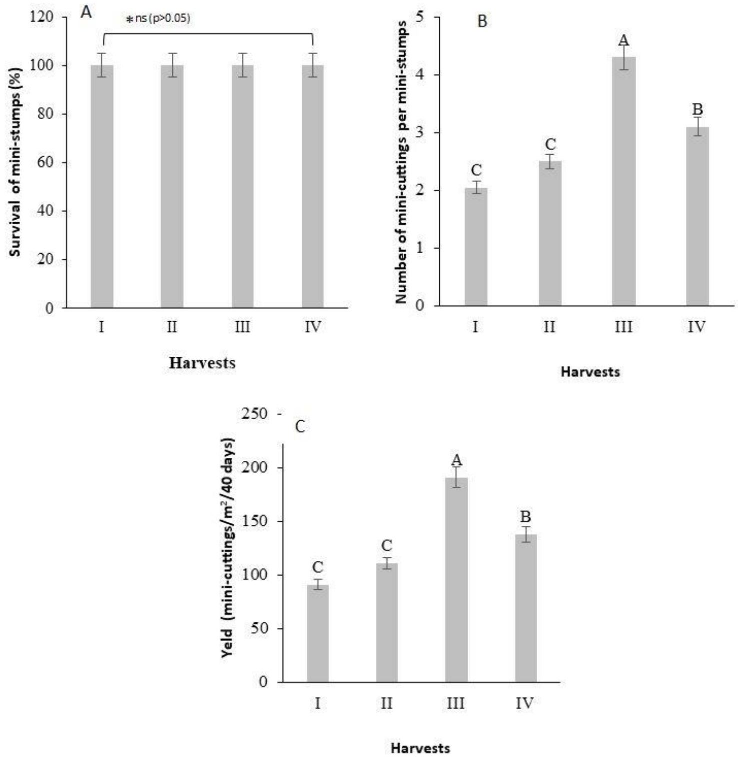

Fig 1. Mini-stump of *Tabebuia aurea*: A - survival (%); B - number of mini-cuttings per mini-stumps; and C - yield (mini-cuttings/m^2/40 days) comparing shoot harvests (I, II, III, and IV) after four successive prunings. Note: Equal capital letters do not differentiate the differ the mini-cuttings harvests by Tukey's test at 5% probability.

results are probably related to the low apical dominance of apical buds, through which there is no inhibition of epicormic buddings (Gibson et al., 2021). These results are also related to the ontogenetic stage of the mini-cuttings from the seeds. In this way, juvenile materials show a trend to grow and develop when they are subjected to different production conditions in propagating systems (Barbosa Filho et al., 2018).

The emerged shoots also showed a good percentage of rooting (Fig. 2B), considering that most commercial forest nurseries generally choose to propagate species with at least 70% rooting (Santos et al., 2020). The high rooting rate found in this study is a result of genetic control, the endogenous balance of the mini-stump, and the propagules produced. It can also be related to physiological, ontogenetic, and morphological factors (Santos et al., 2020).

The second hypothesis that IBA interferes in the rooting of *Tabebuia aurea* mini-cuttings was also confirmed, showing that IBA application increased adventitious root formation. Similar results to other forest species, such as *Melanoxylon brauna* (Gibson et al., 2021) and *Carya illinoinensis* (Hilgert et al., 2021), were found. Auxins play a key role in regulating root development (Daskalakis et al., 2018; Barbosa Filho et al., 2018). Treatment with IBA significantly expands the activities of soluble proteins and ensures a greater flow of these proteins for callus formation and induction of new roots (Shao et al., 2018).

However, root formation can occur without applying auxin, which is why root generation without IBA occurs due to endogenous auxin production by the propagule (Barbosa Filho et al., 2018), as found in this study. In this case, auxin is not a limiting factor for adventitious rooting.

Thus, it was found that in the absence of IBA application, apical mini-cuttings were superior to intermediate cuttings, a fact justified by the greater juvenility of apical propagules in addition to the greater production of endogenous auxin (Correia et al., 2015; De Sá et al., 2022). In addition, factors such as species, genetic, physiological, and anatomical traits show different behaviours in relation to rooting, whether for apical, median, or basal mini-cuttings (De Sá et al., 2022). Thus, the third hypothesis tested was also validated; that is, *Tabebuia aurea* apical mini-cuttings have a higher rooting rate than the intermediate ones. Similar results were previously reported for apical mini-cuttings of *Eucalyptus globulus* clones (Correia et al., 2015) and *Solanum muricatum* (Aghdaei et al., 2019), in which both obtained better means.

Although the emergence of adventitious roots occurs through endogenous processes, such as the metabolism of carbohydrates and auxin, it is known that the use of exogenous auxins helps and promotes the best performance in the rooting of different propagules; however, the concentrations to be used will depend on traits, such as the species, its maturity level, and the concentration in which it is supplied to plants (Wendling et al., 2014). In general, *Tabebuia aurea* has obtained higher means at the lowest IBA concentrations used (2000 and 4000 $mg.L^{-1}$); this trend was also confirmed for *Carya illinoinensis* (Hilgert et al., 2021), *Erythrina crista-galli* (Bisognin et al., 2021), and *Zizyphus jujuba* (Shao et al., 2018), in which the authors found satisfactory results for IBA concentrations between 2000 and 4000 $mg.L^{-1}$.

The attenuation of the adventitious rooting averages for the highest dose (6000 $mg.L^{-1}$ of IBA) would be linked to the juvenility degree of the matrix plant and the propagule,

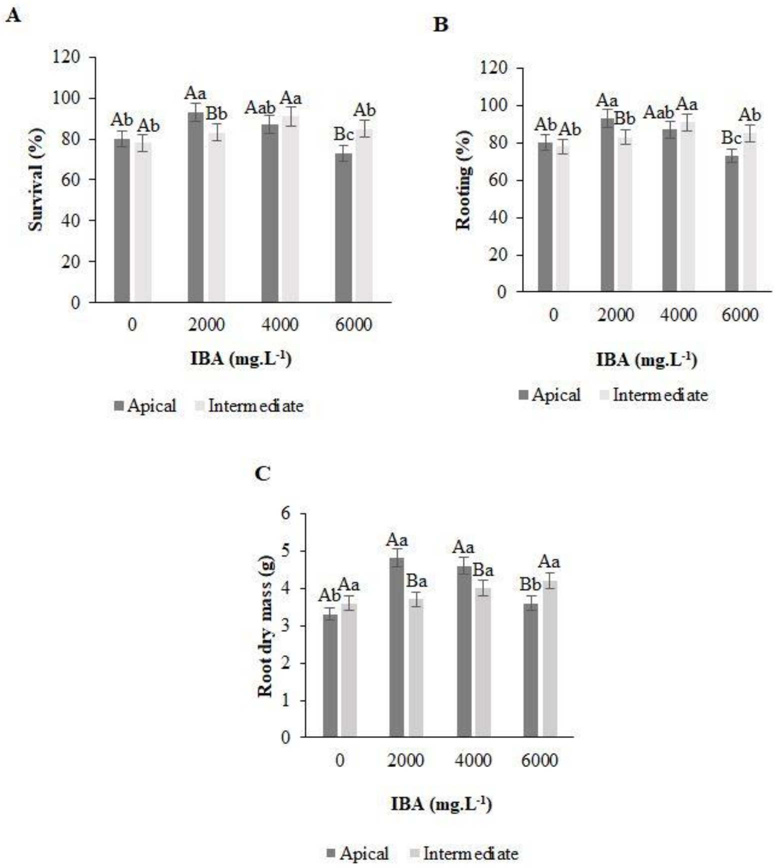

Fig 2. Apical and intermediate *Tabebuia aurea* mini-cuttings, regarding the IBA concentrations (0, 2000, 4000, and 6000 $mg.L^{-1}$): A - survival (%); B - rooting (%); and C - root system dry mass (g). Note: Equal capital letters do not differentiate the differ the type of mini-cutting with the same IBA concentration, and the same lowercase letters do not differ from the IBA concentrations with a type of mini-cutting by Tukey's test at 5% probability.

since the concentration of mini-cutting endogenous auxin (IBA) could be at levels close to satisfactory for the emergence of adventitious roots; however, by continuing to increase exogenous auxin concentrations, the propagule would be suffering with toxicity due to the hormonal imbalance generated (Stuepp et al., 2017; Rinaldi et al., 2017). Thus, for apical mini-cuttings, the IBA concentration of 2000 $mg.L^{-1}$ has higher averages for adventitious rooting than the other concentrations, which is due to the production of endogenous auxin, in addition to having the majority of functional transport vessels and with low lignification, which increases the transport of hormones and carbohydrates, as previously mentioned (Shao et al., 2018).

Therefore, the use of low concentrations of exogenous auxin in cuttings that already have high IBA production (apical mini-cuttings) will positively stimulate adventitious rooting; however, only up to a certain maximum value, after which any increase in the content of this regular plant has an inhibitory effect, in addition to generating necrosis at the mini-cutting basal end (Meneguzzi et al., 2015; Hilgert et al., 2021). This fact explains why the *Tabebuia aurea* intermediate mini-cuttings show higher averages for rooting and survival at the IBA concentration of 4000 $mg.L^{-1}$, that is, they have lower levels of endogenous auxin and consequently lack greater hormonal support. In addition, intermediate cuttings show greater tissue lignification, making rooting difficult and requiring higher auxin contents. This trend was also found in *Sequoia sempervirens* (Pereira et al., 2021), through which the authors found a higher survival and rooting percentage for low-lignified mini-cuttings.

Leaf reduction influenced the rooting and survival of *Tabebuia aurea* mini-cuttings, which confirmed the fourth hypothesis tested. The smallest interferences on the leaf area positively influenced mini-cutting growth and survival, showing higher averages for both traits mentioned. These results are justified because the existence of leaves is considered of fundamental importance for mini-cutting rooting, since the young leaves and buds are the places where the plant syntesises auxin and cofactor, which are translocated through the phloem to the propagule base, promoting exchange activity, xylem differentiation, and root induction (Araújo et al., 2019). Similar results were previously reported for mini-cuttings of other species, such as *Rubus* sp. (Joaquini et al., 2021), *Toona ciliata*, hybrids of *Eucalyptus grandis* x *Eucalyptus urophylla* (Almeida et al., 2020), and *Sequoia sempervirens* (Pereira et al., 2021). These results, therefore, confirm that leaf area maintenance plays a fundamental role in the production of sugars and auxin, among other factors that influence adventitious rooting.

The conduct of leafless mini-cuttings made it impossible for the roots to survive and emerge. These results are attributed to the fact that mini-cuttings with whole leaves or with a low leaf reduction rate tend to provide greater carbohydrate accumulation from the photosynthetic process, favouring a more rapid rooting when compared to the total reduction of the leaf blade, as found in this study (Almeida et al., 2020).

The divergences between the *Tabebuia aurea* mini-cutting rooting in different substrates may be associated with their

Table 2. Survival (%), rooting (%), root system dry mass (RS), aerial part dry mass (AP), average number of roots, and length of the longest root of *Tabebuia aurea* mini-cuttings, regarding the substrate used.

Substrate	Survival (%)	Rooting (%)	Dry mass (g)		Average number of roots	Length of the longest root
			RS	AP		
Coconut fibre	80 b*	80 b	3.72 b	3.91 b	7.51 a	9.08 a
Coconut fibre + organic compost (1:1)	93 a	93 a	5.01 a	6.18 a	4.66 a	7.75 a
Organic compost	87 ab	87 ab	5.36 a	5.73 a	6.12 a	9.12 a

Note: Equal lowercase letters do not differentiate the substrate used by Tukey's test at 5% probability.

Table 3. The physical and chemical traits of coconut fibre, coconut fibre + organic compost (1:1), and organic compost.

Substrate	pH in H_2O	Electrical conductivity ($dS.cm^{-1}$)	Dry density ($kg.m^{-3}$)	Total porosity (%)	Aeration space (%)	Remaining water (%)	Available water (%)
Coconut fibre	6.3	0.5	150	95	40	20	5
Coconut fibre + organic compost (1:1)	5.9	0.5	514.42	77	35	22	6.5
Organic compost	5.7	0.5	878.84	60	30	25	8

different physical and chemical traits. Coconut fibre resulted in the lowest averages when compared to the other treatments. These results can be associated with the high water retention in the coconut fibre, thus causing the cutting to asphyxiate, in addition to a possible chemical deficiency, which, at first, would have affected the mini-cutting rooting and growth (Hussain et al., 2014; Lazcano-Bello et al., 2021). These results were similar to those of other species, such as *Carica papaya* (Oliveira et al., 2018) and *Rubus* sp. (Hussain et al., 2014); both had lower performances using coconut fibre alone.

On the other hand, better results regarding adventitious rooting are found when adding coconut fibre to the organic composite substrate. It is noticed that there is a better adjustment of pH, density, total porosity, aeration, and water availability when there is a combination of organic compost and coconut fibre (Table 3). These traits together justify the better propagule performance regarding adventitious rooting using organic compost and coconut fibre as substrate. The substrate's chemical and physical composition are essential attributes for the optimal development of adventitious roots in mini-cuttings, taking into account that both factors are related to some species' rooting response, as these factors will influence the processes of gas diffusion and aeration in the substrate (Hilgert et al., 2021).

Materials and methods

Plant materials

The stock plants (mini-stumps) were grown in the nursery at Universidade Federal Rural of Semi-árido, in Mossoró, Rio Grande do Norte state. The climate of the region is dry semiarid; the average temperature of the region is 27.4°C, with an average relative humidity of 68.9%, very irregular annual rainfall, with an average of 673.9 mm and a drought period of six to eight months (Melo et al., 2020).

Mini-cutting is an evolution of the cutting technique, differing mainly as to the nutritional, physiological, and phytosanitary control of the produced propagules (mini-cuttings) (Stuepp et al., 2018). Mini-stumps (stock plants) can be produced by rooted cuttings or seedlings to form mini-gardens. In this study, they were produced from seedlings. First, seeds were collected from 20 trees of *Tabebuia aurea*. In sequence, they were sown in trays of 15 cm^3 capacity with a substrate consisting of 50% organic compost and 50% coconut fibre, then kept in a shade house (50% light), and irrigated three times a day until they reached 5 cm in height. Afterwards, the seedlings were taken to a sand-suspended bed containing medium-grain sand to support the mini-stumps placed at a spacing of 15 cm x 15 cm and kept under full sun. When they reached 15 cm in height, the apical dominance was cut (the apical bud), leaving the seedlings 10 cm in height to form the mini-stumps (Figure 3).

The mini-garden was kept in the open air, adopting the semi-hydroponic system. The nutrient solution used in the fertigation consisted of the following salt concentrations: (a) 117.0 $mg.L^{-1}$ of N in nitrate form; (b) 15.75 $mg.L^{-1}$ of N in ammonium form; (c) 14.63 $mg.L^{-1}$ of P; (d) 131.62 $mg.L^{-1}$ of K; (e) 84.0 $mg.L^{-1}$ of Ca; (f) 25.21 $mg.L^{-1}$ of Mg; (g) 73.28 $mg.L^{-1}$ of S; (h) 0.01 $mg.L^{-1}$ of B; (i) 0.02 $mg.L^{-1}$ of Cu; (j) 69.73 $mg.L^{-1}$ of Fe; (k) 0.03 $mg.L^{-1}$ of Mn; (l) 0.008 $mg.L^{-1}$ of Zn; and (m) 0.0016 $mg.L^{-1}$ of Mo (Pimentel *et al.*, 2021). The electrical conductivity of the nutrient solution was maintained from 1.5 to 2.0 mS m^{-2} at 27 ºC.

The mini-cuttings (sprouts produced from mini-stumps) were obtained every 40 days, with a size from 5 to 10 cm (Figure 3). To perform Experiments 2, 3, and 4, the mini-cuttings were prepared as follows: (a) mini-cuttings collected from the mini-stumps; (b) immersion (10 seconds) of the mini-cutting base in indole-3-butyric acid (IBA); (c) conditioning of the mini-cuttings in tubes of 55 cm^3 capacity, containing commercial substrate. Next, the mini-cuttings were taken to a greenhouse with a relative humidity above 80% and a temperature from 28°C to 30°C, remaining until more than 50% of mini-cuttings were rooting (propagules with roots being observed at the lower end of the tube). Subsequently, they were taken to a 50% shading house for 15 days, and irrigated twice a day with 20 mL of water per tube. Finally, the seedlings were taken to an area of full sun, where they remained for 15 days and were irrigated with 15 mL of water per tube twice a day.

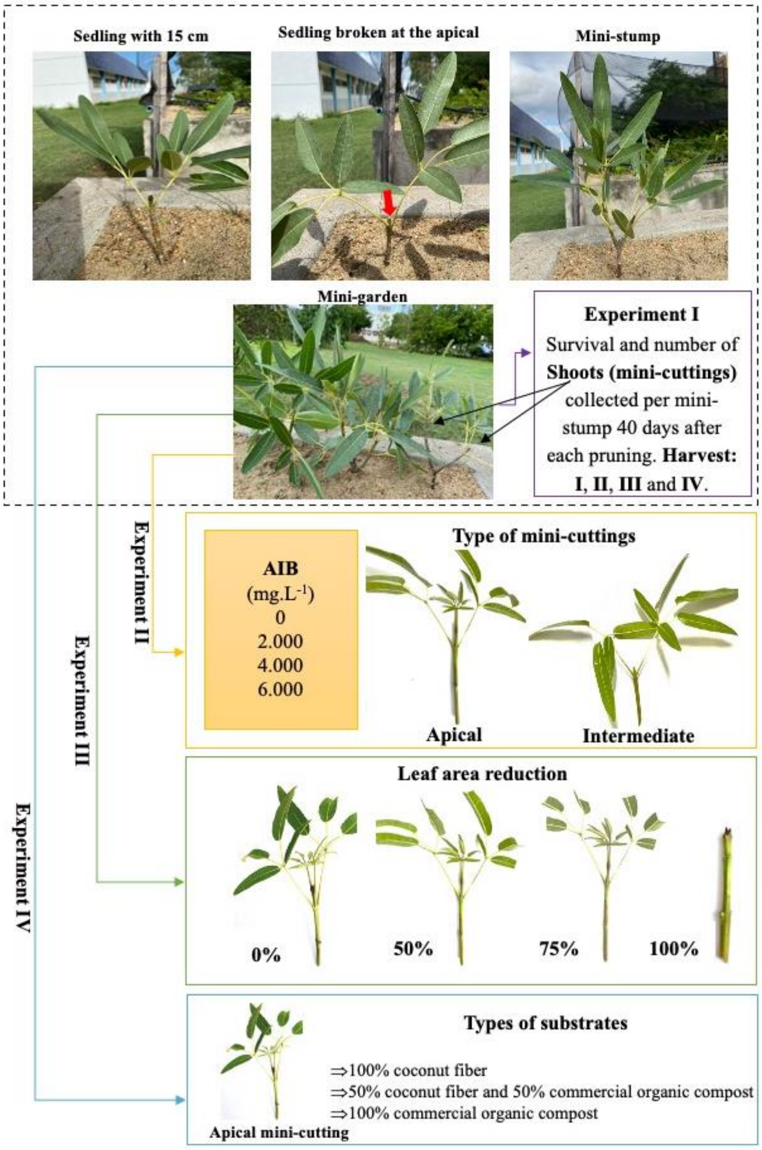

Fig 3. Experimental procedure for the vegetative propagation of *Tabebuia aurea* using a mini cutting technique.

Experimental design

Experiment 1: Survival and production of mini-stumps in the mini-garden

The mini-stump was pruned every 40 days, a period determined by the existence of sprouts with minimal size for producing mini-cuttings. Every 40 days, after each pruning, survival and production were assessed on existing mini-stumps, observing the number of sprouts per mini-stump and the number of mini-stump survivors (Figure 3). The yield of mini-cuttings was calculated from the ratio between the number of mini-cuttings produced per m^2 per 40 days. The mini-stumps were implanted in a completely randomized design with three replicates and 60 mini-stumps per replicate.

Shoots were collected from mini-stumps after four prunings, and the data was compared between harvests (Harvest I, Harvest II, Harvest III, and Harvest IV). Subsequently, the data were subjected to analysis of variance. When a difference was observed between collections using the F-test ($p < 0.05$), the Tukey test was performed instead to compare means.

Experiment 2: Influence of IBA and mini-cutting type on *Tabebuia aurea* adventitious rooting

The buds were segmented into apical (mini-cuttings taken from the apical portion of branches, obtained from the apices of any branch containing the apical bud) and intermediate (mini-cuttings taken from the basal portion of the branch, obtained from any node other than the most distal) mini-cuttings 10 cm in size, as illustrated in Figure 3. The mini-cutting bases (2 cm) were immersed for 10 s in water (without IBA), and in 2000, 4000, or 6000 $mg.L^{-1}$ of IBA. The experiment was set up in a 2 × 4 factorial scheme (2 types of cuttings and 4 IBA concentrations), in a randomised block design, three replicates, and 14 mini-cuttings per plot.

Experiment 3: Influence of leaf area on *Tabebuia aurea* adventitious rooting

Apical mini-cuttings 10 cm in size were immersed for 10 s in IBA solution at a concentration of 2000 $mg.L^{-1}$, with the following treatments referring to leaf area: (a) no leaf area reduction (0%); (b) leaf area reduction by 50%; (c) leaf area reduction by 75%; and (d) 100% of leaf area removed (Figure 3). The experiment was established in a randomised block design with three replicates and 14 propagules per plot.

Experiment 4: Substrate influence on the rooting of *Tabebuia aurea* mini-cuttings

Apical mini-cuttings, with no leaf area reducing, had their bases immersed in IBA solution at a concentration of 2000 $mg.L^{-1}$, and, in sequence, they were planted in three types of substrates: (a) 100% coconut fibre; (b) 50% coconut fibre and 50% commercial organic compost; and (c) 100% commercial organic compost (Figure 3). The main physical and chemical traits of the substrates are shown in Table 3. A randomised block design was adopted with three replicates and 14 mini-cuttings per plot.

Experimental evaluations

In Experiments 2, 3, and 4, described above, the following traits were evaluated: (a) survival; (b) percentage of rooted mini-cuttings; (c) number of roots; (d) length of the longest root; (e) aerial part dry mass; and (f) root system dry mass. Survival was considered by the presence of roots and leaves in the propagules. The mini-cuttings considered rooted were those with roots equal to or greater than 0.5 cm. The number of roots was obtained by counting the roots that emerged at the base of the cutting. The length of the longest root was taken with a millimetre ruler. The aerial part dry mass and root dry mass were obtained with a scale after the plant material remained in a drying oven at 65°C for 72 hours.

Statistical analysis

The assumption of data normality was verified by the Shapiro–Wilk test, and variance homogeneity was verified by the Bartlett test at SISVAR® software. The data were subjected to analysis of variance, and where the F-test was significant ($p < 0.05$), the Tukey test, at 5% significance level, was carried out.

Conclusion

The experiments showed that it is possible to use mini-cuttings as a vegetative propagation technique to multiply the *Tabebuia aurea* species, aiming to assist in recovering degraded areas and commercial plantation production. Mini-stumps obtained from seeds tolerate successive pruning and produce propagules responsive to adventitious rooting. Apical mini-cuttings have higher survival and rooting rates. For apical mini-cuttings, the use of IBA at a concentration of 2000 $mg.L^{-1}$ favours adventitious rooting, while the recommended concentration for intermediate mini-cuttings is 4000 $mg.L^{-1}$.The substrate influences adventitious rooting, and superior results were found for the treatment with coconut fibre associated with organic compost (1:1). Maintaining the leaf area promotes adventitious rooting.

Acknowledgements

We are grateful to the Rural Federal University of Semiarid - UFERSA, and the team at Plant Improvement and Propagation, for their support in the execution of this research.

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