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PROPAGATION OF *SPONDIAS* SPECIES BY CUTTINGS OF DIFFERENT LENGTHS TREATED WITH SUGARS

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Summary: *Spondias cytherea* Sonn. and *S. purpurea* L. (Anacardiaceae) are fruit species greatly appreciated in the tropics. However, they are difficult to cultivate because scions are hard to propagate. Many efforts have been made to develop techniques using auxins for propagation of *Spondias* from cuttings. We believe, however, that the selection of better quality cuttings and their treatment with carbohydrates could be effective at lower expense. We tested cuttings of different lengths (100, 150 and 200 mm) treated with different concentrations (0, 15, 30 and 45 g L^{-1}) of two different carbohydrate types: refined sugar as cheaper treatment and pure sucrose as a control, in the propagation of *S. cytherea* and *S. purpurea*. For *S. cytherea* cuttings of 150 mm were sufficient for good rooting and emergence of new shoots. However, for *S. purpurea* better results were obtained with 200 mm cuttings. For both species there were tendencies for better rooting and emergence of new shoots when the cuttings were treated with sucrose. However, (1) since the use of refined sugar is far less expensive than sucrose, and (2) the difference in rooting of cuttings was not remarkable, we recommend the use of refined sugar for the propagation of *Spondias* scions. There was no significant difference among the carbohydrate concentrations tested for either species.

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Keywords: Carbohydrates; clonal propagation; rooting; *Spondias cytherea*; *Spondias purpurea*.

INTRODUCTION

Spondias cytherea Sonn. (known as ambarella, cajarana, and golden apple) and *S. purpurea* L. (known as jocote, ciruela mexicana, ceriguela, and hog plum) (Anacardiaceae) are species that are greatly valued for the taste of their fruits. In most countries, the fruits are sold in local markets and consumed fresh, making a significant contribution to the diets of people in the tropics. The fresh or

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dried fruit can be made into jellies, sauces or preserves. They are a good source of minerals and vitamin C (Campbell and Sauls, 1994). However, these species have not been fully domesticated, as evidenced by the great morphological diversity among individuals. *Spondias* are still difficult to cultivate, particularly due to the lack of effective protocols for scion production.

The production of high quality scions from selected individuals requires the development of cloning methods. In recent years, many efforts have been made to develop techniques to propagate *Spondias* from cuttings (Lima et al., 2002; Souza and Lima, 2005; Paula et al., 2007) and by grafting (Espíndola et al., 2004; Gomes et al., 2010). The propagation from cuttings has been principally based on the use of auxins for rooting, which can be prohibitively expensive. Nonetheless, propagation of *Spondias* species with cuttings treated with indolbutiric acid shows either no effect (Souza and Lima, 2005) or inconsistent effect, e.g. only herbaceous cuttings rooted (Lima et al., 2002; Paula et al., 2007). Therefore, we believe that the selection of better quality cuttings, as well as their treatment with carbohydrates, may be more simple and cost-effective. Therefore, we tested cuttings of *S. cytherea* and *S. purpurea* of three different lengths treated with refined sugar, which is readily available and inexpensive. To verify if any inhibitory effect would be provoked by the refined sugar, as a control we also treated the cutting with pure sucrose.

MATERIALS AND METHODS

The experiment was conducted at Universidade Federal Rural do Semi-Árido, in Mossoró, RN, Brazil (5º11' S and 37º20' W) in a shaded greenhouse. During the experiment, the mean midday photosynthetically active radiation was about 1,000 mol m^{-2} s^{-1}. Three different cutting lengths (100, 150 and 200 mm) were obtained from *Spondias cytherea* and *S. purpurea* adult plants located on the university campus. The cuttings were in early leaf-out stage. Immediately after their removal from the donor plants, cuttings were defoliated and treated with one of four concentrations (0, 15, 30 and 45 g L^{-1}) of pure sucrose (Reagen, Curitiba, Brazil) or refined sugar solutions, prepared in distilled water. The basal parts of the cuttings were immersed in the solutions for 1 h, then the cuttings were planted in Styrofoam trays with 128 cells (2 × 2 × 4 cm) using vermiculite as substrate. The trays were daily manually irrigated. After 100 days, we evaluated scion development by two criteria: the dry mass of roots as a measure of rooting success, and the dry mass of shoots (leaves plus stems) as a measure of shoot success.

The experiment was conducted with a completely randomized three-factor (three cutting sizes × two carbohydrate types × four carbohydrate concentrations) plot design, with four replicates per treatment. After checking the homogeneity of variances and normality with the Fligner-Killeen and Shapiro-Wilk tests, respectively, the data were submitted to a three-way analysis of variance to identify interactions among factors. Student's *t* test ($\alpha = 0.05$) was employed to establish the effect of treatments. Data analysis and graph generation were made with version 2.13.1 software R (R Development Core Team, 2012) run on a Linux platform, according to Crawley (2007).

RESULTS

Both cutting size and carbohydrate type affected scion success as measured both by rooting and emergence of new shoots in both *Spondias cytherea* and *S. purpurea* (Tables 1 and 2). For *S. cytherea* cuttings of 150 mm were sufficient for good rooting and emergence of new shoots (Fig. 1). However, cuttings not treated with carbohydrates produced the worst results (Fig. 1b and d). For *S. purpurea* better results were obtained with 200 mm cuttings (Fig. 2). There were no significant differences among carbohydrate concentrations tested for either species (Tables 1 and 2), except for the cuttings of 150 mm of *S. cytherea*, where 15 g L^{-1} for both carbohydrate types tested tended to induce better results (Fig. 1). For *S. cytherea* we found a tendency for better rooting and production of new shoots for sucrose as compared to refined sugar (Fig. 1).

DISCUSSION

The nutritional status of donor plants may exert great influence on successful rooting of cuttings, since the root initiation process requires energy (Hartmann et al., 1990). In genotypes where the cuttings produce roots easily, the reserves are generally higher than in genotypes with poor rooting (Hartmann et al., 1990). Therefore, in spite of other physiological factors related to the age of cuttings, we may suppose that bigger cuttings have more energy reserves, thus producing higher quality scions. For *S. cytherea*, cuttings of 150 mm were sufficient for production but for *S. purpurea* bigger cuttings, probably longer than 200 mm, should provide better results for the propagation of this species.

The physiological status of the stock plant at the time when cuttings are excised is of utmost importance for the subsequent rooting process (Hansen et al., 1978)

Table 1. Three-way analysis of variance (*F* values) of the effect of cutting sizes, carbohydrate types, and carbohydrate concentrations on root dry mass (RDM) and shoot dry mass (SDM) of *Spondias cytherea* cuttings. Levels of significance: $^{***}P \leq 0.001$; $^{**}P \leq 0.01$; $^{*}P \leq 0.05$; absence of an asterisk denotes a non-significant effect.

	RDM	SDM
Cutting sizes (I)	3.90*	20.09***
Carbohydrate types (II)	7.75**	35.52***
Carbohydrate concentrations (III)	0.79	1.84
I x II	2.16	3.67*
I x III	0.83	0.59
II x III	0.68	1.49
I x II x III	0.83	0.72

Table 2. Three-way analysis of variance (*F* values) of the effect of cutting sizes, carbohydrate types, and carbohydrate concentrations on root dry mass (RDM) and shoot dry mass (SDM) of *Spondias purpurea* cuttings. Levels of significance: $^{***}P \leq 0.001$; $^{**}P \leq 0.01$; $^{*}P \leq 0.05$; absence of an asterisk denotes a non-significant effect.

	RDM	SDM
Cutting sizes (I)	13.32***	8.27**
Carbohydrate types (II)	6.21*	35.52***
Carbohydrate concentrations (III)	1.52	0.26
I x II	1.30	2.47
I x III	0.58	0.95
II x III	0.38	1.03
I x II x III	1.01	1.68

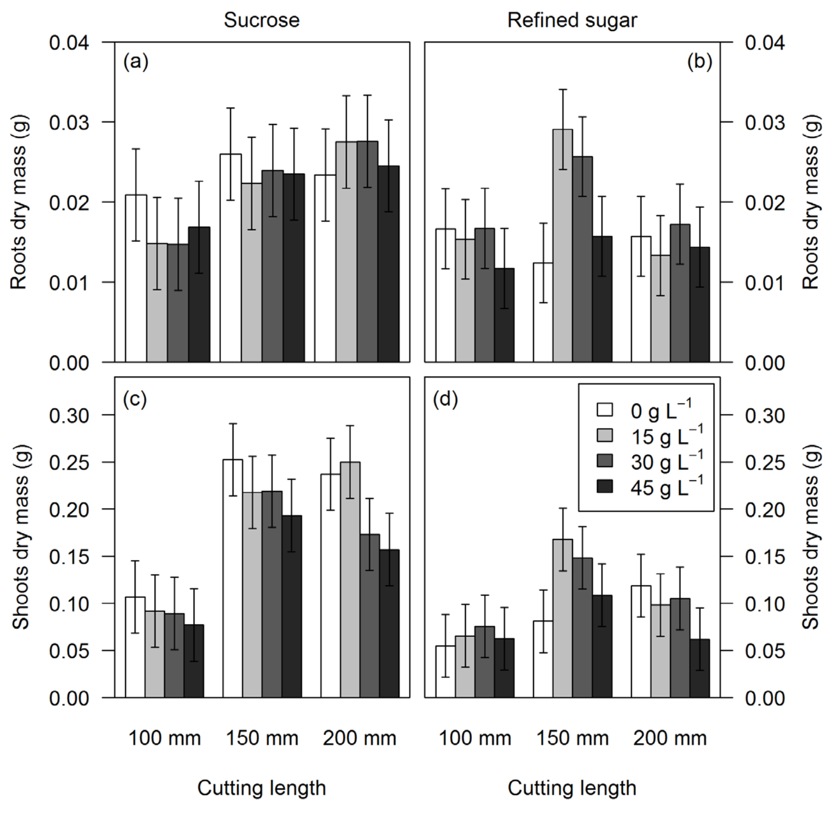

Figure 1. Root dry mass (a and b) and shoot dry mass (c and d) of *Spondias cytherea* cuttings of different sizes treated with four concentrations (0, 15, 30 and 45 g L^{-1}) of pure sucrose or refined sugar. Bars represent the least significant difference according to the Student's *t* test ($\alpha = 0.05$).

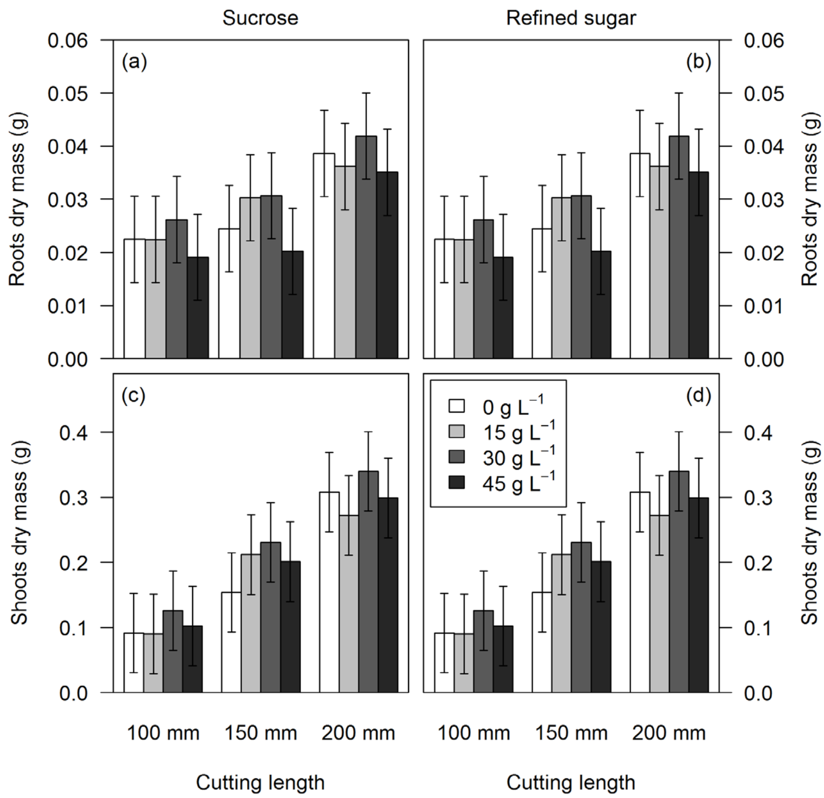

Figure 2. Root dry mass (a and b) and shoot dry mass (c and d) of *Spondias purpurea* cuttings of different sizes treated with four concentrations (0, 15, 30 and 45 g L^{-1}) of pure sucrose or refined sugar. Bars represent the least significant difference according to the Student's *t* test ($\alpha = 0.05$).

and sucrose is considered an essential carbohydrate for the development of roots in stem cuttings (Veierskov et al., 1976). In spite of few studies, the importance of exogenously applied sucrose for rooting of cuttings was reported for *Populus nigra* (Nanda et al., 1968), where auxins had no effect. In addition, Bhattacharya et al. (1985) verified a slight increase in the rooting of *Vigna radiata* etiolated hypocotyl cuttings. In our study, we found a positive effect of carbohydrates in the rooting of cuttings in both species. The slight inhibition of growth caused by refined sugar as compared to sucrose in *S. cytherea* may be related to some component present in the product that should be studied further. Therefore, taking into account that the differences in the rooting of cuttings treated with different carbohydrate types were not remarkable, we recommend the use of refined sugar for scions production in both species, because it is far less expensive than pure sucrose.

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