DOI: 10.5433/1679-0359.2016v37n3p1127

AGRONOMIA

Growth and quality of australian cedar saplings originated from different multiclonal minigarden systems

Crescimento de mudas de cedro australiano oriundas de diferentes sistemas de minijardins multiclonais

Mírian Peixoto Soares da Silva[1*]; Deborah Guerra Barroso[2]; Juliana Sobreira de Souza[3]; Daniele de Alvarenga Ferreira[4]; Taiane Pires de Freitas de Oliveira[5]; Kelly Ribeiro Lamônica[6]; Cláudia Sales Marinho[2]

Abstract

Forestry researchers often evaluate minicutting vegetative propagation of Australian cedar (*Toona ciliata*) as a viable technique for this species. However, the adoption of minigarden systems for commercial propagation still requires viability and quality testing of saplings produced after multiple harvests. In the present work, we evaluate survival, growth, and quality of Australian cedar saplings grown from minicuttings originating from multiple harvests of ministumps planted in gutter or tube systems. Experiments were conducted in a greenhouse using a completely randomized design with a 2 × 4 factorial treatment structure (two minigarden systems and four minicutting harvests). For the gutter system, six minicutting harvests were performed 50, 86, 115, 149, 177 and 212 days after planting ministumps, whereas for the tube system, four harvests were performed 115, 149, 177 and 212 days after planting ministumps. At the end of each sapling production cycle (105 days after each minicutting harvest), saplings were evaluated for survival, foliar area, dry mass of aerial parts, number and length of adventitious roots, dry mass of the root system, height to diameter ratio, ratio between the dry mass of aerial parts and dry mass of root system, and Dickson's Quality Index. Sapling survival was not affected by minigarden system, except for a reduction observed in fourth cycle saplings from the tube system. Sapling quality was also similar between systems. However, sapling growth potential decreased with production cycle, indicating that ministumps lose vigor with multiple harvests.
Key words: Minicuttings. Sapling quality. *Toona ciliata*.

Resumo

A propagação vegetativa por miniestaquia do cedro australiano (*Toona ciliata*) tem sido alvo de pesquisas, mostrando ser uma técnica viável para esta espécie. Entretanto, para a adoção de sistemas de minijardins em canaletão e em tubetes na propagação comercial, ainda é necessário testar a qualidade das mudas produzidas ao longo de colheitas sucessivas. Objetivou-se com este trabalho avaliar a sobrevivência, o crescimento e a qualidade de mudas de cedro australiano, produzidas por

[1] Profª EBTT, Instituto Federal de Educação, Ciência e Tecnologia do Tocantins, IFTO, Campus Avançado Pedro Afonso, TO, Brasil. E-mail: mirian.silva@ifto.edu.br
[2] Profªs, UENF, Campos dos Goytacazes, RJ, Brasil. E-mail: deborah@uenf.br; marinho@uenf.br
[3] Drª em Ecologia e Recursos Naturais, UENF, Campos dos Goytacazes, RJ, Brasil. E-mail: julianauenf@gmail.com
[4] M.e em Produção Vegetal, UENF, Campos dos Goytacazes, RJ, Brasil. E-mail: ferreira.da@gmail.com
[5] Drª em Produção Vegetal, UENF, Campos dos Goytacazes, RJ, Brasil. E-mail: ibitaiane@hotmail.com
[6] Profª EBTT, Instituto Federal de Educação, Ciência e Tecnologia do Tocantins, IFTO, Colinas do Tocantins, TO, Brasil. E-mail: kelly.lamonica@ifto.edu.br
[*] Author for correspondence

Recebido para publicação 01/10/14 Aprovado em 02/03/16

miniestacas, obtidas de minicepas manejadas em sistemas de canaletões e em tubetes, ao longo das colheitas sucessivas. O experimento foi conduzido em casa de vegetação em delineamento inteiramente casualizado em esquema fatorial 2x4 (dois sistemas de minijardins e quatro colheitas de miniestacas). No sistema em canaletão foram realizadas seis colheitas de miniestacas aos 50, 86, 115, 149, 177 e 212 dias após recepagem e quatro no sistema em tubetes aos 115, 149, 177 e 212 dias após recepagem. Ao final de cada ciclo de produção (105 dias a partir de cada colheita), as mudas foram avaliadas quanto à sobrevivência, área foliar, massa seca da parte aérea, número e comprimento das raízes adventícias, massa seca do sistema radicular, as relações entre a altura e o diâmetro, massa seca da parte aérea e a massa seca das raízes e o Índice de Qualidade de Dickson. A sobrevivência das mudas não foi afetada pelo sistema de minijardim, exceto pela redução observada nas mudas produzidas no quarto ciclo do sistema em tubetes. Não há diferença na qualidade das mudas entre os dois sistemas. O crescimento das mudas é reduzido ao longo das colheitas de miniestacas, sugerindo uma perda de vigor das minicepas.
Palavras-chave: Miniestaquia. Qualidade de mudas. *Toona ciliata*.

Introduction

Increasing worldwide demand for timber wood, in addition to heightened concerns with the environment and sustainable development, have led producers to implement afforestation practices with commercial ends. These practices should decrease the pressure on remaining native forests.

In Brazil, forestry studies have focused heavily on the search for new and improved management technologies with increased productivity and better wood quality. In this regard, Australian cedar (*Toona ciliata*, Meliaceae) has shown promising results (GOUVÊA, 2005). This species bears important characteristics from an economic point of view, including a relatively short 15-year cycle, good yields, and high value in the internal and external markets (MURAKAMI, 2008). Moreover, Australian cedar wood resembles Brazilian native cedars (*Cedrela odorata* and *C. fissilis*), adding value to its sub-products.

Producers have usually adopted seed propagation of Australian cedar (LORENZI et al., 2003; PINHEIRO et al., 2003), which bring disadvantages such as irregular production and heterogeneous populations resulting from variable genetic materials. Seasonality and reduced seed viability pose obstacles to production (SCOCCHI et al., 2006). Vegetative propagation by cuttings or minicuttings represents a viable alternative, guaranteeing a steady production of trees and the multiplication of individuals with desired characteristics. According to Santos et al. (2000), minicuttings of *Cedrela fissilis* provide a promising technique for the production of clonal saplings while maximizing quality and uniformity. According to these authors, the use of cuttings represents an option for the propagation of species whose seeds are limited, germinate poorly, or cannot be stored.

The forestry team at UENF has long focused on the vegetative propagation of Australian cedar by minicuttings, and has demonstrated the potential and viability of this technique in numerous works developed by Moraes (2008), Souza et al. (2009), Ferreira et al. (2012), Silva et al. (2012) and Souza et al. (2014). In this body of work, minicuttings were derived from ministumps grown from seeds. However, the adoption of minigarden systems in gutters or tubes for the propagation of Australian cedar will require quality testing of saplings derived from successive harvests of minicuttings.

In this context, the present work aimed at evaluating survival, growth, and quality of Australian cedar saplings produced from minicuttings derived from ministumps managed in gutters and tubes after successive harvests.

Materials and Methods

Experiments were conducted at the Research Support Unit (UAP, from the original Portuguese) at the Norte Fluminense Darcy Ribeiro State University in the municipality of Campos dos Goytacazes, RJ, latitude 21°19′23″S, longitude 41°19′41″W.

Australian cedar saplings were produced from minicuttings with a minimum height of 5 cm, which, in turn, were produced from ministumps kept in two multiclonal minigarden systems using gutters or tubes filled with a commercial forestry substrate (Plantmax®, Eucatex Agro), coconut fiber (Golden Mix®; Amafibra), and filter cake in the proportion of 2:1:1, respectively. This mixture was enriched with 2.2 kg of protected urea and 1.5 kg of simple superphosphate per m^3 of mixture (AZEVEDO et al., 2009). These systems were managed under a greenhouse structure with plastic cover (150-µm agriculture film and 30% netted shade). Ministumps were obtained from seeds from the Seed Production Area (APS, from the original Portuguese) in the city of Venda Nova do Imigrante, state of Espírito Santo.

In the gutters, ministumps were placed at a spacing of 0.15 × 0.15 m, and plants in tubes were transferred to trays at a density of 27 saplings per tray, with a total of 183 ministumps per minigarden system. Every ministump was individually identified, as were the minicuttings from each harvest. When sprouts derived from the ministumps reached a height of 5 cm they were harvested with trimming scissors, and one or two leaves with foliar areas reduced by 60% were kept on each minicutting.

We performed six minicutting harvests from the gutter system and four from the tube system in intervals that varied depending on the growth and vigor of the sprouts. In the gutter system, the first and second harvests were conducted 50 and 86 days after stumps were planted. The succeeding harvests, which took place at approximately 30-day intervals, coincided with tube system harvests at days 115, 149, 177 and 212 after stumps were planted. With every harvest, a new sapling production cycle started, and the saplings from each cycle were managed for 3.5 months (105 days) after minicutting harvest for quality assessment. Only coinciding cycles were included in comparative statistical analyses, comprising a 2 × 4 factorial of two minigarden systems and four sapling production cycles.

Harvested minicuttings were planted without growth regulators in 180cm^3 tubes filled with a forestry commercial substrate (Plantmax®, Eucatex Agro) enriched with an estimated 3- to 4-month supply of slow-release 14-14-14 fertilizer (9 g kg^{-1} of substrate), as per the manufacturer's recommendations. Minicuttings were then placed in a mist chamber with a plastic cover (150µm agriculture film and 30% netted shade) and with intermittent mist spraying every 15 minutes for 20 seconds to prevent dehydration. The minicuttings were kept in the mist chamber for 30 days for rooting, as recommended by Souza (2007). Because air temperature was elevated in the cycles begun at 149 and 177 days after stumps were planted, the mist cycles were altered to 40 seconds every 15 minutes.

In both systems, 20 replications were performed, with a varying number of saplings per experimental group, depending on the number of minicuttings available at each harvest. For the minicuttings originated from gutters, experimental groups contained 12 saplings, while for those originated in tubes, the experimental groups contained 6, 7, 9, and 12 saplings for the production cycles beginning 115, 149, 177, and 212 days after stumps were planted, respectively. After being removed from the mist chamber, the experimental groups were randomly arranged in the greenhouse. Subsequently, every sapling was manually irrigated at least once a day with a hose.

At the end of each production cycle, we selected three saplings from each replication and evaluated sapling survival (SUR), foliar area (FA), dry mass of the aerial parts (DMAP), number and length of adventitious roots (NUM and LEN) and root system mass (RSM). In preparation for this evaluation, saplings were cut at chest height, and FA was measured with a bench electronic measuring device (LI-3000, LI-COR Inc.). Root evaluations were performed after complete removal of soil with the aid of water and sieves. After these initial assessments, both the aerial parts and the root system were separately placed in paper bags, dried in a forced convection oven at 70 ± 2ºC for 72 h, and weighed. Height and diameter measurements were performed with a ruler and digital caliper, respectively.

To determine sapling quality, we first calculated height-diameter ratio (HDR) and the ratio between aerial dry matter and root dry matter (RAR) and then calculated the Dickson Quality Index (DQI) using the formula DQI = TDM/(HDR+RAR) (DICKSON et al., 1960), where TDM represents total dry mass. Data were submitted to analysis of variance, and means were compared by Tukey's test at a 5% significance level.

Results and Discussion

There was interaction between the factors minigarden system (gutters and tubes) and production cycle for the variables height, diameter, RSM, and SUR in the coinciding cycles (Table 1). All evaluated dendrometric characteristics decreased with increasing production cycle except for diameter of saplings from tube system, which also showed a progressive decrease but increased again in the last cycle. This finding suggests loss of ministump vigor, which affected adventitious root growth of the propagules. The pattern observed may result from increased nutrient extraction, especially of nitrogen and potassium, due to the successive minicutting harvests (SOUZA et al., 2014). In multiclonal minigardens such as the ones used here, where ministumps originate from seeds, nutritional requirements may vary with genotype and have an effect on the outcome of the experiment. However, this effect may be corrected through adequate fertilizer management.

We observed that saplings from the gutter system were taller in the first two coinciding cycles but 21% shorter in the penultimate cycle compared to saplings from the tube system (Table 1). Average sapling heights from the gutter and tube systems were 17.2 and 15.4 cm, respectively. Saplings from the third and fifth cycles did not display differences in diameter between the two systems. In spite of the observed differences in height and diameter, no differences could be detected in sapling DMAP and FA from the two systems.

Saplings from the tube system had a larger number and length of adventitious roots in comparison with gutter saplings. These findings resemble those reported by Silva et al. (2012) for Australian cedar saplings originated from minicuttings in the same systems. In the last production cycle, we observed reductions of 43.6% and 17.3% in the number and length, respectively, of adventitious roots in comparison to saplings from the third cycle (Table 1).

The RSM of saplings originated from tubes in the first coinciding cycle was greater than the RSM of third-cycle gutter saplings. In the last cycle, however, this pattern was inverted, and RSM of tube saplings was, on average, 29% lower than that observed in gutter saplings (Table 1). The latter finding suggests the presence of thinner roots in tube saplings, because no differences were observed in root number and length. Thinner roots have greater capacity to absorb water and nutrients, and may represent an adaptive advantage in the stressful conditions that occur soon after planting (FREITAS et al., 2005).

Survival of saplings derived from the two systems exceeded 90% (Table 1). This value falls within the survival range of 80% to 100% usually observed in greenhouse culture. Values fluctuate within this range depending on greenhouse characteristics and management system adopted. In previous work with *Eucalyptus dunnii* minicuttings, sapling survival was 100% upon their leaving the greenhouse, whereas this rate was 90% in the 90 days after planting the sprouts (SOUZA JUNIOR; WENDLING, 2003). Wendling et al. (2007) reported a survival rate of 85.6% for yerba mate saplings obtained from minicuttings. Other authors also obtained 100% survival of Australian cedar saplings produced from minicuttings (SOUZA et al., 2009)

Table 1. Height, diameter, foliar area, dry mass of aerial parts, number of adventitious roots, length of adventitious roots, dry mass of root system e survival of *Toona ciliata* saplings, 105 days after minicutting, depending on production cycle and multiclonal minigarden systems, gutter and tube.

Production cycle	Height (cm)			Diameter (mm)		
	Systems		Average	Systems		Average
	C	T		C	T	
1	14.8	----		4.8	----	
2	14.1	----		5.1	----	
3	26.7 Aa	19.7 Ba	23.2	5.2 Aa	5.2 Aa	5.2
4	21.0 Ab	18.3 Ba	19.6	5.7 Aa	5.0 Ba	5.4
5	9.6 Bc	12.1 Ab	10.8	4.1 Ab	4.0 Ab	4.0
6	11.4 Ac	11.4 Ab	11.4	4.0 Bb	5.1 Aa	4.6
Average	17.2	15.4		4.7	4.9	
CV (%)	11.1			15.6		
	Foliar area (cm²)			Dry mass of aerial parts (g)		
1	415.8	----		2.118	----	
2	443.4	----		2.574	----	
3	649.6	601.9	625.8 a	3.203	3.140	3.172 a
4	446.3	432.9	439.6 b	2.569	2.500	2.534 b
5	124.9	145.6	135.2 c	0.756	1.005	0.880 c
6	176.2	138.9	157.5 c	0.873	0.739	0.806 c
Average	349.2 A	329.8 A		1.850 A	1.846 A	
CV (%)	18.2			15.6		
	Number			Length (cm)		Average
1	15.9	----		117.4	----	
2	17.6	----		155.7	----	
3	23.9	22.8	23.4 a	140.3	152.9	146.6 a
4	18.1	21.2	19.6 a	140.0	153.3	146.7 a
5	18.3	25.2	21.7 a	138.9	182.8	160.8 a
6	12.8	13.6	13.2 b	115.2	127.2	121.2 b
Average	18.3 B	20.7 A		133.6 B	154.0 A	
CV (%)	26.4			20.7		
	Dry mass of root system (g)			Survival (%)		Average
1	0.917	----		94.0	----	
2	1.128	----		100.0	----	
3	1.099 Ba	1.429 Aa	1.264	100.0 Aa	100.0 Aa	100.0
4	0.989 Aa	0.985 Ab	0.987	91.1 Aab	94.3 Aa	92.7
5	0.442 Ab	0.477 Ac	0.459	91.1 Aab	97.8 Aa	94.4
6	0.516 Ab	0.366 Bc	0.440	84.4 Ab	73.4 Bb	78.9
Average	0.762	0.814		91.6	91.3	
CV (%)	16.5			14.9		

Averages followed by the same capital letter in the line and tiny column do not differ among themselves by Tukey's test (5%). Cycles 1 and 2 were not included in the statistical analysis.

Physiological and morphological characteristics serve as sapling quality indicators. Producers more often use morphological traits because they are easily obtained with low cost. Sapling quality may be affected by several factors, including genetic material, irrigation, and nutritional management (RUBIRA; BUENO, 1996) as well as size of container and type of substrate (CARNEIRO, 1995).

For the ratios HDR, RAR and DQI, there were interactions between the factors minigarden system and production cycle. In the gutter system, the RAR ratio was greater in the first two cycles compared to subsequent cycles, indicating faster growth of the aerial parts at the expense of the root system, as further confirmed by sapling height, FA, and DMAP. During subsequent cycles, the RAR ratio indicated that there was more balanced growth of roots and aerial parts; however, saplings were less robust, as indicated by the values of DMAP and RSM (Tables 1 and 2). Nevertheless, all saplings in the present study had a DQI above 0.20, which is the minimum value for a high quality sapling (HUNT, 1990).

No differences in RAR among cycles were detected for tube saplings, although decreases were observed in both DMAP and RSM. Between systems, a difference could be detected only in the first coinciding cycle, in which tube saplings had a lower average RAR of 2.23 (Table 2), indicating that these plants displayed better root growth than did gutter system saplings in the same cycle.

Table 2. Averages ratio between aerial dry matter and root dry matter (RAR), height-diameter ratio (HDR) and then calculated the Dickson Quality Index (DQI) of *Toona ciliata* saplings, 105 days after minicutting, depending on production cycle and multiclonal minigarden systems, gutter and tube.

Production cycle	RAR		HDR		DQI	
	Systems		Systems		Systems	
	Gutter	Tube	Gutter	Tube	Gutter	Tube
1	2.44	----	3.00	----	0.57	----
2	2.32	----	2.80	----	0.73	----
3	2.93 Aa	2.23 Ba	5.13 Aa	3.81 Ba	0.54 Ba	0.76 Aa
4	2.65 Aa	2.59 Aa	3.74 Ab	3.63 Aa	0.57 Aa	0.56 Ab
5	1.70 Ab	2.06 Aa	2.38 Bc	2.96 Ab	0.29 Ab	0.29 Ac
6	1.73 Ab	2.15 Aa	2.81 Ac	2.50 Ab	0.30 Ab	0.25 Ac
CV (%)	23.58		15.76		19.95	

Averages followed by the same capital letter in the line and tiny column do not differ among themselves by Tukey's test (5%). Cycles 1 and 2 were not included in the statistical analysis.

Few studies of Australian cedar have reported quality indices. However, such indices have been used in studies of other species to evaluate the quality of saplings grown with different substrates and fertilizer concentrations. In a study of *Coffea arabica,* for example, it was reported that supplementation of a commercial substrate with 10 kg m^{-3} of slow-release fertilizer resulted in average values of HRD, DQI, and RAR of 4.01, 0.21, and 4.71, respectively (MARANA et al., 2008). Souza et al. (2013), who assessed the effects of N and P supplementation on initial growth and quality of canafístula (*Peltophorum dubium)* saplings cultivated in red oxisol soil, reported that the lowest RAR value of 0.99 was achieved in the treatment with the highest dose of P (125.16 mg kg^{-1} of P_2O_5).

Values of HDR decreased with production cycle for saplings from both systems, remaining within a range of 2.38 to 5.13 (Table 2). Higher HDR values reflect a lower diameter-to-height ratio, which could indicate etiolated saplings that are below market standards. Producers can resolve such problems by adapting fertilizer, irrigation, and climate adaptation systems. It is worth noting that, in the present study, saplings were not etiolated. According to Carneiro (1995), the HDR represents one of the most important morphological parameters in the evaluation of sapling growth, although some variation will occur depending on the species. According to this same author, the recommended HDR for *Pinus taeda* ranges from 5.4 to 8.1.

When comparing the DQI of saplings from the two systems, we found differences only in the first coinciding cycle, when gutter saplings had a lower average DQI of 0.54 compared to an average of 0.76 for tube saplings. In both systems, DQI values decreased with production cycle (Table 2), probably as result of decreasing ministump vigor, and indicating the need for minigarden management aimed at maintaining productivity and quality levels.

Conclusions

Regardless of minigarden system, Australian cedar sapling survival remained within acceptable levels, except in the fourth production cycle for saplings produced using the tube system. Sapling growth potential decreased with the number of minicutting harvests, suggesting that ministumps lose vigor with time. Saplings had a similar quality level regardless of system.

References

AZEVEDO, E. B.; MARINHO, C. S.; MUNIZ, R. A.; CARVALHO, A. J. C. Substratos fertilizados com ureia revestida e o crescimento e estado nutricional da muda de citros. *Acta Scientiarum. Agronomy*, Maringá, v. 31, n. 1, p. 129-137, 2009.

CARNEIRO, J. G. A. *Produção e controle de qualidade de mudas florestais.* Curitiba: UFPR/FUPEF; Campos: UENF, 1995. 451 p.

DICKSON, A.; LEAF, A. L.; HOSNER, J. F. Quality appraisal of white spruce and white pine seedling stock in nurseries. *The Forestry Chronicle*, Mattawa, v. 36, n. 1, p. 10-13, 1960.

FERREIRA, D. A.; BARROSO, D. G.; SILVA, M. P. S.; SOUZA, J. S.; FREITAS, T. A. S.; CARNEIRO, J. G. A. Influência da posição das miniestacas na qualidade de mudas de cedro australiano e no seu desempenho inicial no pós-plantio. *Revista Ciência Florestal*, Santa Maria, v. 22, n. 4, p. 715-723, 2012.

FREITAS, T. A. S. de; BARROSO, D. G.; CARNEIRO, J. G. de A.; PENCEL, R. M.; LAMONICA, K. R.; FERREIRA, D. de A. Desempenho radicular de mudas de eucalipto produzidas em diferentes recipientes e substratos. *Revista Árvore*, Viçosa, MG, v. 29, n. 6, p. 853-861, 2005.

GOUVÊA, C. F. *Estudo do desenvolvimento floral em espécies arbóreas da família Meliaceae*. 2005. Tese (Doutorado em Ciências) – Universidade de São Paulo, Piracicaba.

HUNT, G. A. Effect of styroblock design and cooper treatment on morphology of conifer seedlings. In: TARGET SEEDLING SYMPOSIUM, MEETING OF THE WESTERN FOREST NURSERY ASSOCIATIONS, GENERAL TECHNICHAL REPORT RM-200, 1., 1990, Roseburg. *Proceedings...* Fort Collins: USDA, 1990. p. 218-222.

LORENZI, H.; SOUZA H. M. de; TORRES, M. A. V.; BACHER L. B**.** *Árvores exóticas no Brasil:* madeireiras, ornamentais e aromáticas. Nova Odessa: Instituto Plantarum, 2003. 385 p.

MARANA, J. P.; MIGLIORANZA, E.; FONSECA, E. P.; KAINUMA, R. H. Índices de qualidade e crescimento de mudas de café produzidas em tubetes. *Revista Ciência Rural*, Santa Maria, v. 38, n. 1, p. 39-45, 2008.

MORAES, D. G. *Enraizamento de miniestacas caulinares e foliares de cedro australiano e brotações de minicepas.* 2008. Trabalho de Conclusão de Curso (Graduação em Agronomia) – Universidade Estadual do Norte Fluminense Darcy Ribeiro, Campos dos Goytacazes.

MURAKAMI, C. H. G. Cedro Australiano: valorização de espécies nobres. *Boletim Florestal – Informativo Florestal do Norte Pioneiro*, São Paulo, v. 7, n. 2, p. 1-6, 2008.

PINHEIRO, A. L.; LANI, L. L.; COUTO, L. *Cultura do cedro australiano para produção de madeira serrada*. Viçosa, MG: UFV, 2003. 42 p.

RUBIRA, J. L. P.; BUENO, L. O. *Cultivo de plantas forestales en contenedor*. Madrid: Centro de Publicaciones, 1996. 189 p.

SANTOS, G. A. dos; XAVIER, A.; WENDLING, I.; OLIVEIRA, M. L. Uso da miniestaquia na propagação clonal de *Cedrela fissilis* (Cedro-Rosa). In: CONGRESSO E EXPOSIÇÃO INTERNACIONAL SOBRE FLORESTAS, 6., 2000, Porto Seguro. *Resumos...* Rio de Janeiro: Instituto Ambiental Biosfera, 2000. p. 203.

SCOCCHI, A.; DIERINGER, E.; MROGINSKI, E.; MROGINSKI, L. Conservación de semillas de cedro australiano (*Toona ciliata*). *Plant Genetic Resources Newsletter, FAO – IPGRI,* Maccarese, v. 1, n. 137, p. 22-25, 2006.

SILVA, M. P. S.; BARROSO, D. G.; SOUZA, J. S.; FERREIRA, D. A.; CARNEIRO, J. G. A. Enraizamento de miniestacas e produtividade de minicepas de cedro australiano manejadas em canaletões e tubetes. *Revista Ciência Florestal*, Santa Maria, v. 22, n. 4, p. 703-713, 2012.

SOUZA JUNIOR, L. de; WENDLING, I. Propagação vegetativa de *Eucalyptus dunnii* via miniestaquia de material juvenil. *Boletim de Pesquisa Florestal*, Colombo, v. 1, n. 46, p. 21-30, 2003.

SOUZA, J. C. A. V. de. *Propagação vegetativa de cedro Australiano (Toona ciliata M. Roem) por miniestaquia*. 2007. Dissertação (Mestrado em Produção Vegetal) – Universidade Estadual do Norte Fluminense Darcy Ribeiro, Campos dos Goytacazes.

SOUZA, J. C. A. V. de; BARROSO, D. G.; CARNEIRO, J. G. de A.; TEIXEIRA, S. L.; BALBINOT, E. Propagação vegetativa de cedro australiano (*Toona ciliata* M. Roemer) por miniestaquia. *Revista Árvore*, Viçosa, MG, v. 33, n. 2, p. 205-213, 2009.

SOUZA, J. S.; BARROSO, D. G.; SILVA, M. P. S.; FERREIRA, D. A.; GRAVINA, G. A.; CARNEIRO, J. G. A. Produtividade de minicepas de cedro australiano e remoção de nutrientes pela coleta sucessiva de miniestacas. *Revista Ciência Florestal*, Santa Maria, v. 24, n. 1, p. 71-77, 2014.

SOUZA, N. H.; MARCHETTI, M. E.; CARNEVALI, T. O.; RAMOS, D. D.; SCALON, S. P. Q.; SILVA, E. F. Estudo nutricional da canafístula: crescimento e qualidade de mudas em resposta à adubação com nitrogênio e fósforo. *Revista Árvore*, Viçosa, MG, v. 37, n. 4, p. 717-724, 2013.

WENDLING, I.; DUTRA, L. F.; GROSSI, F. Produção e sobrevivência de miniestacas e minicepas de erva-mate cultivadas em sistema semi-hidropônico. *Pesquisa Agropecuária Brasileira*, Brasília, v. 42, n. 2, p. 289-292, 2007.