ISSN 1807-1929
Revista Brasileira de Engenharia Agrícola e Ambiental
v.21, n.2, p.83-87, 2017
Campina Grande, PB, UAEA/UFCG – http://www.agriambi.com.br

DOI: http://dx.doi.org/10.1590/1807-1929/agriambi.v21n2p83-87

Urban solid waste in the production of *Lafoensia pacari* seedlings

Alan H. M. de Abreu[1], Leticia B. Marzola[2], Lucas A. de Melo[3], Paulo S. dos S. Leles[4], Elton L. S. Abel[2] & Jorge M. Alonso[1]

[1] Universidade Federal Rural do Rio de Janeiro/Programa de Pós Graduação em Ciências Ambientais e Florestais. Seropédica, RJ. E-mail: alanhenriquem@gmail.com (Corresponding author); j_makh@hotmail.com
[2] Universidade Federal Rural do Rio de Janeiro. Seropédica, RJ. E-mail: engflorestalleticia@gmail.com; eltonabel@florestal.eng.br
[3] Universidade Federal de Lavras/Departamento de Silvicultura. Lavras, MG. E-mail: lucas.amaral@dfc.ufla.br
[4] Universidade Federal Rural do Rio de Janeiro/Departamento de Silvicultura. Seropédica, RJ. E-mail: pleles@ufrrj.br

Key words:
sewage sludge
urban waste
biosolid

A B S T R A C T

This study aimed to verify the potential of urban solid wastes as substrate for production of seedlings of *Lafoensia pacari*. Five treatments were tested, four with solid wastes and one standard substrate, namely: sewage sludge from Alegria Wastewater Treatment Plant (WTP); sewage sludge from Ilha do Governador WTP; sewage sludge from Sarapuí WTP; domestic garbage compost (Fertlurb); and a commercial substrate made of biostabilized pine bark (standard substrate). The wastes received 20% (in volume) of shredded coconut fiber. At 105 days after sowing, the seedlings were evaluated for different quality parameters. Seedlings produced with Sarapuí WTP sewage sludge showed the best results in all the parameters, followed by seedlings produced with sewage sludge from Alegria and Ilha do Governador WTPs, which did not differ. Seedlings produced with domestic garbage compost showed satisfactory results, higher than the ones observed for seedlings produced with commercial substrate. The urban solid wastes with 20% of coconut fiber showed high potential and can be recommended for the composition of substrate in the production of *Lafoensia pacari* seedlings.

Palavras-chave:
lodo de esgoto
lixo domiciliar
biossólido

Resíduos sólidos urbanos na produção de mudas de Lafoensia pacari

R E S U M O

Objetivou-se, neste trabalho, verificar o potencial de resíduos sólidos urbanos como substratos na produção de mudas de *Lafoensia pacari*. Cinco tratamentos foram testados dentre os quais quatro resíduos urbanos e um substrato padrão, sendo: lodo de esgoto da Estação de Tratamento de Esgotos (ETE) Alegria; lodo de esgoto da ETE Ilha do Governador; lodo de esgoto da ETE Sarapuí; composto de lixo urbano (Fertlurb) e substrato comercial à base de casca de pinheiro bioestabilizada (substrato padrão). Foram acrescidos, aos resíduos, 20% em volume de fibra de coco triturada; aos105 dias após a semeadura avaliaram-se as variáveis referentes à qualidade de mudas; as mudas produzidas com substrato à base lodo de esgoto da ETE Sarapuí apresentaram os melhores resultados em todas as variáveis, seguidos pelas produzidas com os lodos das ETE Alegria e Ilha do Governador, que não diferiram entre si. As mudas produzidas com composto de lixo urbano apresentaram resultados satisfatórios e superiores ao observado nas mudas produzidas com substrato comercial. Os resíduos sólidos urbanos acrescidos de 20% de fibra de coco apresentaram potencial elevado podendo ser recomendados para a composição de substratos na produção de mudas de *Lafoensia pacari*.

Ref. 013-2016 – Received 3 Mar, 2016 • Accepted 18 Nov, 2016 • Published 5 Jan, 2017

Introduction

Currently, urban solid wastes constitute a large environmental liability, occupying large volumes in the landfills and decreasing the life span of these spaces. The recycling of these materials aiming at the formulation of substrates to produce forest seedlings could be a more sustainable way of disposal, besides guaranteeing the long-term supply of organic matter and low cost for nursery owners (Caldeira et al., 2012a).

In this context, the domestic urban garbage and sewage sludge emerge as two of the main wastes to be recycled. The use of sewage sludge in the production of forest seedlings has been successfully tested and the positive result on the growth of the seedlings has been attributed to the high concentrations of nutrients and organic matter contained in this material (Faria et al., 2013; Rocha et al., 2013; Trazzi et al., 2014).

The domestic urban garbage, properly separated and composted, can also be used as substrate for various purposes (Nóbrega et al., 2008; Silva et al., 2014). The reuse of urban garbage in the formulation of substrates for seedlings production has high environmental value, because it returns to the productive cycle a material that, if treated as waste, has high cost of final destination (Zapata et al., 2005).

In order to test the effectiveness in the use of these wastes, it is important to prioritize species that are used for various purposes, such as *Lafoensia pacari* St. Hill., also known as 'dedaleiro'. This species is widely used in plantations of forest restoration and urban landscaping, due to its plasticity, small and medium size, and large white-yellowish flowers (Lorenzi, 2002; Carvalho, 2006).

In this context, this study aimed to evaluate the potential of using urban solid waste in the composition of substrates for the production of *Lafoensia pacari* seedlings.

Material and Methods

The experiment was carried out from October 2013 to January 2014, in the forest nursery of the Forest Institute located at the Federal Rural University of Rio de Janeiro (UFRRJ), in Seropédica, RJ, Brazil (22° 45' 27" S; 43° 41' 46" W; 30 m). The climate of the region, according to Köppen's classification, is Aw (Brasil, 1980), tropical with summer rains. According to the data of the last 20 years of the weather station of the Agricultural Research Company of Rio de Janeiro (PESAGRO-RJ), the mean annual rainfall is 1245 mm, with driest period in June, July and August, and water excess in December, January and February. The mean time of insolation is 2527 h, the mean annual evaporation is 1576 mm and the relative air humidity is 69%.

The sewage sludges used in the experiment were provided by the Water and Sewerage State Company of Rio de Janeiro (CEDAE) and came from three wastewater treatment plants (WTP): Alegria WTP, Ilha do Governador WTP and Sarapuí WTP, which received only sewage of domestic origin. The three stations have activated sludge secondary treatment systems and compaction of the secondary sludge, through centrifuges. After the dewatering in centrifuges, the sludges used in the experiment differed regarding the dehydration method. The sludges of Alegria and Ilha do Governador WTPs remained approximately 90 days on drying beds under full sun, until reaching moisture close to 30%, while the sludge from the Sarapuí WTP was dehydrated through thermal drying, exposed to approximately 350 °C for 30 min, coming out of the dryer with moisture close to 10%. After these processing steps and stabilization, representative samples were collected and subjected to the chemical and microbiological analyses required by the CONAMA Resolution No. 375/2006 (Brasil, 2006).

The Fertlurb urban waste compost was provided by the Municipal Urban Cleaning Company of Rio de Janeiro (COMLURB). The Fertlurb is produced from the composting of organic resides present in the domestic garbage, from the city of Rio de Janeiro. These organic wastes are collected, sorted and composted until they are properly stabilized for use. It should be pointed out that, because of the large amount of plastic and glass fragments, the compost needed to be standardized before use by sieving through a 10 mm mesh.

The tested treatments were: T1 – Sewage sludge from Alegria WTP; T2 – Sewage sludge from Ilha do Governador WTP; T3 – Sewage sludge from Sarapuí WTP; T4 - Fertlurb (urban garbage compost) and T5 – Commercial substrate based on stabilized pine bark residues (standard substrate used in forest nurseries). The five treatments were mixed with 20% shredded coconut fiber, to improve the porosity of the substrates. After formulation of the substrates, representative samples were collected for chemical analysis (Table 1). The experimental design was completely randomized, with five treatments and four replicates, and each replicate consisted of 18 seedlings.

The containers consisted of 280 cm^3 tubes filled with the substrates corresponding to each treatment. After filling, the tubes were arranged on beds under full sun and only then sowing was performed. For protection against adverse weather, the trays were covered with a 50% shade screen, from sowing until the plants reached a height close to 5 cm, approximately at 30 days after sowing. Irrigation was performed using micro-sprinklers, three times a day. Since the aim was to evaluate the potential of the substrates, no complementary chemical fertilizations were performed. At 60 days after sowing, when the seedlings were approximately 15 cm high, they were spaced by changing the density to occupy 50% of the tray, thus decreasing the competition for light.

At 105 days after sowing, shoot height (H) and collar diameter (D) were measured. After data compilation, the six central seedlings of each plot were selected, totaling 24

Table 1. Total contents (%) of macronutrients and organic matter present in the substrates formulated with urban solid wastes and in commercial substrate

Substrates	[1]N	[2]P	[2]K	[3]Ca	[3]Mg	[4]MO
Alegria WTP	3.88	0.62	0.52	0.24	0.02	54.4
Ilha WTP	3.34	1.12	0.21	0.69	0.03	57.9
Sarapuí WTP	4.23	1.73	0.18	0.88	0.02	51.6
Fertlurb	0.81	0.53	0.12	0.69	0.38	33.0
Commercial substrate	0.49	0.17	0.16	1.49	0.58	31.0

[1]Sulfuric digestion - Kjeldhal distillation; [2]Mehlich extractor; [3]1 mol L^{-1} KCl extractor; [4]Walkley-Black method; OM - Organic matter

seedlings per treatment, for the evaluation of shoot dry matter (SDM), root dry matter (RDM) and total dry matter (TDM). The obtained data were used to calculate the variables height/diameter ratio (H/D) and shoot dry matter/root dry matter ratio (SDM/RDM) (Carneiro, 1995). In addition, the Dickson quality index was also calculated, which considers the calculations, the robustness (H/D ratio) and the equilibrium of biomass distribution in the seedling (TDM and SDM/RDM ratio), considering the results of various important variables used for quality evaluation (Dickson et al., 1960). The higher the value of DQI, the better the quality of the seedlings in the lot, theoretically.

The data of all evaluated characteristics and ratios were subjected to analysis of variance and, when significant effects were observed, to Tukey test ($p \leq 0.05$). The statistical analyses were performed using the software 'Sistema de Análise Estatística e Genética' (SAEG, 2007).

Results and Discussion

The seedlings produced in the treatment formulated with sludge from the Sarapuí WTP showed significantly higher results in almost all analyzed variables, followed by the seedlings of the treatments with sludge from Alegria and Ilha do Governador WTPs, which did not differ statistically (Table 2). In the sequence, the treatment with Fertlurb urban garbage compost showed means higher than those of the commercial substrate, but lower than those of treatments with sewage sludge.

Based on the growth variables of the seedlings, it can be inferred that the sewage sludge positively influenced the growth of *Lafoensia pacari* seedlings. Various authors have attributed the higher growth of seedlings produced in substrates containing sewage sludge to the high contents of nutrients and organic matter found in this waste (Caldeira et al., 2012b; Delarmelina et al., 2013; Gomes et al., 2013; Rocha et al., 2013).

Trazzi et al. (2014), analyzing the potential of sewage sludge as component of the substrate for the production of *Tectona grandis* seedlings, tested different proportions of sludge, coconut fiber and carbonized rice husk. These authors found results that corroborate the positive contribution of the sludge to the growth in height and diameter of forest seedlings and indicated proportions of 80% of sewage sludge and 20% of coconut fiber or 60% of sewage sludge and 40% of carbonized rice husk for the production of teak seedlings.

In general, the sewage sludge showed the best results of height and diameter, in comparison to the other treatments, and the Sarapuí WTP stood out. The best results found in the treatments with sewage sludge are probably due to the higher concentration of nutrients in this waste, especially N and P (Table 1). These nutrients are highly required in the initial growth stages of the seedlings, with important role in the initial impulse of shoot growth, which justifies the higher means in height and diameter in the treatments with higher contents of these nutrients (Faria et al., 2013; Trazzi et al., 2014).

The higher growth of *Lafoensia pacari* seedlings observed in the sludge from the Sarapuí WTP is justified, because it is the only one, among the evaluated sludges, subjected to thermal drying. Carvalho et al. (2015) concluded that, for activated sludges, as those used in the present study, thermal drying preserves better the nutrients and maintains biodegradable fractions of the carbon, and this process is more indicated for the production of sludge to be used as organic fertilizer. These authors also mention that, in longer drying processes, such as those applied to the sludges of Alegria and Ilha do Governador WTPs, which use drying beds, besides a probable leaching of nutrients, the presence of moisture and oxygen allows microorganisms to consume part of the C present in the material, especially the soluble C, which tends to be the most readily available. The sludge generated this way would be the most indicated to be used as soil conditioner, since its organic matter is more stabilized.

As an intrinsic feature of *Lafoensia pacari*, its height growth is favored detriment of diameter growth, which explains the relatively high values of the H/D ratio, in all treatments. According to José et al. (2005), seedlings with higher H/D ratio may have difficulty to stand upright after planting; thus, values below 10 are recommended. However, Delarmelina et al. (2013) call the attention for the need of more studies to determine the classes of optimal values of H/D ratio for species of the Brazilian flora, because this index is highly variable depending on the species.

The sludge from the Sarapuí WTP also showed the best values of dry matter variables, which may be related to the greater concentration of nutrients in this sludge, in which the greater supply of N and P also led to greater increment in SDM, RDM and consequently TDM, parameters highly dependent on the nutrition provided by the substrate. Santos et al. (2008), in study with seven native arboreal species, observed that, as the P supply increased, there were increments in shoot and root dry matter production for the studied species. The same can be observed in the present experiment, in which the treatments with sewage sludge, which contain higher concentration of P, also showed higher biomass production.

It is possible to observe that the lowest means of SDM/RDM ratio were found in the treatment with commercial substrate (Table 2). According to Caldeira et al. (2013), the SDM/RDM ratio is lower in environments of lower fertility

Table 2. Quality variables for *Lafoensia pacari* seedlings produced with different urban wastes, at 105 days after sowing

Treatment	H (cm)	D (mm)	H/D	SDM (g plant^{-1})	RDM (g plant^{-1})	TDM (g plant^{-1})	SDM/RDM	DQI
Alegria WTP	62.1 b	6.76 b	9.30 ab	7.65 b	3.12 b	10.78 b	2.51 ab	0.93 b
Ilha WTP	66.5 b	6.46 b	10.35 a	8.59 b	3.10 b	11.68 b	2.78 a	0.89 b
Sarapuí WTP	72.1 a	8.99 a	8.02 b	10.67 a	4.45 a	15.13 a	2.40 ab	1.45 a
Fertlurb	44.0 c	4.53 c	9.77 ab	3.56 c	1.70 c	5.26 c	2.10 b	0.45 c
Commercial substrate	11.2 d	1.17 d	9.53 ab	0.66 d	0.65 d	1.31 d	1.01 c	0.12 d

H – Shoot height; D – Collar diameter; H/D – Height/diameter ratio; SDM – Shoot dry matter; RDM – Root dry matter; TDM –Total dry matter; SDM/RDM – Shoot dry matter/root dry matter ratio; DQI – Dickson quality index; Means followed by the same letter in the column do not differ statistically by Tukey test ($p \geq 0.95$)

and may be considered as a strategy of the plant, which invests in root growth instead of shoot growth to absorb as much as nutrients as possible under that condition. The same behavior was observed in this experiment, in which the lowest values of SDM/RDM were found in the treatment with commercial substrate.

Confirming the results of the other quality parameters, previously presented, the highest mean of DQI was also found in seedlings produced with substrate formulated using sludge from the Sarapuí WTP, followed by the treatments with sludge from Alegria and Ilha do Governador WTPs, which did not differ statistically and showed means higher than those of the treatment with urban garbage compost. High DQI values are achieved when the seedlings have low H/D ratio (seedlings without etiolation), balanced values of SDM/RDM (seedlings with root system capable of supplying the shoots) and high value of total organic matter (biomass). On the other hand, the lowest means of DQI were found in the treatment with commercial substrate.

These results corroborate the efficiency of the substrates produced with urban solid waste in the quality of *Lafoensia pacari* seedlings. López et al. (2008), analyzing the use of composted urban waste as substrate, also found results that confirm the efficiency of both sewage sludge and urban garbage compost in the growth of forest seedlings.

The worst results were obtained in the treatment with commercial substrate, probably due to the lack of complementary fertilization, which is essential when this type of substrate is used. On the other hand, the treatments with sewage sludge and urban garbage compost formed quality seedlings at 105 days after sowing without the need for complementary fertilization. Caldeira et al. (2012a) analyzed the potential of sewage sludge to produce seedlings of *Tectona grandis* and concluded that this is a viable alternative, because of the good results obtained, saving of fertilizers and environmental benefit.

Therefore, it can be inferred that the use of these urban solid wastes as substrate emerges as an alternative to simplify the production of seedlings in tubes, decreasing the dependence of one of the most crucial and emblematic phases of this production system, which is the need to replace the nutrients in the substrate through basal and/or top-dressing fertilizations.

Conclusions

1. The urban solid wastes mixed with 20% of coconut fiber showed high potential and can be recommended for the composition of substrates in the production of *Lafoensia pacari* seedlings.

2. The sewage sludge from the Sarapuí WTP showed the best results, followed by the sludges from Alegria and Ilha do Governador WTPs. The Fertlurb showed satisfactory results, higher than those of the commercial substrate.

Acknowledgments

The authors thank the Water and Sewerage State Company of Rio de Janeiro (CEDAE) for the support to the research.

Literature Cited

Brasil. Ministério de Minas e Energia: Departamento Nacional da Produção Mineral. Projeto RADAM Brasil. Folhas sc. 21. Juremo: Geomorfologia, pedologias, vegetação e uso potencial da terra, Rio de Janeiro: MME/DNPM, 1980. 420p.

Brasil. Ministério do Meio Ambiente. Conselho Nacional do Meio Ambiente. Resolução - CONAMA nº 375/2006. Define critérios e procedimentos para o uso agrícola de lodos de esgoto gerados em estações de tratamento de esgoto sanitário e seus produtos derivados. Diário Oficial da República Federativa do Brasil, Brasília: CONAMA, n. 167, 2006.p.141-146.

Caldeira, M. V. W.; Delarmelina, W. M.; Lube, S. G.; Gomes, D. R.; Gonçalves, E. O; Alves, A. F. Biossólido na composição de substrato para a produção de mudas de *Tectona grandis*. Floresta, v.42, p.77-84, 2012a. http://dx.doi.org/10.5380/rf.v42i1.26302

Caldeira, M. V. W.; Delarmelina, W. M.; Peroni, L.; Gonçalves, E. O.; Silva, A. G. Lodo de esgoto e vermiculita na produção de mudas de eucalipto. Pesquisa Agropecuária Tropical, v.43, p.155-163, 2013. http://dx.doi.org/10.1590/S1983-40632013000200002

Caldeira, M. V. W.; Gomes, D.R.; Gonçalves, E. O.; Delarmelina, W. M.; Sperandio, H. V.; Trazzi, P. A. Biossólido como substrato para produção de mudas de *Toona ciliata* var. *australis*. Revista Árvore, v.36, p.1009-1017, 2012b. http://dx.doi.org/10.1590/S0100-67622012000600002

Carneiro, J. G. de A. Produção e controle de qualidade de mudas florestais. Curitiba: UFPR/FUPEF, 1995. 451p.

Carvalho, C. S.; Ribeirinho, V. S.; Andrade, C. A.; Grutzmacher, P.; Pires, A. M. M. Composição química da matéria orgânica de lodos de esgoto. Revista Brasileira de Ciências Agrárias, v.10, p.413-419, 2015. http://dx.doi.org/10.5039/agraria.v10i3a5174

Carvalho, P. E. R. Espécies arbóreas brasileiras. Brasília: Embrapa Informação Tecnológica; Colombo: Embrapa Florestas, 2006. 1039p.

Delarmelina, W. M.; Caldeira, M. V. W.; Faria, J. C. T.; Gonçalves, E. O. Uso de lodo de esgoto e resíduos orgânicos no crescimento de mudas de *Sesbania virgata* (Cav.) Pers. Revista Agroambiente, v.7, p.184-192, 2013. http://dx.doi.org/10.18227/1982-8470ragro.v7i2.888

Dickson, A.; Leaf, A. L.; Hosner, J. F. Quality appraisal of white spruce and white pineseedling stock in nurseries. Forest Chronicle, v.36, p.10-13, 1960. http://dx.doi.org/10.5558/tfc36010-1

Faria, J. C. T.; Caldeira, M. V. W.; Delarmelina, W. M.; Lacerda, L. C.; Gonçalves, E. O. Substratos a base de lodo de esgoto na produção de mudas de *Senna alata*. Comunicata Scientiae, v.4, p.342-351, 2013.

Gomes, D. R.; Caldeira, M. V. W.; Gonçalves, E. O.; Delarmelina, W. M.; Trazzi, P. A. Lodo de esgoto como substrato para produção de mudas de *Tectona grandis* L. Cerne, v.19, p.123-131, 2013. http://dx.doi.org/10.1590/S0104-77602013000100015

José, A. C.; Davide, A. C.; Oliveira, S. L. Produção de mudas de aroeira (*Schinus terebynthifolius* Raddi) para recuperação de áreas degradadas pela mineração de bauxita. Cerne, v.11, p.187-196, 2005.

López, R.; Cabrera, F.; Madejon, E.; Sancho, F.; Alvarez, J. M. Urban composts as an alternative for peat in forestry nursery growing media. Dynamic Soil, v.2, p.60-66, 2008.

Lorenzi, H. Árvores brasileiras: Manual de identificação e cultivo de plantas arbóreas nativas do Brasil. v.2. 2.ed. Nova Odessa: Platarum, 2002. 368p.

Nóbrega, R. S. A.; Paula, A. M.; Vilas Boas, R. C.; Nóbrega, J. C. A.; Moreira, F. M. S. Parâmetros morfológicos de mudas de *Sesbania virgata* (Caz.) Pers e de *Anadenanthera peregrina* (L.) cultivadas em substrato fertilizado com composto de lixo urbano. Revista Árvore, v.32, p.597-607, 2008. http://dx.doi.org/10.1590/S0100-67622008000300020

Rocha, J. H. T.; Backes, C.; Diogo, F. A.; Pascotto, C. B.; Borelli, K. Composto de lodo de esgoto como substrato para mudas de eucalipto. Pesquisa Florestal Brasileira, v.33, p.27-36, 2013. http://dx.doi.org/10.4336/2013.pfb.33.73.331

SAEG - Sistema para Análises Estatísticas, versão 9.1. Viçosa: UFV, 2007.

Santos, J. Z. L.; Resende, A. V.; Corte, E. F. Crescimento, acúmulo de fósforo e frações fosfatadas em mudas de sete espécies arbóreas nativas. Revista Árvore, v.32, p.799-807, 2008. http://dx.doi.org/10.1590/S0100-67622008000500003

Silva, R. F.; Eitelwein, M. T.; Cherubin, M. R.; Fabbris, C.; Weirich, S.; Pinheiro, R. R. Produção de mudas de *Eucalyptus grandis* em substratos orgânicos alternativos. Ciência Florestal, v.24, p.609-619, 2014. http://dx.doi.org/10.5902/1980509815745

Trazzi, P. A.; Caldeira, M. V. W.; Reis, E. F.; Silva, A. G. Produção de mudas de *Tectona grandis* em substratos formulados com biossólido. Cerne, v.20, p.293-302, 2014. http://dx.doi.org/10.1590/01047760.201420021134

Zapata, N.; Guerrero, F.; Polo, A. Evaluación de corteza de pino y residuos urbanos como componentes de sustratos de cultivo. Agricultura Técnica, v.65, p.387-400, 2005. http://dx.doi.org/10.4067/S0365-28072005000400004