ADVANCES IN FORESTRY SCIENCE

OPEN ACCESS

Use of slow-release fertilizers in the production of *Handroanthus impetiginosus* seedlings

Fernanda Leite Cunha [1*] *Juscelina Arcanjo dos Santos*[2] *Paloma Carvalho Diniz* [1] *Lucas Amaral de Melo*[1] *Nelson Venturin*[1]

[1]Universidade Federal de Lavras, Departamento de Ciências Florestais, Laboratório de Silvicultura S/N, Lavras - MG, Brasil
[2]Universidade de Brasília, Departamento de Ciências Florestais, Campus Universitário Darcy Ribeiro S/N, Brasília, DF, Brasil.

Original Article

***Corresponding author:**
fernandaleitecunha@gmail.com

Keywords:
Ipê roxo

Nutrition

Controlled fertilization

Palavras-chave:
Ipê roxo

Nutrição

Fertilização controlada

Received in
2021/10/09

Accepted on
2022/10/10

Published in
2022/12/31

DOI:
http://dx.doi.org/10.34062/afs.v9i4.13072

ABSTRACT: The species *Handroanthus impetiginosus* has great economic interest due to the quality of its wood. Aiming to understand and expand the knowledge about the formation of seedlings with quality of the species, was study the efficiency and adequate doses of two slow-release fertilizers in the production of seedlings of *Handroanthus impetiginosus*. The experiment was carried out in a randomized block design, in a factorial (2x5). Two fertilizers (SRF1 and SRF2) were taken in five doses (0, 3, 6, 9, 12 kg dm^{-3}). Height, stem diameter, H/SD, shoot dry mass, root and total dry mass, and Dickson Quality Index were measured. For each variable, a maximum dose of technical efficiency (MDTE) was set. An analysis of variation and comparison of means was carried out using the Tukey test for the two fertilizers used and a regression analysis of the means for the doses used. All analyzes were evaluated using the R software. All variables showed positive quadratic growth. The results of the study indicate that both fertilizers are suitable for the production of seedlings of *Handroanthus impetiginosus*, in the MDTE of 11.65 kg dm^{-3} for SRF1 and 9.19 kg dm^{-3} for SRF2.

Uso de adubos de liberação lenta na produção de mudas de *Handroanthus impetiginosus*

RESUMO: A espécie *Handroanthus impetiginosus* possui grande interesse econômico devido a qualidade da sua madeira. Visando entender e ampliar os conhecimentos sobre a sua formação de mudas com qualidade da espécie, foi estudado a eficiência e as doses adequadas de dois adubos de liberação lenta na produção de mudas de *Handroanthus impetiginosus*. O experimento foi conduzido em delineamento em blocos casualizados, em fatorial (2x5). Foram avaliados dois adubos (SRF1 e o SRF2) em cinco doses (0, 3, 6, 9, 12 kg dm^{-3}). Foram mensurados a altura, diâmetro de coleto, H/SD, massa seca da parte aérea, do sistema radicular e total, e o Índice de Qualidade de Dickson. Para cada variável foi calculado a dose máxima de eficiência técnica (MDTE). Realizou-se a análise de variância e a comparação de médias pelo teste Tukey para os dois adubos utilizados e análise de regressão das médias para as doses utilizadas. Todas as análises foram realizadas utilizando o software R. Todas as variáveis apresentaram crescimento quadrático positivo. Os resultados deste estudo indicam que ambos os adubos são adequados para produção de mudas de *Handroanthus impetiginosus*, nas MDTE de 11,65 kg dm-3 para SRF1 e 9,19 kg dm-3 para SRF2.

Introduction

The species *Handroanthus impetiginosus*, popularly known as ipê-roxo, is a native tree species, belonging to the Bignoneacea family, indicated for various fins, such as landscaping, logging, food and preservation and recovery of degraded areas (Ribeiro and Coêlho, 2021). However, there is a need to produce information on appropriate techniques for the production of seedlings of the species, which makes it necessary to develop protocols and literature, which favors its production of seedlings with quality, at less cost and time, thus being able to meet the objectives of the plantations (Massad et al. 2017).

Among the factors that influence the quality and production costs of seedlings of forest species, the nutritional demands of the species can be highlighted (Dias et al. 2018). According to Pagliarini et al. (2014), the need for fertilization stems from the fact that the substrate is not always able to provide all the nutrients that plants need for adequate growth. Among the substrate fertilization techniques in forest nurseries, the use of slow-release fertilizers represents one of the most viable and rational alternatives (Gomes et al. 2020).

According to Santos et al. (2020) slow-release fertilizers (SRF) can reduce labor and energy costs, damage to seeds or seedlings due to salinity of the growing medium, in addition to maintaining a synchronism of nutrient release with growth and development needs of the plants. Due to these characteristics, its efficiency was evident in the production of *Aspidosperma parvifolium* seedlings (Menegatti et al. 2017) and in the production of *Cordia trichotoma* seedlings (Berghetti et al. 2016).

Despite being more effective, slow release fertilizers (SRF) have higher costs than immediate availability fertilizers (Rossa et al. 2011). However, according to Rossa et al. (2013), the maintenance costs of seedlings in nurseries with the use of SRF can be lower when compared to the use of conventional fertilizers. For this, it is necessary to use the appropriate sources and doses with the nutritional demand of the forest species. Thus, the objective of this work was to evaluate the efficiency and adequate doses of two different sources of slow release fertilizer in the production of seedlings of *Handroanthus impetiginosus.*

Material and Methods

The experiments were installed and conducted in the forest nursery of the Universidade Federal de Lavras located in the southern region of Minas Gerais (21° 13' 14.033" S and 44° 58' 0.232" W). The climate of the region was classified as proposed by Köppen as Cwb with a tropical aspect of altitude, mild summers, humid mesothermal (Alvares et al. 2013).

The seedlings of *Handroantus impetiginosus* were produced from April 2019 to January 2020, with an average temperature of 28.31 ºC, and an average minimum monthly rainfall of 8.6 mm and a maximum of 190.2 mm. Seeds from collections carried out in provenances distributed in the south of Minas Gerais were used. The seeds were sown in 110 cm^3 tubes, which remained for 60 days in the shade house (50% irradiance and irrigation by microsprinkler three times a day with five minutes duration each, and flow rate of 140 L h^{-1}). Subsequently, the seedlings were transferred to full sun for hardening (irrigation four times a day for five minutes each, and a flow rate of 95 L h^{-1}).

The treatments were composed of two types of slow release fertilizers. SRF1 is characterized by being encapsulated with elemental sulfur and coated with non-water-soluble organic polymers. This fertilizer presents nutrients release from four to six months and has a formulation of 10% N, 15% P2O5, 20% K_2O, 8.64% S, 0.39% B, 0.39% Cu and 0.39% Zn. SRF2 is characterized by being coated with an organic polymer, composed of alkyd resin, commonly used for the production of forest seedlings. The nutrient release time is four to six months and has a formulation of 15% N, 9% P2O5, 12% K2O, 1.3% Mg, 5.9% S, 0.46% Fe, 0.05% Cu and 0.05% Mn and 0.02%.

The substrate used was 50% Maxfértil commercial substrate (Pinus bark, ash, vermiculite, sawdust and biostabilizers), 25% carbonized rice husk and 25% coconut fiber. To homogenize the tested doses to the base substrate, a concrete mixer was used for five minutes.

The experiment was arranged in a 2 x 5 factorial scheme (two types of SRF for five doses) in a completely randomized design (DIC), with four replications, with the plot consisting of 20 seedlings. The slow release fertilizers used were SRF1 and SRF2 at doses of 0, 3, 6, 9, 12 kg m^{-3}, according with Rossa et al. (2011).

At 270 days, the height (H) and collar diameter (SD) of the 12 central seedlings of each plot were measured. Height was measured with the aid of a millimeter ruler in cm, from the substrate level to the apical bud. The SD was measured at the substrate level using a digital caliper accurate to 0.01 millimeters.

The shoot dry matter (SDM), the root system dry matter (RSDM) and, by their sum, the total dry matter (TDM) were also evaluated. For these evaluations, five seedlings were used per plot, and the material was dried in an oven with forced air circulation regulated at 75 ºC for 72 hours.

From the data of the analyzed variables, the morphological indices were calculated: Robustness Index (H/SD) and the Dickson Quality Index (DQI) (Dickson et al. 1960), calculated through the equation 1:

$$IQD = \frac{TDM}{\left(\frac{H}{SD}\right)+\left(\frac{SDM}{RSDM}\right)} \quad (1)$$

Where: TDM= total dry matter; H= height; SD=stem diameter; SDM= shoot dry mass and RSDM= root system dry mass.

The data obtained were submitted to error normality analysis using the Shapiro-Wilk test ($P < 0,05$) When verifying normality, analysis of variance (ANOVA) was performed, and once the significant difference was verified, the averages were compared using the Tukey test test ($P < 0,05$), for the two fertilizers used. A regression analysis of the means test ($P < 0,05$) was carried out at a level of 5% probability of error, for the doses used, using the R software.

The maximum technical efficiency dose (MDTE) was calculated for the variables in which there was a significant difference by the F test test ($P < 0,05$). For this, a linear regression analysis of the variables was performed as a function of the doses of the tested fertilizers, considering the significance of the coefficients test ($P < 0,05$) and by the coefficient of determination (R^2). The MDTE of the variables of interest corresponded to the first derivative of the adjusted equations set equal to zero. When the calculated value exceeded the maximum dose tested, the MDTE considered was 12 kg m^{-3}.

Results and discussion

There was a significant interaction ($P<0.05$) between the types of fertilizers and the doses applied, for all variables analyzed (Figure 1, 2 and Table 1). Thus evincing a relation between these two factors in the production of *Handroanthus impetiginosus.* The lowest growth observed was found for the treatment without fertilization, which proves the need for nutritional complementation for the formation of seedlings with quality, regardless of the substrate composition, as verified by Aguilar et al. (2020).

The biometric parameters evaluated for the SRF2 fertilizer showed a quadratic behavior in relation to the doses of applied fertilizers, as observed for *Cordia trichotoma* (Berghetti et al. 2016), *Aspidosperma parvifolium (*Menegatti et al., 201) and *Dipteryx alata* (Aguilar et al. 2020). However, the use of SRF1 had a positive linear effect, as found by Gonçalves et al. (2013) and Goulart et al. (2007) studying the application of doses of readily soluble nitrogen fertilizers, on height, in seedlings of *Mimosa caesalpiniaefolia* and *Tabebuia serratifolia.*

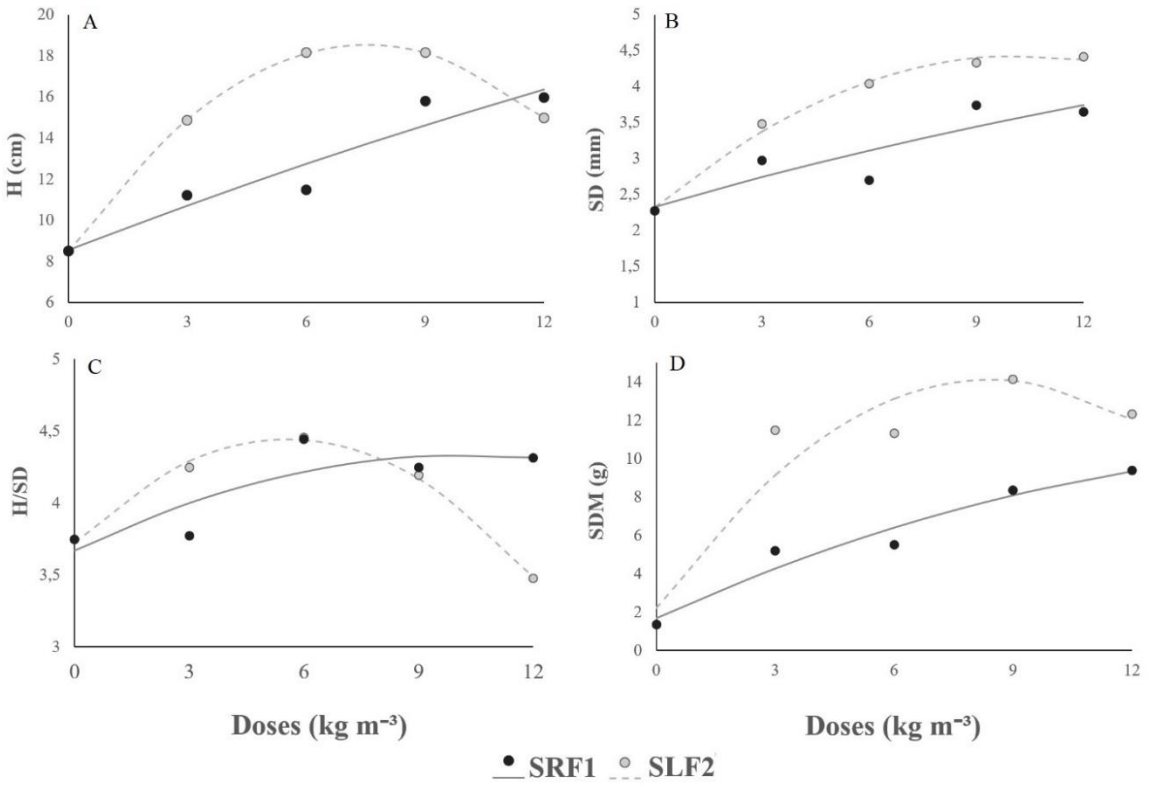

Figure 1. Effect of growth and maximum dose technical efficiency (MDTE) of the variables A: height (H), B: stem diameter, C: robustness index (H/SD), D: shoot dry matter (SDM), in the seedlings of *Handroanthus impetiginosus* seedlings, at 270 days of age.

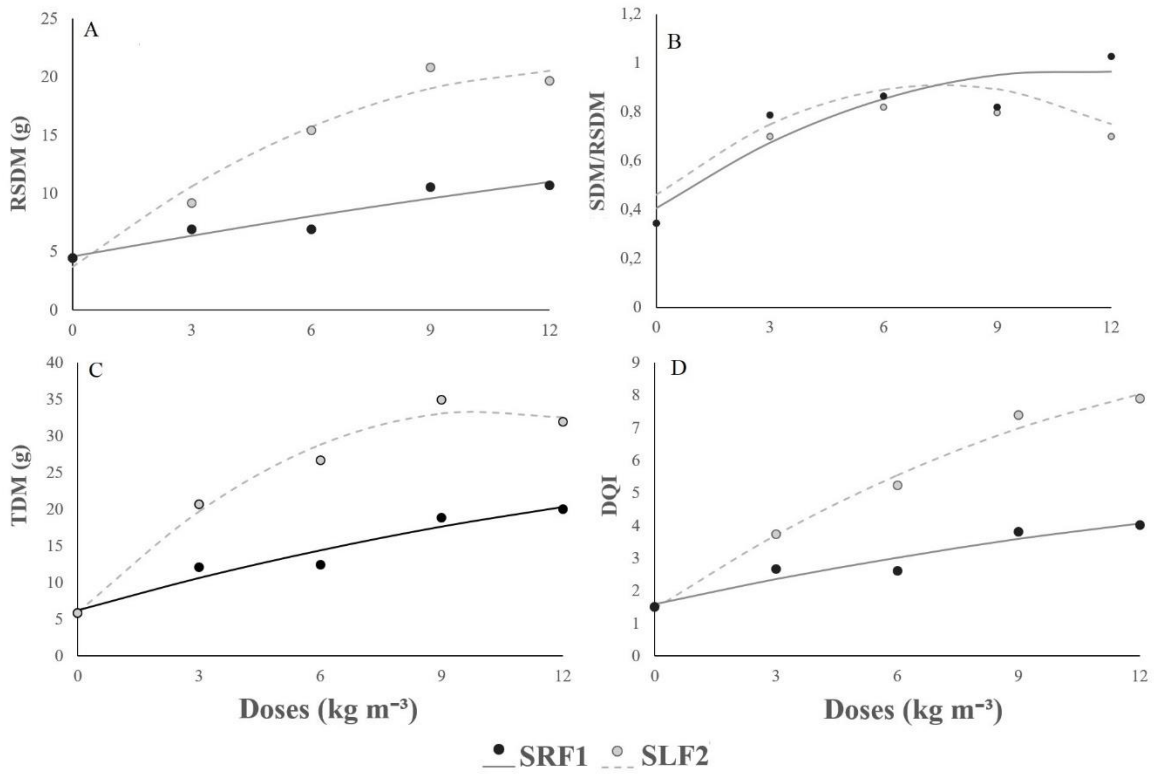

Figure 2. Effect of growth and maximum dose technical efficiency (MDTE) of the variables A: root system dry matter (RSDM), B: total dry matter (TDM), C: SDM/RSDM, D: Dickson Quality Index (DQI), in the seedlings of *Handroanthus impetiginosus* seedlings, at 270 days of age.

Table 1. Estimated coefficients and precision measurements (determination coefficient (R^2) adjusted and standard error of the mean – Sy) for the adjustments made for the growth variables for the studied fertilizers.

Polyblen						
Variables	**B0**	**B1**	**B2**	**MDTE**	**R^2 (%)**	**Sy**
H (cm)	8,53	0,75	-0,01	12,00	91,83	0,82
SD (mm)	2,33	0,14	0,00	12,00	79,71	0,30
H/SD	3,67	0,13	-0,01	10,29	72,64	1,38
SDM (g)	1,68	0,93	-0,02	12,00	95,22	0,09
RSDM (g)	4,56	0,63	-0,01	12,00	90,93	0,78
SDM/RSDM	0,40	0,10	0,00	10,95	85,17	0,77
TDM (g)	6,24	1,56	-0,03	12,00	93,99	0,21
DQI	1,59	0,27	-0,01	25,37	92,19	0,15
Osmocote						
Variables	**B0**	**B1**	**B2**	**MDTE**	**R^2 (%)**	**Sy**
H (cm)	8,48	2,67	-0,18	7,53	99,00	0,97
SD (mm)	2,33	0,41	-0,02	10,29	99,28	0,61
H/SD	3,73	0,26	-0,02	5,56	99,54	2,60
SDM (g)	2,21	2,81	-0,17	8,47	90,71	0,09
RSDM (g)	3,72	2,59	-0,10	12,00	96,52	1,57
SDM/RSDM	0,46	0,12	-0,01	7,52	34,04	1,19
TDM (g)	5,93	5,40	-0,27	10,18	98,30	0,17
DQI	1,46	0,81	-0,02	18,37	98,97	0,19

According to Figure 1, it is observed that the growth for seedlings fertilized with SRF2 was superior to SRF1, like was observed for *Eucalyptus grandis* seedlings, in which, SRF2 provided greater growth and better-quality seedlings, in relation of SRF1. The authors comments that increased growth of the seedlings fertilized with SRF2, may be related to a reduced leaching of the nutrients by the substrate, and its higher nitrogen content. Muniz et al. (2016) and Pagliarini et al. (2014), also observed superior results of the use of SRF2 in relation to the use of soluble fertilizers of immediate release, for *Eucalyptus camaldulensis*, and for *Cariniana legalis*.

The MDTE found for heights (Tabela1) were 7.52 kg m^{-3} and 12 kg m^{-3}, with growth of 18.53 cm and 15.96 cm, for fertilizers SRF1 and SRF2, respectively. In the work by Berghetti et al. (2016), the authors found a MDTE of 6.1 kg m^{-3} for the production of *Cordia trichotoma* seedlings at 210 days, Menegatti et al. (2017) found a MDTE of 5.5 kg m^{-3} for *Aspidosperma parvifolium* seedlings at 150 days. Rossa et al. (2015) observed a MDTE of 11.80 in the production of *Eucalyptus grandis* seedlings at 174 days. These results reflect the importance of studies to evaluate the effects of fertilization with slow-release fertilizers for each species.

According to Szareski et al. (2015), the evaluation of the diameter of the collar is of fundamental importance in the evaluation of the potential of the seedlings for survival and growth after planting the species. Thus, the seedlings should have a larger diameter of the collar, to enhance the balance of shoot growth. The doses that provide the greatest growth for the variable are 12 and 10.28 kg m^{-3}, providing a growth of 3.65 and 4.43 mm, for SRF1 and SRF2, respectively. Rosa et al. (2014) found MDTE of 6.22 kg m^{-3} with growth of 3.5 mm for seedlings of *Cabralea canjerana* at 220 days. Berghetti found MDTE of 5.7 kg m^3 with growth of 3 mm, seedlings of *Cordia trichotoma*, at 210 days.

According to Wendling and Dutra (2010), for eucalyptus the minimum value recommended for planting in the field is 2 mm, so all tested dosages are suitable for planting. This highlights that the use of SRF is efficient for the SD development of seedlings. However, the definition of a stem diameter value depends on several factors such as species, location and production techniques (Santana et al., 2019).

The robustness index (H/SD) is one of the most important morphological characters to estimate seedling growth after definitive planting in the field, as it indicates the balance of plant growth (Souza et al., 2013). According to Araújo et al. (2018), the ideal index should be between 5.4 and 8.1. However, none of the dosages tested for both fertilizers would be within the recommended range, which may indicate that this recommendation would not be appropriate for the species, since they showed vigor in the evaluations at 270 days, as verified for *Eucalyptus camaldulensis* seedlings (Kratz and Wedling, 2016). The MDTE found for the robustness index were 10.28 and 5.56 with averages of 4.43 and 4.44.
SDM is directly related to the photosynthetic capacity and vigor of plants, so the higher the value of the variable, the better the adaptation of the seedling after planting (Santana et al., 2019). The MDTE, which promotes the highest growth of SDM, is 12 and 8.47 kg m^{-3}, with the accumulation of 9.36 and 14.10g of biomass, corresponding to SRF1 and SRF1, respectively. Berghetti found MDTE of 7 kg m^3 with growth of 2.3 g for *Cordia trichotoma* seedlings at 210 days.

RSDM is an important parameter to estimate the survival and initial growth of seedlings after planting in the field, due to the water and nutrient absorption function of the roots (Lange et al., 2014). The MDTE found for the variable was 10.95 kg m^{-3} and 10.52 kg m^{-3}, an accumulation of 10.66 and 19.5 g for SRF1 and SRF2, respectively. The SDM/RSDM ratio showed a MDTE of 10.95 kg m^{-3}, 7.52 kg m^{-3}, with means of 0.96 and 0.90, for SRF1 and SRF2, respectively. According to Honorio et al. (2019), the index expresses the balance of seedling growth, considering that smaller ratios indicate a greater ability of seedlings to survive and establish themselves in the field.

For TDM, the MDTE found was 12 kg m^{-3} and 10.18 kg m^{-3}, which corresponds to the accumulation of 25.12 and 33.43 g. Berghetti et al. (2016), found a MDTE of 5.9 kg m^{-3}, with an accumulation of 6 g, for *Cordia trichotoma*, at 210 days. Rosa et al. (2014) found MDTE of 9.05 kg m^{-3} with growth of 5 mm, for seedlings of *Cabralea canjerana*, at 220 days. According to Rossa et al. (2015) the use of slow-release fertilizer caused higher SDM, RSDM and TDM, in relation to the use of conventional formulated, immediate-release fertilizers in the fertilization of the substrate, in *Eucalyptus grandis* seedlings, even at lower doses.

The Dickson Quality Index (DQI) is an excellent parameter to evaluate the quality of seedling formation, mainly because it expresses the H/SD and SDM/RSDM ratios. For the DQI, a MDTE of 12 kg m^{-3} and 12 kg m^{-3} was obtained, with averages of 4.02 and 7.89, for SRF1 and SRF2, respectively.

Information is scarce on the production of *Handroanthus impetiginosus* seedlings and the final stage in the nursery, when seedlings are sent to the field, thus, these studies are fundamental to compare optimal growth indices. In general, studies have shown that forest species respond positively to SRF1 e SRF2, like was demonstrated for Cunha et al (2021) and Rossa et al. (2015) for *Eucalyptus grands* seedlings.

The location of the nursery and the cost to acquire each source of fertilizer must always be analyzed with caution, in order to always choose sources that provide better quality of seedlings, with lower acquisition cost. The optimization of the growth of seedlings with quality at a lower cost is of paramount importance for the nursery planner. In this way, despite both fertilizers studied showed quality seedling formation, the use of SRF2 should be preferential, because promoted greater growth and quality in the seedlings, which can provide greater survival and growth in the field.

Despite the superiority of the use of SRF2 in relation to SRF1, corroborating the work of Cunha et al. (2021), studying the quality of the use of SRF1 and SRF2, in the growth quality of *Eucaliptus grandis* seedling production, for better comparisons and investigations on the quality of fertilizers in the growth of the species, future studies are indicated, using sources of closer formulations. However, the present study indicates that the MDTE was 11.65 kg m^{-3} and 9.19 kg m^{-3}, for SRF1 and SRF2, respectively.

Conclusion

All evaluated production parameters responded positively to the use of the fertilizers coated with organic polymer, composed of non-water soluble organic polymers (SRF1) and organic polymers composed of alkyd resin (SRF2), showing efficient for the production of seedling of *Handroanthus impetiginosus*, at doses of 11.65 kg m^{-3} and 9.19 kg m^{-3}. However, the use of SRF2 should be preferred, as it provided better quality of seedling formation compared to SRF1.

Acknowledgment

The present work was carried out with the support of the Produquímica Company and the Coordination for the Improvement of Higher Education Personnel - Brazil (CAPES) - Financing Code 001.

References

Aguilar MVM, Massad MD, Dutra TR, Silva FG, Menezes ES, Santos AR (2020) Desenvolvimento de mudas de baru em resposta a diferentes volumes de tubetes e doses de adubo de liberação lenta. *Caderno de Ciências Agrárias Agrarian Sciences Journal*, 12: 01–10.

Alvares CA et al. (2013) Koppen's climate classification map for brazil. meteorologische. *Zeitschrift* , 22 (6): 711-728.

Araújo MM, Navrosku MC, Schorn LA (2018) *Produção de sementes e mudas - um enfoque à silvicultura*. Camobi - Santa Maria, Editora UFMS: Universidade Federal de Santa Maria, 448p.

Berghetti ALP, Araujo MM, Tonetto TS, Aimi SC, Navroski MC, Turchetto F, Zavistanovicz, TC (2016) Growth of *cordia trichotoma* seedlings in different sizes of recipients and doses of fertilizer. *African journal of agricultural research*, 11(28): 2450-2455.

Dias GP, Rodrigues AA, Costa AM, Carlos L, Vasconcelos Filho SV, Batista PF (2018) Morphological, anatomical and physiological characteristics of acrocarpus fraxinifolius wight e arn seedlings according to containers and fertilization. *Cerne*, 24:430-438.

Dinalli RP, Castilho RMM, Gazola RN (2012). Utilização de adubos de liberação lenta na produção de mudas de *vigna radiata*. *Revista Científica Eletrônica de Agronomia*, 21(1):10-15.

Dickson A, Leaf A, Hosner JF (1960) Quality appraisal of white spruce and white pine seedling stock in nurseries. *Forestry Chronicle*, 36:10- 13, 1960.

Gonçalves EO, Paiva HN, Neves JCL, Gomes JM (2013) Nutrição de mudas de *mimosa caesalpiniaefolia* benth. sob diferentes doses de N, P, K, Ca e Mg. *Ciência Florestal*, 23(2): 73-286.

Gomes EM, Vieira LM, Fagundes CM, Rossa UB, Tofaneli MBD (2020) Controlled-release fertilizer increases growth, chlorophyll content and overall quality of loquat seedlings. *Comunicata Scientiae*, 11: 01-08.

Goulart LML, Paiva HN, Leite HG, Xavier A, Duarte ML (2017) Produção de mudas de ipê-amarelo (*tabebuia serratifolia*) em resposta a fertilização nitrogenada. *Floresta ambiental*, 24.

Honorio ABM, Lopes MBS, Siebeneichler SC, Souza CM, Leal TCAB (2019) Análise de crescimento e parâmetros fisiológicos em mudas de *dipteryx alata* vogel. Pesquisa Aplicada & *Agrotecnologia*, 12(1):41-52.

Kratz D, Wendling I. Crescimento de mudas de *Eucalyptus camaldulensis* em substratos à base de casca de arroz carbonizada (2016) *Revista Ceres*, 63:348-354.

Lange A, Silva Junior JG, Caione G (2014) Substratos para produção de mudas de *Schizolobium amazonicum*. *Tecnologia e ciência agropecuária*, 8(1): 49-54.

Massad MD, Dutra TR, Meireles IES, Sarmento MFQ, Santos AR, Menezes ES (2017) Avaliação do crescimento de canafístula em diferentes densidades de mudas por bandeja e volumes de tubetes. *Ecologia e Nutrição Florestal* 5: 1-9.

Menegatti RD, Guollo KG, Navroski MC, Vargas OF (2017) Fertilizante de liberação lenta no desenvolvimento inicial de *aspidosperma parvifolium Scientia agraria paranaensis, marechal cândido rondon*, 16 (1): 45-49.

Muniz CO, Lôbo LM, Fernandes FPR, Ferreira EM, Brasil EPF (2013) Efeito de diferentes adubos NPK no processo de produção de mudas de eucalipto. *Enciclopédia biosfera,* 9(17)1162.

Pagliarini MK, Castilho RMM, Alves MC (2014) Influência de fertilizantes convencional e de liberação lenta no desenvolvimento de mudas de jequitibá (C*ariniana legalis*) *tecnologia & Ciências* Agropecuaria, 8(1):23-27.

Rossa UB, Angelo AC, Nogueira AC, Reissmann CB, Grossi F, Ramos MR (2011) Fertilizante de liberação lenta no crescimento de mudas de *Araucaria angustifolia* e *ocotea odorifera. Floresta* 41(3): 491-500.

Rossa UB, Angelo AC, Nogueira AC, Bognola IA, Pomianoski DJW, Soares PRC, Barros LTS (2013) Fertilização de liberação lenta no crescimento de mudas de paricá em viveiro. Pesquisa Florestal Brasileira, 33(75) : 227-234.

Rossa UB, Angelo AC, Bognola IA, Westphalen DJ, Milani JE (2015) Fertilizante de liberação lenta no desenvolvimento de mudas de *Eucalyptus grandis*. *Floresta*, 45 - 85.

Ribeiro JES, Coêlho ES (2021) Factores abióticos sobre aspectos ecofisiológicos de *Handroanthus impetiginosus* y *Handroanthus serratifolius*. Bosque, 42(1): 121-129.

Santana MS, Almeida APS, Pontes AF, Costa CAA, Oliveira ARF, Silva Matos RRS (2019) Produção de mudas de ipê roxo em substratos a base de caule decomposto de babaçu. *Agropecuária Científica no Semiárido*, 15(4) :275-280.

Santos AR Gonçalves EO, Gibson EL, Araújo EF, Caldeira MVW (2020) Controlled-release fertilizer in the growth of *Dalbergia nigra* seedlings. *Floresta*, 50:1203-1212.

Souza EGF, Barros Júnior AP, Silveira LM, Santos MG, Silva EF (2013) Emergência e desenvolvimento de mudas de tomate em substratos contendo esterco ovino. *Revista Ceres*, 60(6):902-907.

Szareski1 JV, Souza VQ, Nardino M, Ferrari M, Martini RT (2015) Influência de diferentes substratos na produção de *Peltophorum dubium*. *Enciclopédia Biosfera,* 11(22).

Wendling I, Dutra LF (2010) Produção de mudas de eucalipto por sementes. in: Wendling I, Dutra LF P*rodução de mudas de eucalipto*. Colombo: Embrapa Florestas p. 13-47.