Universidade Federal do Paraná
Setor de Ciências Agrárias
Pós-graduação em Engenharia Florestal
Revista Floresta

EFFICIENCY OF ORGANIC COMPOST IN THE DEVELOPMENT OF *Moringa oleifera* LAM. SEEDLINGS

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Received for publication: 11/11/2021– Accepted for publication: 27/10/2022

Resumo

Eficiência de composto orgânico no desenvolvimento de mudas de Moringa oleifera Lam. O objetivo desse estudo foi avaliar a eficiência de composto orgânico produzido por meio da compostagem no desenvolvimento de mudas de *Moringa oleifera*. O experimento foi conduzido em Feira de Santana – BA, Brasil. O delineamento foi montado em blocos casualizados (DBC), com sete tratamentos e quatro repetições. Foram testados os seguintes tratamentos: substrato comercial; areia (S); S/composto orgânico (OC) 80/20; S/OC 60/40; S/OC 40/60; S/OC 20/80; S/OC 0/100. O composto orgânico foi formado por resíduos de poda e restos de hortaliças que não passaram por cozimento. A adição do composto orgânico promoveu as maiores médias para os parâmetros altura, número de folhas, razão da altura/diâmetro do coleto, massa seca da raiz e massa seca da parte aérea. Para área foliar, razão altura/massa seca da parte aérea e diâmetro do coleto as proporções do composto não influíram. Médias superiores nos parâmetros como comprimento e diâmetro da raiz tuberosa e massa seca da estrutura tuberosa foram observados no substrato comercial, podendo indicar estresse das mudas nesse tratamento. Substratos com menor proporção do composto orgânico são mais indicados para produção de mudas de moringa.
Palavras-Chave: Adubo orgânico, compostagem, substrato.

Abstract

This study aimed to evaluate the efficiency of organic compost produced through composting in the development of *Moringa oleifera* seedlings. The experiment was carried out in a greenhouse in Feira de Santana- BA, Brazil. The design was randomized blocks (RBD), with seven treatments per block and four replicates. The following treatments were tested: commercial substrate; sand (S); S/organic compost (OC) 80/20; S/OC 60/40; S/OC 40/60; S/OC 20/80; S/OC 0/100. The organic compost was formed by pruning residues and vegetable remains that were not cooked. The addition of organic compost promoted the highest means for the parameters height, number of leaves, height/collar diameter ratio, root dry mass and shoot dry mass. For leaf area, height/shoot dry mass ratio and collar diameter, the proportions of the compost had no influence. Higher means of parameters such as tuberous root length and diameter and tuberous structure dry mass were observed in the commercial substrate, which may indicate stress in seedlings of this treatment. Substrates with a lower proportion of organic compost are more suitable for the production of *M. oleifera* seedlings.
Keywords: Organic fertilizer, composting, substrate.

INTRODUCTION

Moringa oleifera LAM. is a species that belongs to the Moringaceae family (CARVALHO *et al*., 2017). It has good adaptability to the conditions of the Brazilian Northeast region (ANDRADE *et al*. 2016), as it tolerates arid and semi-arid regions of low rainfall (MARINHO *et al*., 2016). In addition, the nutritional and medicinal potential of this plant is a very relevant factor (OLAYENIV *et al*., 2016), given the use of its leaves in both animal (GUALBERTO *et al*., 2014) and human (LEONE *et al*., 2018) diets. It can be harvested at different times from other crops (OLSON AND FAHEY, 2011), becoming a viable alternative mainly in the northeast region (MARINNHO *et al*., 2016). Although this species can grow in poorly fertile and sandy soils, the use of good quality substrates is fundamental for seedling production (ALMEIDA *et al*., 2019).

According to Costa *et al.* (2011), factors such as substrate, irrigation and nutrition are associated with seedling production. For the composition of substrates for agricultural cultivation, recycled organic solid residues are indicated (MEENA *et al*., 2019; ALVARENGA *et al*., 2016). An alternative used to compose substrates for plant production is the organic compost formed by plant residues, animal residues and degraded sewage sludge, as these can improve the physical-chemical attributes of the soil (ROSA JÚNIOR *et al*., 1998; CALDEIRA *et al*., 2012). They provide efficient nutrients for plant growth and are a low-cost production option, becoming a viable alternative for the seedling production phase (SEDIYAMA *et al*., 2014; FARIA *et al*., 2016).

The utilization of organic residues in the form of organic compost also brings benefits to the environment, given the greater sustainability of the agricultural system due to nutrient recycling as well as the reduction of environmental contamination resulting from the inadequate disposal of the residues generated (PRIMO *et al.*, 2010). In view of the above, this study aimed to evaluate the efficiency of different proportions of organic compost in the development of *M. oleifera* seedlings through morphophysiological analyses.

MATERIAL AND METHODS

Experimental material

The organic compost used in the experiment was produced in the composting area belonging to the Environmental Education Team (EEA) at the State University of Feira de Santana (UEFS) in Feira de Santana, Bahia, Brazil (12°11’46’’S / 38°58’05’’W), from March 2019 to June 2019. To produce the organic compost, composting piles were prepared with 300 kg and 1.20 m height, composed of pruning residue from the UEFS campus and residues (fruits and vegetables) from the UEFS university restaurant with a 1:1 ratio. In addition, the commercial substrate Topstrato Vida Verde® and coarse washed sand (1.8 to 2.3 mm diameter) were used for comparison in the experiment. The sand underwent a washing treatment in running water and was subsequently dried in the sun under plastic.

The organic compost and the commercial substrate were analyzed for macro and micronutrients.

The organic compost showed the following characteristics: pH (H_2O) = 7.6; in mg/dm^3 P = 91.2; K = 840.6; Na = 0; Z = 1.8; Mn= 10.1; Fe = 34.6; Cu = 1.5; B = 0.73; in cmol(c)/dm^3 Ca^{2+} = 9.5; CEC = 4.75; Mg^{2+} = 1; Al^{3+}= 0; H+Al= 0.5; OM = 13.15%. For the commercial substrate, the physical-chemical characterization showed the following values: pH (H_2O) = 6; in mg/dm^3 P = 91.2; K = 1720.4; Na = 121.0; Z = 6.7; Mn = 37; Fe = 34.6; Cu = 4.7; B = 0.2; in cmol(c)/dm^3 Ca^{2+} = 3.3; CEC = 11.8; Mg^{2+} = 1.3; Al^3+ = 0; H+Al = 2.8; OM = 54%.

M. oleifera seeds were obtained from a farm in the region of Irecê, Bahia (11°22’10’’S / 41° 36’ 07’’W). They were collected in June 2019 and stored in plastic packages at room temperature until laboratory analyses were performed. The results were expressed as a percentage. The *M. oleifera* seeds used in this experiment had germination percentage of 95%.

Conducting the experiment

The experiment was conducted between September and November 2019 in the municipality of Feira de Santana, Bahia, Brazil (12°16’07’’S / 38°56’21’’W), in a randomized block design with seven treatments per block. Seedlings were produced in 280-cm^3 tubes, and sowing was performed using one seed of *M. oleifera* at 2 cm depth. The following treatments were tested: (1) commercial substrate Topstrato Vida Verde®; (2) sand (S); (3) S/organic compost (OC) (80/20 S/OC); (4) (60/40 S/OC); (5) (40/60 S/OC); (6) (20/80 S/OC); (7) (0/100 S/OC). Each treatment was composed of 25 tubes, totaling 700 tubes, arranged in 16 trays and 4 blocks in a greenhouse. Irrigation of the seedlings was performed with micro-sprinklers for times of 15 minutes in the morning and 15 minutes in the afternoon throughout the experiment. During the experiment, temperature and relative humidity were evaluated daily with a digital thermohygrometer. During the seedling production period, the relative humidity ranged from 41% to 63% and the average was 55%, while temperature ranged from 27 °C to 36 °C and the average was 30.2 °C.

At 45 days after sowing, three plants of each treatment per block were collected and the following characteristics were evaluated: shoot height (H), measured with a millimeter ruler in cm from the intersection of the shoots with the substrate level; collar diameter (CD), determined using a caliper with 0.01 mm accuracy, measuring the stem 1.0 cm above the substrate; and number of leaves (NL), determined by simple count of fully expanded leaves.

The seedlings were divided into three parts: shoots, secondary roots and root tuberous structure. Subsequently, the seedlings were placed in Kraft paper bags, dried in a forced circulation oven at 75 °C until reaching constant weight and weighed on a digital scale, indicating the results of shoot dry mass (SDM), secondary root dry mass (SRDM), tuberous structure dry mass (TSDM) and total dry mass (TDM). To determine TSDM, secondary roots were separated from the tuberous region of the root. TDM was obtained by summing the parameters SDM, SRDM and TSDM. Total root dry mass (TRDM) was obtained by summing SRDM and TSDM.

Leaf area (LA), expressed in cm^2, was estimated with a LICOR® LI-3000 leaf area meter.

The following variables were measured: ratio between shoot height and collar diameter (H/CD); ratio between shoot height and shoot dry mass (H/SDM); ratio between shoot dry mass and secondary root dry mass (SDM/SRDM); and tuberous root length (TRL) and diameter (TRD), expressed in mm and measured using a caliper with 0.01 mm accuracy. Dickson quality index (DQI), which determines seedling quality, was calculated using the following formula (DICKSON *et al.*, 1960):

$$DQI = \frac{TDM}{\left(\frac{H}{CD} + \frac{SDM}{TRDM}\right)}$$

where: DQI is Dickson quality index, TDM is total dry mass (g), H is shoot height (cm), CD is collar diameter (mm), SDM is shoot dry mass (g), and TRDM is total root dry mass (g).
The data obtained were subjected to analysis of variance and Tukey test at 5% significance level in SISVAR software (FERREIRA, 2011).

RESULTS

The organic compost added to the substrate favored shoot and root growth in *Moringa oleifera* seedlings. Higher means of the evaluated parameters were observed in treatments that contained lower proportions of the organic compost. Of these parameters, the seedlings showed higher means of H in the treatment S:OC 80/20 (Table 1). Regarding the CD parameter, the treatments with proportions of the organic compost did not differ from each other, but were superior when compared to sand and commercial substrate (Table 1). For the NL parameter, the treatment S:OC 60/40 led to a higher mean, not significantly differing from the treatments S:OC 80/20 and S:OC 40/60.

In relation to the TRD and TRL parameters, seedlings cultivated in commercial substrate had higher means. With the increase in the proportion of organic compost in the treatment, there was a reduction in the means of these parameters. Only in the S:OC 0/100 treatment was there an increase in these parameters compared to previous treatments with organic compost (Table 1). Only for CD, no significant difference was observed in the comparison of the different types of treatments (Table 1). For H/CD, higher means were observed in the S:OC 80/20 treatment compared to the others (Table 1).

Table 1. Shoot height (H), collar diameter (CD), number of leaves (NL), tuberous root diameter (TRD), tuberous root length (TRL) and height to collar diameter ratio (H/CD) of *Moringa oleifera* seedlings at 45 days after sowing, subjected to treatments with different proportions of organic compost.

Tabela 1: Avaliação da altura (H), diâmetro do coleto (CD), número de folhas (NL), diâmetro da raiz tuberosa (TRD), comprimento da raiz tuberosa (TRL) e razão da altura com diâmetro do coleto (H/CD) de mudas de *Moringa oleifera* aos 45 dias após a semeadura, submetidas a tratamentos com diferentes proporções de composto orgânico.

TREATMENTS	H (cm)	CD (mm)	NL (un)	TRD (mm)	TRL (mm)	H/CD (cm/mm)
Sand	14.50 c	2.49 b	5.08 abc	11.33 b	47.12 a	6.10 c
Commercial	16.66 c	2.79 b	5.00 bc	14.83 a	46.58 a	6.22 bc
(S:OC 80/20)	32.41 a	4.10 a	6.74 ab	10.15 bc	41.34 b	8.74 a
(S:OC 60/40)	29.83 ab	4.01 a	7.16 a	8.74 cd	28.12 c	7.97 ab
(S:OC 40/60)	25.66 ab	4.01 a	6.75 ab	5.15 ef	16.48 d	7.41 abc
(S:OC 20/80)	24.50 b	3.80 a	4.50 c	3.10 f	15.37 d	7.23 bc
(S:OC 0/100)	25.11 b	3.60 a	5.21 abc	7.09 de	29.94 c	7.05 abc
Significance	0.2722	0.0034	0.0022	0.5322	0.0254	0.0017
CV (%)	12.33	8.52	15.8	11.64	6.46	9.67

Treatments: Commercial substrate Topstrato Vida Verde® (commercial); sand (A), and organic compost (OC) with sand in proportions (S:OC 80/20); (S:OC 60/40); (S:OC 40/60); (S:OC 60/40); (S:OC 20/80); (S:OC 0/100). Different lowercase letters in the column differ from each other by Tukey test at 5% significance level.

For SRDM, the S:OC 80/20 treatment led to higher mean, not differing from S:OC 60/40. Regarding SDM, the treatments S:OC 80/20 and S:OC 60/40 promoted higher means, not differing from S:OC 40/60 and S:OC 20/80 (Table 2). As for TSDM, seedlings cultivated in the commercial substrate showed higher means and this treatment differed from the others (Table 2). Analysis of TDM showed greater growth of the tuberous root in seedlings cultivated in the commercial substrate. However, seedlings cultivated in this substrate did not differ from those subjected to the treatments S:OC 80/20, S:OC 60/40 and S:OC 40/60, because these led to greater development of SDM, causing the means to be similar between treatments (Table 2).

Table 2. Results of the analysis of secondary root dry mass (SRDM), shoot dry mass (SDM) and tuberous structure dry mass (TSDM) and total dry mass (TDM) of *Moringa oleifera* seedlings cultivated in different treatments with organic compost.

Tabela 2. Resultado da análise da massa seca da raiz secundária (SRDM), massa seca da parte aérea (SDM) e massa seca da estrutura tuberosa (TSDM) e massa seca total (TDM) de mudas de *Moringa oleifera* cultivadas em diferentes tratamentos com composto orgânico.

TREATMENTS	**SRDM (g)**	**SDM (g)**	**TSDM (g)**	**TDM(g)**
Sand	0.092 bc	0.078 c	1.268 b	1.43 ab
Commercial	0.066 bc	0.114 c	2.108 a	2.28 a
(S:OC 80/20)	0.240 a	0.655 a	0.872 b	1.76 a
(S:OC 60/40)	0.173 ab	0.647 a	0.579 b	1.39 ab
(S:OC 40/60)	0.111 bc	0.540 ab	0.432 c	1.08 ab
(S:OC 20/80)	0.077 bc	0.494 ab	0.303 c	0.87 c
(S:OC 0/100)	0.028 c	0.346 b	0.374 c	0.74 bc
Significance	0.0278	0.0120	0.0051	0.0347
CV (%)	17.9	13.4	16.9	28.6

Means followed by the same letters do not differ by Tukey test at 5% significance level.

For H/SDM, no statistical difference was observed between treatments with organic compost, and the sand and commercial substrate treatments led to higher means (Table 3). In the analysis of SDM/SRDM, treatments with higher proportions of organic compost promoted higher means when compared to the others (Table 3). For TRDM, higher means were observed in the commercial substrate and sand treatments, not differing from those found in S:OC 80/20, S:OC 60/40 and S:OC 40/60, which led to higher values of tuberous structure dry mass compared to the other treatments (Table 3).

Table 3. Height to shoot dry mass ratio (H/SDM), shoot dry mass to secondary root dry mass ratio (SDM/SRDM) and total root dry mass (TRDM) of *Moringa oleifera* seedlings cultivated under different proportions of organic compost and evaluated at 45 days after sowing.

Tabela 3. Razão entre a altura e a massa seca da parte aérea (H/SDM), razão massa seca da parte aérea com massa seca das raízes secundárias (SDM/SRDM) e massa seca radicular total (TRDM) de mudas de *Moringa oleifera* cultivadas em diferentes proporções de composto orgânico e avaliadas aos 45 dias após a semeadura.

TREATMENTS	H/SDM (cm/g)	((R SDM/SRDM (g/g)	TRDM (g)
Sand	192.5 a	0.985 c	1.36 a
Commercial	155.0 a	1.835 c	2.17 a
(S:OC 80/20)	51.81 b	2.992 b	1.11 ab
(S:OC 60/40)	47.31 b	3.925 b	0.75 ab
(S:OC 40/60)	45.05 b	3.887 b	0.54 ab
(S:OC 20/80)	76.76 b	6.605 a	0.38 c
(S:OC 0/100)	76.06 b	2.357 b	0.40 bc
Significance	0.0446	0.0090	0.0160
CV (%)	22.3	24.6	18.6

Means followed by the same letters do not differ by Tukey test at 5% significance level.

Higher means of LA in *Moringa oleifera* seedlings were observed in treatments containing organic compost when compared to the sand and commercial substrate treatments, and it was possible to observe that the different proportions of organic compost did not influence the increase of this parameter. There was no significant relationship between treatments for leaf area (Table 4). As for Dickson quality index (DQI), higher means were observed in the sand and commercial substrate treatments, which differed from the others (Table 4).

Table 4. Means of treatments in analysis of leaf area (LA) in cm^2 and Dickson quality index (DQI) of *Moringa oleifera* seedlings cultivated in different proportions of substrate with organic compost at 45 days after sowing.
Tabela 4. Médias dos tratamentos em análise de área foliar (LA) em cm^2 e índice de qualidade de Dickson (DQI) de mudas de *Moringa oleifera* cultivadas em diferentes proporções de substrato com composto orgânico aos 45 dias após a semeadura.

TREATMENTS	LA (cm^2)	DQI
Sand	21.34 b	0.24 b
Commercial	35.27 b	0.37 a
(S:OC 80/20)	96.63 a	0.20 b
(S:OC 60/40)	98.03 a	0.16 bc
(S:OC 40/60)	106.4 a	0.14 bc
(S:OC 20/80)	82.8 a	0.11 c
(S:OC 0/100)	103.1 a	0.09 c
Significance	0.3623	0.0317
CV (%)	18.3	8.1

Means followed by the same letters do not differ by Tukey test at 5% significance level.

DISCUSSION

Seedlings cultivated in the treatments from S:OC 80/20 to S:OC 40/60 showed higher height and number of leaves when compared to those under the other treatments with organic compost, in addition to the commercial substrate and sand, which led to lower means. This result may be associated with adequate water retention in these proportions of sand with organic compost, promoting greater root and shoot growth. In another study comparing proportions of organic substrates, Medeiros *et al.* (2017) observed an increase in the height of *M. oleifera* seedlings cultivated in treatment with a 1:1 proportion of soil and bovine manure. In a study on the growth of *Moringa oleifera* seedlings using plant residue in the substrate composition, Ndiaye *et al.* (2018) found high number of leaves for these composts, emphasizing the need to know the most efficient proportion for the production of vigorous seedlings.

For the parameters leaf area and collar diameter, treatments with the proportions of organic compost did not differ from each other. These, however, were superior to the sand and commercial substrate treatments. Pereira *et al.* (2012) observed a higher mean for the leaf area of *Cichorium intibus* seedlings cultivated in a proportion of 95/2.5/2.5 of organic compost containing plant residue, sand and basalt powder, when compared to seedlings grown in commercial substrate. Comparatively, the result observed in this study indicates that the composition of the organic compost used influences the evaluation of these parameters.

The root system of *M. oleifera* differed according to the treatments in which they were cultivated. In the commercial substrate, there was a more pronounced growth of tuberous root diameter. For Padayachee and Beijnath (2012), these structures are adaptations that *M. oleifera* has developed for survival. The longest tuberous root length was observed in treatments containing sand and commercial substrate, which indicates that the plant was not under ideal conditions for growth, and a consequence of this was the reduction of height compared to treatments containing organic compost.

For the height to collar diameter ratio, the S:OC 80/20 treatment promoted higher means in *M. oleifera* seedlings. The results of this experiment corroborate the data reported by Caldeira *et al.* (2008), who concluded that *Schinus terebinthifolius* Raddi seedlings grown on substrate formed by a 20/80 proportion of organic compost containing plant residues and soil showed higher means of height and collar diameter, demonstrating balance in growth.

For height to shoot dry mass ratio, the means of seedlings in treatments with organic compost did not differ from each other and were lower than those observed in the other treatments. Padilha *et al.* (2018) found a lower mean of the height to shoot dry mass ratio in *Peltophorum dubium* seedlings grown on substrate with 100% organic compost formed by plant residues, when compared with those of seedlings grown on commercial substrate. This result indicates that the proportion of the organic compost in the substrate may lead to different responses according to the species and its needs.

As observed for the shoot growth of seedlings cultivated in organic compost, there was an increase in shoot dry mass in the treatments S:OC 80/20 and S:OC 60/40, which led to higher values when compared to the others.

For tuberous root diameter and length, as the proportions of organic compost increased in the substrate, there was a reduction in the growth of this structure. However, seedlings of the treatment S:OC 0/100 showed an increase when compared to those of the treatments S:OC 40/60 and S:OC 20/80. This result can be explained by the fact that the organic compost retains a lot of moisture, causing compaction of the substrate and reducing aeration, making *Moringa oleifera* roots brittle and consequently reducing the effective absorption of nutrients. This result was also reported by Rodrigues *et al.* (2016), who observed fragmentation of the roots of *M. oleifera* seedlings grown in substrate with higher proportion of organic compost of urban waste with green coconut fiber (100/0), causing injury to the plants. Root system fragmentation occurred due to the reduction in root thickness among seedlings in the treatments. This result was observed in the root dry mass parameter, for which seedlings of the treatment S:OC 80/20 had higher means, not differing from those subjected to S:OC 60/40. The data of this experiment corroborate the results observed by Almeida *et al.* (2019), who analyzed the growth of *M. oleifera* seedlings in different organic substrates.

For having greater shoot growth than root growth, seedlings of treatments with higher proportions of organic compost showed higher values of shoot dry mass to root dry mass ratio. Shoot dry mass cannot be much larger than shoot dry mass, since it can cause problems in terms of plant support and/or water absorption by the roots after transplantation (CALDEIRA *et al.,* 2013). According to these authors, in the evaluation of SDM/SRDM, means from 2 to 3.75 are the most indicated for forest seedlings. Seedlings cultivated in treatments with the proportions S:OC 80/20 and S:OC 60/40 showed values close to those indicated by Caldeira *et al.* (2013). Higher values of this parameter may indicate imbalance in plant development, for example the values observed in the treatments S:OC 20/80 and S:OC 0/100 of this experiment.

The higher mean of the total dry mass of seedlings cultivated in the commercial substrate was due to the greater growth of the tuberous root. However, seedlings cultivated in this substrate did not differ from those subjected to treatments with organic compost in the proportions S:OC 80/20, S:OC 60/40 and S:OC 40/60, because in these treatments there was superior development of shoot dry mass, causing the means to be similar between treatments.

For the Dickson quality index (DQI), higher means were observed in the sand and commercial substrate treatments, compared to the others, with the lowest mean obtained with the proportion of 100/0. The values found in this study are close to the data obtained by Lazo *et al.* (2021), who evaluated *Moringa oleifera* seedlings grown on different substrates containing bovine manure and sewage sludge. According to Gomes *et al.* (2013), factors such as species, seedling management, substrate type and proportion, container volume and seedling age may cause variation in Dickson quality index.

CONCLUSIONS

- The use of organic compost from plant residues is efficient for the production of *M. oleifera* seedlings, presenting itself as a viable and effective alternative when compared to the commercial substrate.
- For greater development of height and root dry mass, the treatment with 80/20 proportion is the most indicated.
- The commercial substrate treatment promoted greater growth of the tuberous structure of *Moringa oleifera* under the conditions of this experiment.
- Higher proportions of organic compost in the substrate are not indicated because they cause reduction in biomass production due to root fragmentation.

ACKNOWLEDGEMENTS

We thank the Coordination for the Improvement of Higher Education Personnel (CAPES - Brazil - Funding Code 001), and the Bahia State Research Support Foundation (FAPESB) for granting the scholarship to the first author.

REFERENCES

ALMEIDA, G.N.; SILVA, L.G.C. da; ALMEIDA, G.N.; COSTA, J.R.S.; LEITE, M.J.H.; SILVA, E.C.A. Desenvolvimento de mudas de *Moringa oleifera* submetidas a diferentes substratos. **Ciência Agrícola**, Rio Largo, v.17, n.2, p.1-6, set, 2019.

ANDRADE, L. C. T.; DE, FRANÇA, F. R. M.; RAMOS, A. L. D.; SILVA, G. F. DA. Avaliação da estabilidade do biodiesel produzido a partir da *Moringa oleifera* Lam. **Scientia Plena**, Sergipe, v.12, n.5, p.1-7, maio, 2016.

CALDEIRA, M.; ROSA, G.; FENILLI, T.; HARBS, R. Composto orgânico na produção de mudas de aroeira-vermelha. **Scientia Agraria**, Santa Catarina, v.9, n.1, p.27-33, jan, 2008. CALDEIRA, M.V.W.;

DELARMELINA, W.M.; LÜBE, S.G.; DANIELE RODRIGUES GOMES, D.R.; GONÇALVES, E.O.; ALVES, A.F. Biossólido na composição de substrato para a produção de mudas de *Tectona grandis*. **Floresta**, Espirito Santo, v. 42, n. 1, p. 77-84, jan/mar. 2012.

CALDEIRA, M.V.W. PERONI, L.; GOMES, D.R.; DELARMELINA, W.M.; TRAZZI, P.A. Diferentes proporções de biossólido na composição de substratos para a produção de mudas de timbó (*Ateleia glazioveana* Baill). **Scientia Forestalis**, Piracicaba, v.93, n.40, p. 15-22, mar, 2012.

CALDEIRA, M.V.; 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**, Espirito Santo, v. 43, n. 2, p. 155-163, jul, 2013.

CARVALHO, A. A.; MONTENEGRO, A.A.A.; SANTOS, C.S.; SILVA, T.G.F. Zoneamento agrometeorológico da moringa para o estado de Pernambuco em condições atuais e projeções futuras. **Journal of Environmental Analysis and Progress**, Pernambuco, v.2, n.3, p. 194-202, jul, 2017.

COSTA, E.; SANTOS, L. C. R. dos; CARVALHO, C. de.; LEAL, P. A. M.; GOMES, V. do A. Volumes de substratos comerciais, solo e composto orgânico afetando a formação de mudas de maracujazeiro-amarelo em diferentes ambientes de cultivo. **Revista Ceres**, Viçosa, v.58, n.2, p.216-222, mar/abr, 2011a.

FARIA, J.; CALDEIRA, M.; DELARMELINA, W.; E ROCHA, R. Substratos alternativos na produção de mudas de *Mimosa setosa* Benth. **Ciência Florestal**, Recife, v.26, n.4, p.1075-1086, 2016.

FERREIRA, D. F. Sisvar: a computer statistical analysis system. **Ciência e Agrotecnologia**, Lavras, v.35, n.6, p. 1039-1042, nov. 2011.

GOMES, D.R.; CALDEIRA, M.V.W.; DELARMELINA, W.M.; GONÇALVES, E.O.; TRAZZI, P.A. Lodo de esgoto como substrato para produção de mudas de *Tectona grandis L.* **Cerne**, Espírito Santo, v. 19, n. 1, p. 123-131, mar. 2013.

GUALBERTO, A. F.; FERRARI, G. M.; ABREU, K. M.P.; PRETO, B.L. Características, propriedades e potencialidades da moringa (*Moringa oleifera* Lam.): aspectos agroecológicos. **Revista Verde**, Juazeiro, v 9, n. 5, p.19-25, 2014.

LAZO, J.A.; VIEIRA, I. T. R.; FERNANDES, M.F.R.; ROCHA, L.R.; FERREIRA, G.A.P.; GERARDO RIBEIRO ZUBA JUNIOR, G. R.Z.; SANTOS, L.D.T.; SAMPAIO, R.A. Crescimento e desenvolvimento de mudas de *Moringa oleifera*, produzidas em substratos com lodo de esgoto e esterco bovino**. Revista Cubana de Ciências Agrárias**, Cuba, v.55, n. 2, p.237-246, abr, 2021.

LEONE, A.; BERTOLI, S.; DI LELLO, S.; BASSOLI, A.; RAVASENGHI, S.; BORGONOVO, G.; FORLANI, F.; BATTEZZATI, A. Effect of *Moringa oleifera* leaf powder on postprandial blood glucose response: *In vivo* study on Saharawi people living in refugee camps. **Nutrients**, USA, v.10, n.10, p. 1-14, 2018.

MARINHO, J. B. M; ARRUDA, A. M. V.; FERNANDES, R. T. V.; MELO, A. S.; SOUZA, R. F.; SANTOS, L. O. G.; MESQUITA, A. C. N. Use of moringa in animal and human nutrition: review." **Pubvet**, Maringá, v. 10, p. 619-627, 2016.

MEDEIROS, R.L.S.; CAVALCANTE, A.G.; CAVALCANTE, A.C.P.; SOUZA, V.C. Crescimento e qualidade de mudas de *Moringa oleífera* Lam. em diferentes proporções de composto orgânico. **Revista Ifes Ciência**, Espirito Santo, v.3, n. 1, p.204-216, jun. 2017.

NDIAYE, O. Efeitos do substrato na germinação e crescimento de mudas de *Moringa oleifera* Lam., *Acacia mellifera* (Vahl) Benth. e *Zizyphus mauritiana* Lam. **Sociedade Científica Reforesta**, n.6, p.86-99, dez, 2018.

OLAYEMIV, A. T.; OLANREWAJU1, M.J.; OLORUNTOBA, A.C. Toxicological evaluation of *Moringa oleifera* Lam. seeds and leaves in Wistar rats. **Pharmacognosi Commnunications**, Austrália, v. 6, n. 2, p. 100-111, 2016.

OLSON, M. E.; FAHEY, J. W. Moringa oleifera: un árbol multiusos para las zonas tropicales secas. **Revista Mexicana de Biodiversidad**, México, v.82, p.1071-1082, 2011.

PADAYACHEE, B.; BAIJNATH, H. An overview of the medicinal importance of Moringaceae. **Journal of Medicinal Plants Research**, Durban v.6, n.48, p.5831-5839, dec, 2012. PEREIRA, D.C.; GRUTZMACHER, P.; BERNARDI, F.H.; MALLMANN, L.S.; COSTA, L.A.M.; COSTA, M.S.S.M. Produção de mudas de almeirão e cultivo no campo em sistema agroecológico. **Revista Brasileira de Engenharia Agrícola e Ambiental**, Cascavel, v.16, n.10, p.1100–1106, out, 2012.

PADILHA, M.S.; BARETTA, C.R.D.M.; SOBRAL, L.S.; KRAFT, E.; OGLIARI, A.J. Crescimento de mudas de canafístula com o uso de adubação biológica e bioestimulante em diferentes substratos**. Enciclopédia Biosfera**, Goiânia, v.15, n.27, p.95 - 106, jun, 2018.

PRIMO, D.C.; FADIGAS, F.S.; CARVALHO, J.C.R.; SCHMIDT, C.D.S.; FILHO, A.C.S.B. Avaliação da qualidade nutricional de composto orgânico produzido com resíduos de fumo. **Revista Brasileira de Engenharia Agrícola e Ambiental**, Campina Grande, v.14, n.7, p.742–746, jul, 2010.

RODRIGUES, L.A.; MUNIZ, T.A.; SAMARÃO, S.S.; E CYRINO, A.E. Qualidade de mudas de *Moringa oleifera* Lam. cultivadas em substratos com fibra de coco verde e compostos orgânicos. **Revista Ceres**, Viçosa, v. 63, n.4, p. 545-552, jul/ago, 2016.

ROSA JUNIOR, E.J.; DANIEL, O.; VITORINO, A.C.T.; SANTOS FILHO, V.C. Efeito de diferentes substratos sobre o desenvolvimento de mudas de *Eucalyptus grandis* Hill, em tubetes. **Revista de Ciências Agrárias**, Portugal, v.1, n.2, p. 18-22, 1998.

SEDIYAMA, M.A.N.; SANTOS, I. C. dos; LIMA, P. C. Cultivo de hortaliças no sistema orgânico. **Revista Ceres**, Viçosa, v. 61, p. 829-837, dez, 2014.