Current Research in Agricultural Sciences
2021 Vol. 8, No. 1, pp. 1-10.
ISSN(e): 2312-6418
ISSN(p): 2313-3716
DOI: 10.18488/journal.68.2021.81.1.10

CULTIVATION AND NUTRITIONAL QUALITY OF *Moringa Oleifera* LAM. PRODUCED UNDER DIFFERENT SUBSTRATES IN SEMI-ARID REGION IN NORTHEAST BRAZIL

Ana Luiza de Melo Lucena[1+]
Manoel Bandeira de Albuquerque[2]
Magnolia Martins Alves[3]
Raul Santos Rocha de Araujo[4]
Cassio Ricardo Goncalves da Costa[5]

[1,2,3,4]*Department of Phytotechnics and Environmental Sciences, Federal University of Paraiba, Brazil.*
[1]*Email: mlanaluiza@gmail.com*
[2]*Email: bandeira1997@gmail.com*
[3]*Email: magecologia@hotmail.com*
[4]*Email: raul.s.r.araujo@gmail.com*
[5]*Federal Rural University of the Semi, Arid, Brazil.*
[5]*Email: cassioagronomoufpb@gmail.com*

(+ Corresponding author)

Article History
Received: 8 January 2021
Revised: 4 February 2021
Accepted: 26 February 2021
Published: 17 March 2021

Keywords
Moringa oleifera Lam
Emergency
Substrate
Organic fertilization.

ABSTRACT

The *Moringa oleifera* Lam. it is a perennial, arboreal species, rapidly growing, resistant to drought and with leaves, flowers and edible fruits. With this research the objective to evaluate the effect of different substrates in the emergence and development of seedlings of Moringa. The experiment was carried out at the Plant Ecology Laboratory of the Department of Phytotechnics and Environmental Sciences, at the Center for Agricultural Sciences, at the Federal University of Paraíba. The experimental desing was completely randomized, with eight treatments T1= sand washed (control), T2= sand + coconut fiber, T3= sand + rice bark, T4= sand + bovine manure, T5= sand + pine powder, T6= sand + chicken manure, T7= sand + vegetable ash and T8= quail, with four repetitions of 25 seeds totaling 100 seeds for each treatment. The substrates were used in proportion 3:1, and these proportions were determined in terms of weight and all the sieved substrates, arranged in 6 cm x 29.5 cm x 45.5 cm trays, with an approximate capacity of 7 liters of substrate. The following parameters were evaluated: the emergence percentage, first count, emergence speed index, seedling height, plant height, root length, number of leaves, dry leaf biomass, stalk, root and total. The germination and initial development of *M. oleífera* seedlings were satisfactory in sand and favored when fibrous materials of vegetable origin (coconut fiber, rice bark or pine powder) or bovine manure were added to the substrate. The addition of manure sand from birds (chicken and quails) and vegetable ash did not favor the substrate for germination of *Moringa oleifera* Lam. seeds.

Contribution/Originality: In search of alternatives to reduce costs and maintain the yield and quality of the production of *Moringa oleifera* Lam, we tested the use of alternative natural substrates. The influence of using different substrate alternatives on the nutritional quality of this crop is an economically viable and beneficial to the environment.

1. INTRODUCTION

Popularly known as moringa (*Moringa oleifera* Lam.), It is a species belonging to the Moringaceae family [1]. It is an arboreal vegetable that reaches 8 to 12 meters in height, has slight growth, the ability to resist in poor soils, requiring minimal attention in long periods of drought Höhn, et al. [2]. Souza and Lorenzi [3] consider this species as a rustic plant, resistant to drought and with leaves, flowers, fruits, seeds and roots are edible and have vitamins A, B and C, all essential amino acids, in addition to being rich in important minerals , among them iron, calcium and magnesium [4].

It presents oilseeds [5] which gives it great potential for the extraction of oil for the production of biofuel. Because it is very drought tolerant, it can be cultivated in arid and semi-arid regions, with annual rainfall below 300 mm, in addition to being cultivated in almost all classes of soils, except in those where waterlogging is possible [6].

Seedling transplanting is an option to minimize losses and ensure benefits such as greater crop uniformity, elimination of thinning, reduced crop cycle, economy of inputs [7]. Good quality seedlings develop better and, consequently, will provide good formation of the root system, with better ability to adapt to the new location after transplantation, positively affecting its production [8].

The use of fertilization in the production of tree seedlings has been extensively researched, and in most cases, the results demonstrate the importance of fertilization to obtain more vigorous seedlings and with a better stand after planting in the field [9].The production of seedlings is conditioned to the use of substrates that must have desirable physical, biological and chemical properties [10].

The substrates are essential in the quality of the seedlings, and they must present good conditions of humidity, macropores and microporosity, availability of nutrients and water, capacity to exchange cations and good association with the roots [11, 12] in addition to being free of pathogens and having a low salt content. Currently, there are several commercial substrates ready for use, but their added value compromises the producer's income [13]. In search of alternatives to reduce costs and maintain yield and quality in production, the producer has adopted the use of alternative substrates [11].

In this way, the performance of experiments to test the influence of different substrate alternatives on the behavior of this culture should gain greater attention so that in the future it is possible to explore this culture in an economically viable way and with a minimum of aggression to the environment.

Given the above, the objective of this research was to evaluate the development of seedlings of *Moringa oleífera* Lam. Submitted to the planting of different substrates.

2. MATERIAL AND METHODS

The experiment was carried out at the Plant Ecology Laboratory of the Department of Phytotechnics and Environmental Sciences, of the Agricultural Sciences Center of the Federal University of Paraíba (UFPB), located in the municipality of Areia, Paraíba. The moringa seeds used came from matrices located at Sítio Carnaúba, municipality of Nazarezinho-PB.

The experimental design used was completely randomized with eight treatments T1 = washed sand (control), T2 = sand + green coconut fiber, T3 = sand + rice husk, T4 = sand + bovine manure, T5 = sand + pine powder, T6 = sand + chicken manure, T7 = sand + vegetable ash and T8 = sand + quail litter and four repetitions of 25 seeds, totaling 100 seeds for each treatment. Using an eight-liter bucket, the sand was mixed with the other substrates in a 3: 1 ratio, these proportions were determined in terms of weight and all the sieved substrates, arranged in trays with dimensions of 6 cm x 29, 5 cm x 45.5 cm, with an approximate capacity of 7 liters of substrate, these were kept moist, being watered according to need, then twice a day until the end of the experiment.

Chicken manure and quail litter (produced from sugarcane cultural remains) were collected at the Aviary belonging to the Center for Agricultural Sciences / UFPB, in Areia-PB. The substrates: rice husk, cattle manure, pine powder, vegetable ash and coconut fiber were obtained commercially. Seedling collection was performed fifteen days after sowing, when the emergency stabilized.

The evaluated variables were:

- Seedling emergence: where the emerged seedlings were monitored daily and the percentage of emergence was calculated using the ratio: Number of seedlings emerged / Total number of seeds x 100.
- Emergency speed index (IVE): calculated at the end of the test from the daily data on the number of normal seedlings using the formula:

$$IVE = \frac{G_1}{N_1} + \frac{G_2}{N_2} + \ldots + \frac{G_n}{N_n},$$

Where:

IVE = emergency speed index.

G1, G2, Gn = number of normal seedlings computed in the first, second and so on, until the last count.

N1, N2, Nn = number of days after sowing, in the first, in the second and so on, until the last count.

- First Count: Corresponding to the accumulated percentage of seeds emerged until the third day after the start of the test.
- Seedling height and root length: Both parameters were measured with a graduated ruler, the height of the seedling stem to the upper end of the last leaf emitted and the length of the seedling root root to the lower end of the main root, values expressed in centimeters.
- Number of Leaves: Counting the number of leaves (NF) in all seedlings of each treatment.
- Biomass: When the seedlings were 15 days after sowing, they were harvested, leaves, stem and root separated. The roots were washed in running water and packed in Kraft paper bags, and dried in an oven with forced air circulation, at approximately 65°C, until constant weight was obtained. Subsequently, dry mass of the leaf (DML), dry mass of the stem (DMS) and dry mass of the root (DMR) were evaluated, determined on an analytical balance with an accuracy of 0.001g and the data are expressed in g plant-1. From the primary data, the total dry mass (DMT) was determined.
- The collected data were subjected to analysis of variance and the means compared using the Tukey test at 5% probability. Statistical analyzes were performed using the R Core Team software (2020) and the averages contrasted by Anova.

3. RESULTS AND DISCUSSION

Regarding seedling emergence, it was observed that it is of the epigeal type and started on the fourth day after sowing. First, the curved hypocotyl appeared on the surface, after one day, the leafy cotyledons emerged, as can be seen in Figure 1. All treatments obtained seed emergence on the fifth day, except for treatment T7 (sand + vegetable ash) in which there was no seed emergence during the experiment. Terra, et al. [14] growing lettuce in the soil + vegetable ash substrate found the smallest emergence with an average of 7.83% in this substrate and considered the high soil correction potential of this material, a fact confirmed by the pH value, which due to the addition of ash vegetation increased from 5.91 to 10.51.

It was observed that the seedling emergence of all treatments did not differ statistically, as can be seen in Figure 2. Such average values were: the control T1- sand (96%), T2- coconut fiber (99%), T3 - rice husk, T4 - cattle manure and T5 - pine powder (98%), T6 - chicken manure (94%) and T8 - emergency quail bed (92%). A similar result was obtained by Bezerra, et al. [15] in the Moringa emergency using the coconut fiber substrate with 98.3%. Lower values were found by Noronha, et al. [16] evaluating the physiological quality of Moringa seeds on germitest paper with emergence of 86, 89, 48 and 88%. In studies carried out with moringa seeds, Pereira, et al. [9] estimated that for commercialization of a seed lot, it must have at least 80% emergency.

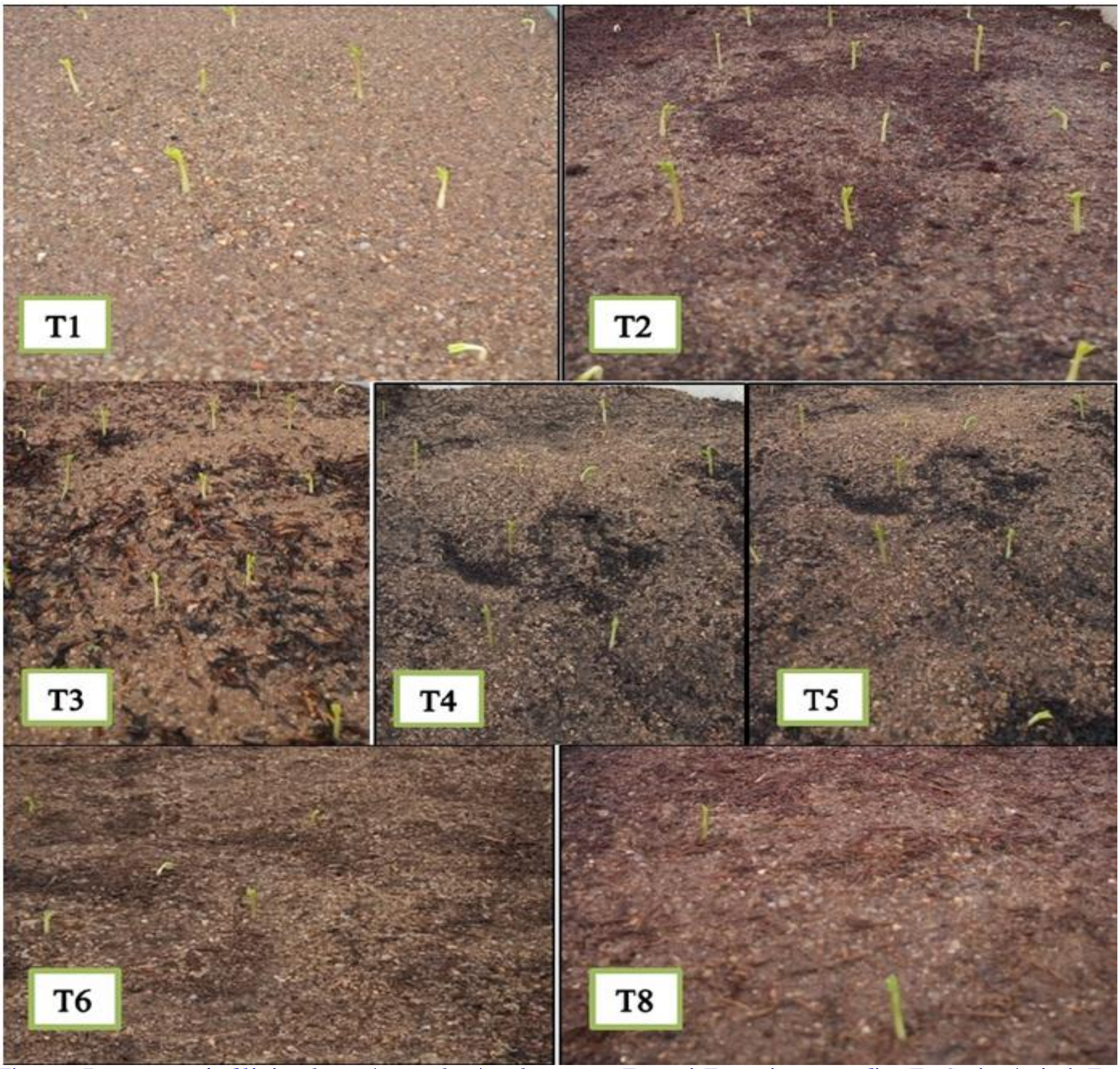

Figure-1. Emergence on the fifth day after sowing as a function of treatments: T1- sand, T2- sand + coconut fiber, T3- Sand + rice husk, T4- sand + bovine manure, T5- sand + pine powder, T6- sand + chicken manure and T8- sand + quail litter. Source: Ana Luíza de Melo Lucena, Areia-PB 03/01/2020.

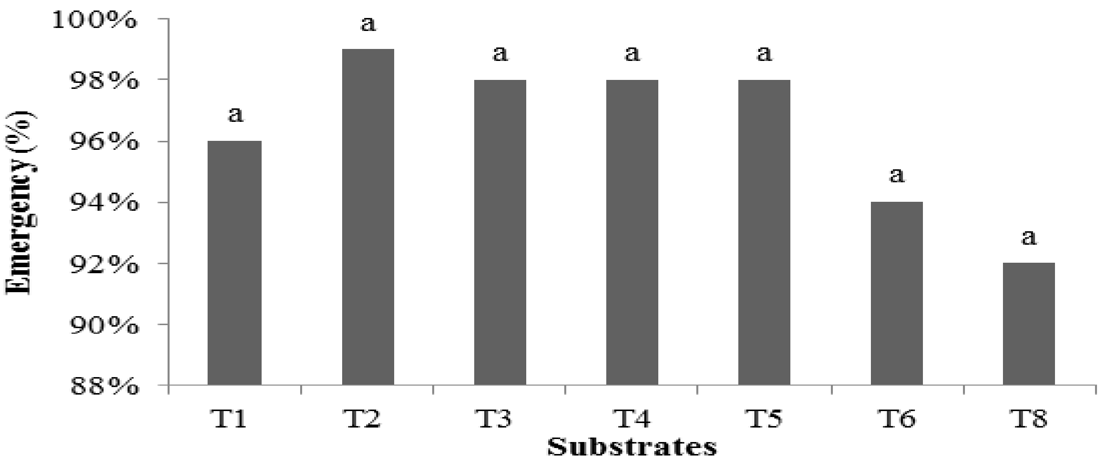

Figure-2. Average values of emergence according to the substrates. Same letters do not differ from each other by the Tukey test (P<0.05).

According to Alves, et al. [17] studying *Adenanthera pavonina* (L.), obtained 67% emergency using 75% sand + 25% bovine manure. However Honorio, et al. [18] obtained 91.7% of emergence using the same proportion of the substrate for the species *Euterpe oleraceae* Mart., Whereas in the present study, the T4 treatment with the same proportion, obtained satisfactory result for Moringa, presenting 98% of emergence . It should be noted that the condition of the best substrate is variable for each species, in which different results can be obtained according to the species under study, that is, seeds of different species may require different physical and chemical conditions to achieve satisfactory germination rates or emergency [19].

The first count and the Emergency Speed Index can be used to identify batches with faster emergence in the field or in the greenhouse, thus minimizing the adverse conditions that occur during germination and seedling establishment [20]. The first count Figure 3 was performed on the fourth day after sowing, achieving better results between treatments T1 to T5 with averages of 85% to 67% and lower results in treatments T6 and T8, 26 and 27% respectively, as we confirm in Figure 1.

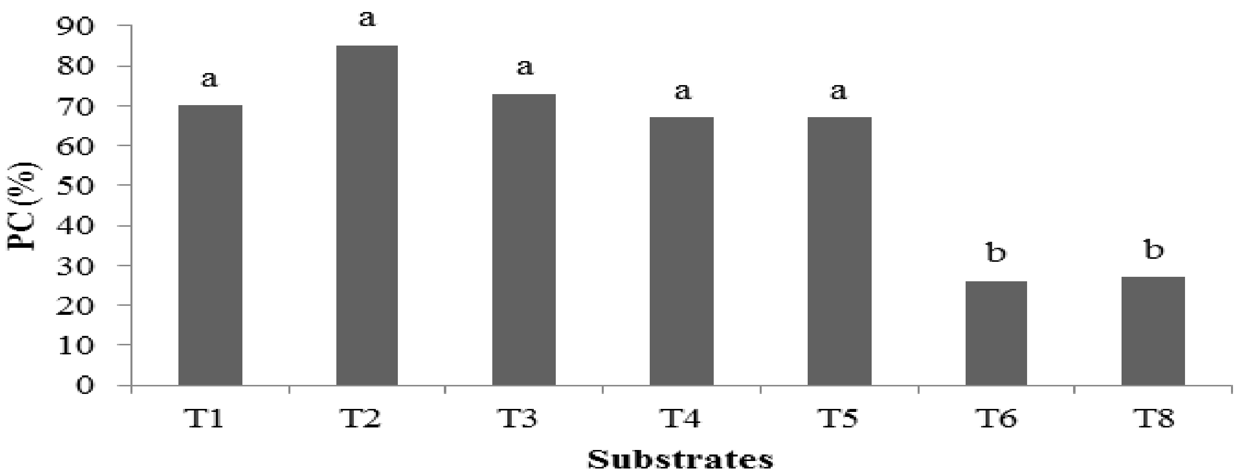

Figure-3. Average values of the first count according to the substrates. Same letters do not differ from each other by the Tukey test (P<0.05).

In Figure 4, it is possible to observe the effect of substrates on the emergence speed index of seeds of this species, with no significant differences being observed, that is, the tested substrate combinations are statistically equal to the 5% probability level. , with averages between 24.7 and 22.6 between treatments T2 and T8, probably because they provide good drainage and porosity, allowing the entry of air and water with adequate amounts for the establishment of seedlings.

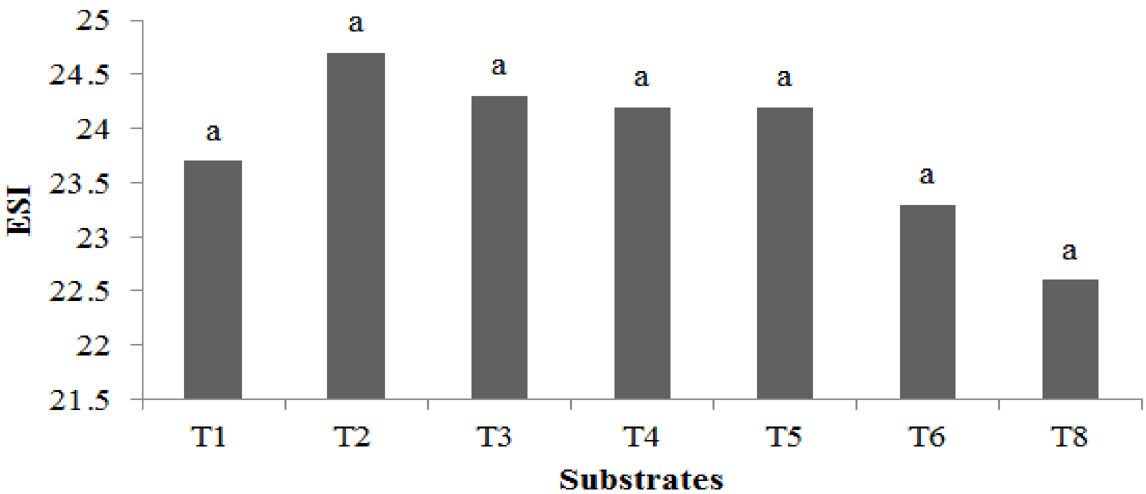

Figure-4. Average values of the emergency speed index as a function of the substrates. Same letters do not differ from each other by the Tukey test (P<0.05).

This result can be justified by Barbosa [21] who states that the substrate can indirectly influence the emergency capacity, since its physical and chemical properties such as high porosity and the presence of electrical charges provide greater water absorption, at the same time. That maintains a good aeration. As a result, there is enough water in the seeds to help break down tegumentary dormancy, in addition to activating the enzymes responsible for the germination process.

Regarding the height of seedlings, it is observed in Figure 5 that the best performances were obtained with the treatments T1 (sand), T2 (sand + coconut fiber) and T4 (sand + bovine manure) with averages 25.9; 26.2; 25.8 cm respectively, statistically correlating with treatment T3 (sand + rice husk), which showed an average of 24.9 cm, but differing from treatments T5 (sand + pine powder), T6 (sand + chicken manure) and T8 (sand + quail bed) in which they presented lower performances with averages of 22.5; 14.5 and 15.4 cm. In an emergency study with *Campomanesia pubescens*, Periotto and Gualtieri [22] using the substrate sand + coconut powder obtained shorter lengths in height. Guimarães, et al. [23] evaluating substrates containing different organic residues and mineral fertilizers for the production of castor beans, concluded that the substrate composed of bovine manure provided the best growth of castor. Results obtained by Farfan, et al. [24] prove that the use of compost based on mango leaves and bovine manure enriched with agricultural plaster promoted greater height of moringa seedlings. Mexal and Lands [25] report that the plant height presents a good estimate of the initial seedling growth in the field, being accepted as a good measure of the plant's performance potential.

The highest mean values of root length Figure 5 were obtained with treatment T2 (sand + coconut fiber), followed by treatments T3, T4, T1 and T5, in which they presented averages between 6.81, 6.6, 5.83, 5.76 and 5.41 cm respectively. Lower average values found in treatments T6 (sand + chicken manure) and T8 (sand + quail litter) with averages 3.96 and 3.24 cm, with these values it is possible to confirm that there was not a good performance in the plant development of both treatments, in agreement with what was observed by Neves, et al. [26] who concluded that at the seedling level, substrates from poultry manure were the ones that showed the lowest phylotechnical efficiency for all the characteristics evaluated in the production of moringa. In Figure 5, we can examine the difference in seedling growth between treatments T6 (sand + chicken manure) and T2 (sand + coconut fiber), where treatment T6 has a shorter length.

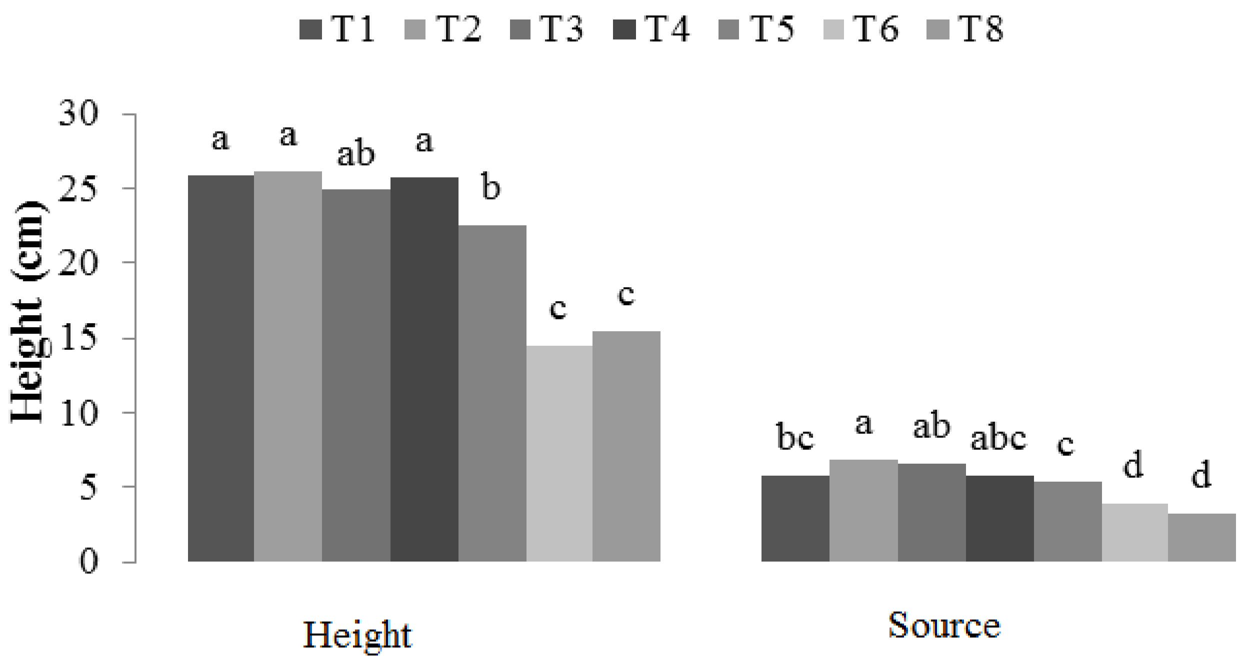

Figure-5. Mean values for seedling height and root length as a function of substrates. Same letters do not differ by Tukey's test (P <0.05).

In Figure 6, it is possible to observe results referring to the number of leaves, where the treatments T1, T2, T3, T4 and T5 did not differ statistically, however the treatment T4 obtained an average number of leaves higher than the others (15.4). The treatments T6 and T8 obtained inferior results. As seen in the variables previously analyzed, the substrates T1 to T5 behaved similarly, with the exception of treatments T6 and T8, which both showed an average reduction of 18.5% in leaves when compared to the other treatments, when observing the structure of these seedlings, we noticed that the leaf blade and the entire plant structure were not well developed, resulting in several consequences when exposed to the field. Various ecological actions can influence, in different ways and intensity, growth, reproduction, survival and plant abundance.

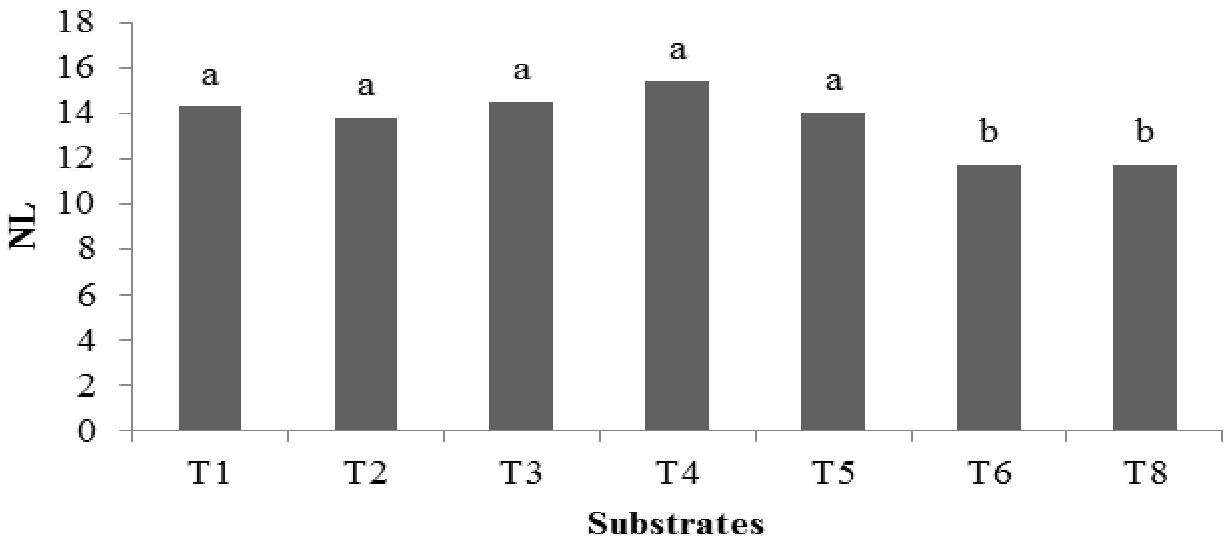

Figure-6. Average values for the number of leaves depending on the substrates. Same letters do not differ by Tukey's test (P <0.05).

Lower values were found by Neves, et al. [27] studying the germination of Moringa in substrates sand and 75% earth + 25% bovine manure with an average of 7.47 and 7.17 leaves. Medeiros, et al. [28] when evaluating different sources of organic matter in the production of seedlings, found that the plants of *Jatropha curcas* L. had higher height, in addition to the greater number of leaves and leaf area, in the treatments that contained bovine manure when compared to those produced in substrate containing chicken litter.

For Biomass, it is observed that the dry mass of the leaf (DML), dry mass of the stem (DMS), dry mass of the root (DMR) and total dry mass (DMT), obtained significant interactions between the different substrates. The MSF Figure 7 obtained maximum production of 3.53 g plant-1 with the substrate sand + bovine manure, correlating with the substrates of the T1, T2, T4 and T5 treatments, in which they obtained averages close to the T3 treatment (sand + manure). The minimum production was found in the substrates T6 and T8, where the plants presented a degree of atrophy, due to the level of stabilization of the substrates.

For DMS the maximum production was found in treatment T3 presenting 1.50 g plant-1, corroborating with treatment T2 (sand + coconut fiber), which proved to be a good substrate for the germination of this species. Then treatments T1, T4 and T5 with averages between 1.09 and 0.98 g plant-1, lower results found for treatments T6 and T8 where the stem biomass was equivalent to 0.2 g plant^{-1}.

The DMR showed a slightly different behavior from the others, with the maximum production found in T3 (sand + rice husk) with 1.34 g plant-1, which can be explained by the properties of the rice husk in terms of retention capacity of water. According to Guerrini and Trigueiro [29] substrates with a mixture of carbonized rice husks in a proportion between 40% to 70% are considered the most suitable for the production of forest essence seedlings because they present an adequate balance between density, porosity and water retention. Afterwards, he obtained a median growth in treatments T2, T4 and T5, again treatments T6 and T8, with lower growth values at the end of the experiment.

Regarding the T1 treatment, due to the sand showing several structural qualities such as high porosity, good water drainage and aeration, which are fundamental factors for improving the architecture of the root system, this substrate shows a good performance when used only for germination or incorporated into other substrates, in agreement with Cavalcanti, et al. [30] who states that the sand has been used by several researchers in tests with emergence and growth of various species, in any size. Sand is an important conditioner of the soil structure. Its physical properties provide conditioning and the aeration and permeability of the soil will depend on it.

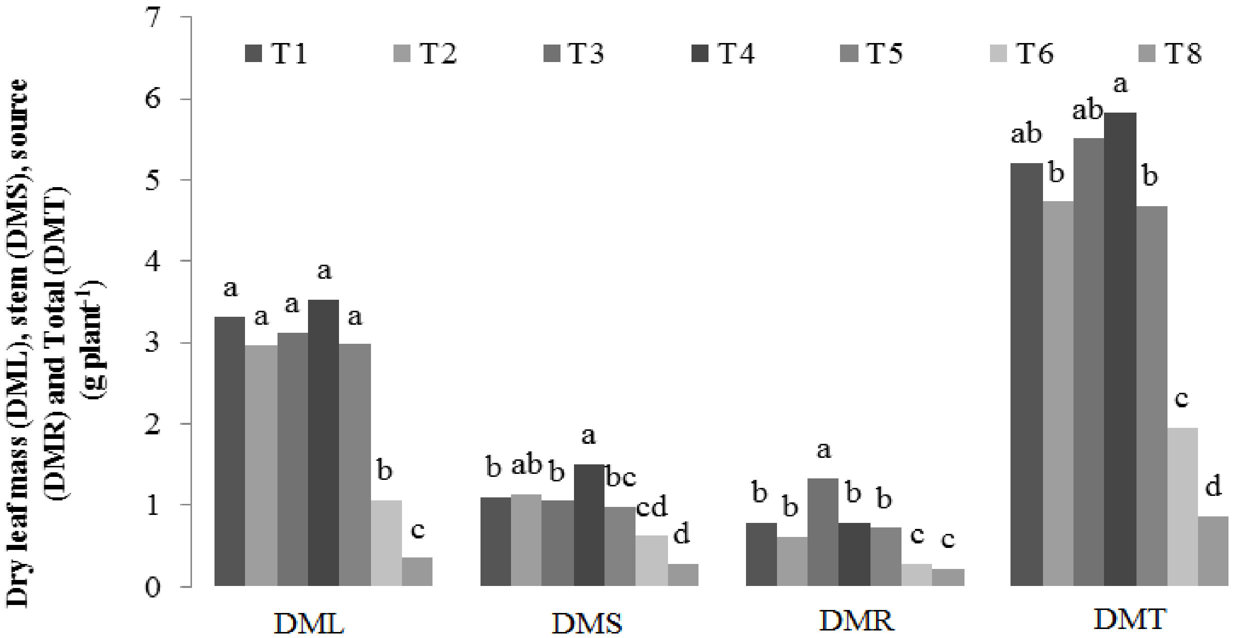

Figure-7. Average values of dry mass of leaf, stem, root and total depending on the substrates. Same letters do not differ by Tukey's test ($P < 0.05$).

We can observe the highest accumulation of total biomass (DMT) in the T4 treatment (sand + cattle manure), which can be attributed to the chemical fertility of the substrate associated with the porosity of the sand, which allowed for good aeration, water retention and the continuous availability of nutrients for plants, minimizing the probability of nutritional deficiencies during the period of seedling formation. Such behavior was also verified for *Sesbania virgata* grown with organic compost made of bovine manure [31]. In the case of the T7 treatment, as it is only a mixture of sand and vegetable ash, it should be noted that in this case there is an absence of nitrogen in the substrate (lost due to volatilization in the burning of the plant material), which may explain the low performance in this treatment in the most of the measured variables.

4. CONCLUSION

Germination and initial development of *M. oleífera* seedlings were satisfactory in sand and favored when fibrous materials of vegetable origin (coconut fiber, rice husk or pine powder) or bovine manure were added to the substrate. The addition of manure sand from poultry (chicken and quail) and vegetable ash did not favor the substrate for germination of Lam Moringa seeds.

Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no competing interests.
Acknowledgement: All authors contributed equally to the conception and design of the study.

REFERENCES

[1] J. R. S. Costa, G. N. Almeida, L. G. C. Silva, G. N. Almeida, and E. C. A. Silva, "Conditioning of moringa seedlings at different irrigation cycles," *Engineering in Agriculture Magazine*, vol. 27, pp. 80-87, 2019. Available at: https://doi.org/10.13083/reveng.v27i1.894.

[2] D. O. Höhn, C. Fonseca, S. R. Avila, A. F. Guedes, and L. A. O.-. Fernandes, "Moringa oleifera Lam, characteristics and potential uses: A sustainable alternative for the development of small rural communities," *Journals of Agroecology*, vol. 13, pp. 1-10, 2018.

[3] V. C. Souza and H. Lorenzi, "Systematic Botany: illustrated guide for identifying families of native and exotic phanerogams in Brazil, based on APG II," ed Nova Odessa: Plantarum Institute, 2008, p. 704.

[4] National Research Council, *Lost crops of Africa: Volume II: Vegetables, Development, security and cooperation*. Washington, DC: National Academy of Science, 2006.

[5] H. Lorenzi and F. J. Matos, *Medicinal plants in Brazil: Native and exotic cultivated*. Nova Odessa: Instituto Plantarum, 2002.

[6] J. B. M. Marinho, A. M. V. Arruda, R. T. V. Fernandes, A. S. Melo, R. F. Souza, L. O. G. Santos, and A. C. N. Mesquita, "Use of moringa in animal and human nutrition: review," *PUBVET*, vol. 10, pp. 619-627, 2016.

[7] F. L. F. Saidelles, M. V. W. Caldeira, W. N. Schirmer, and H. V. Sperandio, "Carbonized rice husk as a substrate for the production of monkfish and garapeira seedlings," *Semina: Ciências Agrárias*, vol. 30, pp. 1173-1186, 2009. Available at: https://doi.org/10.5433/1679-0359.2009v30n4Sup1p1173.

[8] L. P. Silva, A. C. Oliveira, N. F. Alves, V. L. Silva, and T. L. Silva, "Use of alternative substrates in the production of pepper and pepper seedlings," *Colloquium Agrariae*, vol. 15, pp. 104-115, 2019. Available at: 10.5747 / ca.2019.v15.n3.a303.

[9] K. T. O. Pereira, A. L. G. Cavalcante1, R. P. Dantas, L. A. Lima, L. P. Gomes, and F. A. Oliveira, "Effect of fertilizer levels on the production of moringa seedlings," presented at the In: Inovagri International Meeting, 2., 2014, Fortaleza-Ceara. Annals. Fortaleza: INOVAGRI, 2014.

[10] A. C. Araújo, A. C. Araújo, M. K. L. Dantas, W. E. Pereira, and M. A. I. Aloufa, "Use of organic substrates in the production of papaya formosa seedlings," *Revista Brasileira de Agroecologia*, vol. 8, pp. 210-216, 2013.

[11] F. B. Nadai, J. B. C. Menezes, H. C. R. M. Catão, T. Advíncula, and C. A. Costa, "Production of tomato seedlings according to different forms of propagation and substrates," *Revista Agro*, vol. 9, pp. 261-267, 2015. Available at: https://doi.org/10.18227/1982-8470ragro.v9i3.2348.

[12] L. A. d. M. Costa., M. S. S. d. M. Costa, D. C. Pereira, F. H. Bernardi, and S. Maccari, "Evaluation of substrates for the production of tomato and cucumber seedlings," *Revista Ceres*, vol. 60, pp. 675-682, 2013. Available at: https://doi.org/10.1590/S0034-737X2013000500011.

[13] F. C. M. Gonçalves, F. P. Arruda, F. L. Sousa, and J. R. Araújo, "Germination and development of cubanelle pepper seedlings on different substrates," *Revista Mirante*, vol. 9, pp. 35-45, 2016.

[14] M. A. Terra, F. F. Leonel, C. G. Silva, and A. M. Fonseca, "Vegetable ash in the germination and development of lettuce," *Agrogeoambiental Magazine*, vol. 6, pp. 1-8, 2014.

[15] A. M. E. Bezerra, V. G. Moment, and F. S. Medeiros, "Seed germination and seedling development of moringa (Moringa oleifera Lam.) Depending on the weight of the seed and the type of substrate," *Horticultura Brasileira*, vol. 22, pp. 295-299, 2004.

[16] B. G. Noronha, A. D. Medeiros, and P. M. Dias, "Evaluation of the physiological quality of Moringa oleifera Lam seeds," *Forest Science*, vol. 28, pp. 1-11, 2018.

[17] M. M. Alves, E. U. Alves, L. R. de Araujo, P. C. Araujo, M. d. Neta, and d. S. MS, "Initial growth in seedlings of Adenanthera pavonina L. for different substrates," *Agronomic Science Magazine*, vol. 46, pp. 352-357, 2015.

[18] A. B. M. Honorio, M. S. Rhonan, P. H. A. Marinho, T. C. A. B. Leal, and P. B. Souza, "Germination of Euterpe oleraceae (Mart.) Seeds in different substrates," *Agrarian Academy, Scientific Center Knowing*, vol. 4, pp. 1-12, 2017.

[19] I. V. M. Oliveira, I. H. L. Cavalcante, and A. B. G. Martins, "Influence of the substrate on the emergence of black sapota seedlings," *Revista Caatinga, Mossoró*, vol. 19, pp. 383-386, 2006.

[20] W. M. Nascimento and R. S. Pereira, "Tests to evaluate the physiological potential of lettuce seeds and their relationship with germination under adverse temperatures," *Brazilian Journal of Seeds*, vol. 29 pp. 1-15, 2007.

[21] A. F. Barbosa, "Germination and initial growth of adenanthera pavonina l. fertilized with organic compost," *Monograph (Graduation of Technology in Agroecology) UFRB*, p. 74, 2017.

[22] F. Periotto and S. C. J. Gualtieri, "Germination and initial development of Campomanesia pubescens (DC.) O. BERG (MYRTACEAE) on different substrates," *Forest Science*, vol. 27, pp. 743-752, 2017.

[23] M. M. B. Guimarães, L. S. Severino, N. E. Beltrão, F. X. Costa, J. F. Xavier, and A. M. A. Lucena, "Production of castor bean seedling on substrate containing different organic residues and mineral fertilizer," presented at the In: Annals. Aracajú: 2nd Brazilian Castor Congress, 2006.

[24] S. J. A. Farfan, C. A. Barbosa, R. G. Parente, M. I. L. Pereira, and F. F. Olivier, "Development of the moringa oleífera lam. Submitted to different types of substrates with soil and organic matter," *Agroecology Notebooks*, vol. 10, pp. 1-10, 2016.

[25] J. L. Mexal and T. D. Lands, "Target seedling concepts: height and diameter. In: Target seedling symposium, meeting of the western forest nursery associations, general technical report rm-200, Roseburg," in *Proceedings... Fort Collins: USDA, Forest Service*, 1990, pp. 17-35.

[26] J. M. G. Neves, H. P. Silva, and R. F. Duarte, "Use of alternative substrates for the production of moringa seedlings," *Revista Verde, Mossoró*, vol. 5, pp. 173 - 177, 2010.

[27] N. N. A. Neves, T. A. Nunes, M. C. C. Ribeiro, G. L. Oliveira, and C. C. Silva, "Seed germination and seedling development of Moringa oleifera Lam," *Revista Caatinga, Mossoró*, vol. 20, pp. 63-67, 2007.

[28] K. Medeiros, V. Sofiatti, H. Silva, R. Lima, A. Lucena, G. C. Vasconcelos, and N. H. C. A. Arriel, "Jatropha curcas L. seedlings produced in different sources and doses of organic matter," in *Proceedings of the Brazilian Castor Congress and International Symposium on Oilseeds Energetic*, 2010, pp. 1413-1419.

[29] I. A. Guerrini and R. Trigueiro, "Physical and chemical attributes of substrates composed of biosolids and carbonized rice husks," *Brazilian Journal of Soil Science*, vol. 28, pp. 1069-1076, 2004. Available at: https://doi.org/10.1590/S0100-06832004000600016.

[30] N. B. Cavalcanti, G. M. Resende, and L. T. L. Brito, "Emergence and growth of umbuzeiro (Spondias tuberosa Arr. Cam.) In different substrates," *Ceres Magazine*, vol. 25, p. 69, 2002.

[31] L. B. Sousa, R. S. A. Nóbrega, J. S. Lutosa Filho, S. P. N. Amorim, L. V. M. Ferreira, and J. C. A. Nóbrega, "Cultivation of Sesbania virgata (Cav. Pers) on different substrates," *Rev. Cienc. Agrar*, vol. 58, pp. 240-247, 2015. Available at: http://dx.doi.org/10.4322/rca.1942.