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INITIAL GROWTH OF MORINGA SUBMITTED TO DIFFERENT SUBSTRATE COMPOSITIONS AND IRRIGATION REGIMES

CRESCIMENTO INICIAL DA MORINGA SUBMETIDA A DISTINTAS COMPOSIÇÕES DE SUBSTRATOS E REGIMES DE IRRIGAÇÃO

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ABSTRACT: Water deficiency is a limiting factor of greater significance in the survival and initial growth of plants. Moringa (Moringa oleifera Lam) is a fast-growing plant originating in India, which adapts easily to the edaphoclimatic conditions of northeastern Brazil. However, information on the production of seedlings of this species is still scarce under different substrate compositions associated with irrigation regimes. Thus, the objective of this work was to characterize the vegetative behavior of moringa plants submitted to different compositions of substrates and irrigation regimes. The experiment was carried out in a screened environment (50% mesh), from September to October 2020, in the experimental area of the State University of Piauí, Campus Cerrado do Alto Parnaíba, Uruçuí. An experimental design in a factorial scheme was adopted, the first factor being two irrigation regimes (50% and 100% of ETo) and the second factor, five types of substrates (SB1 = red latosol; SB2 = commercial substrate; SB3 = soil + manure; SB4 = soil + vegetable ash; SB5 = soil + coffee grounds), with 5 replicates. At 45 days after sowing, the following variables were analyzed: plant height, stem diameter, number of leaves, leaf area and total dry phytomass (leaf, stem and root). The initial growth parameters of the moringa crop were significantly affected by the interaction between the factors (irrigation regimes x substrates), with the best results obtained for the substrate compositions (commercial, red latosol, soil + coffee grounds and soil + manure), by applying the water regime concerning the availability of 100% of the reference evapotranspiration.

Keywords: *Moringa oleifera Lam.; seedling production; water deficit.*

RESUMO: A deficiência hídrica é um fator limitante de maior significância na sobrevivência e crescimento inicial de plantas. A moringa (Moringa oleifera Lam) é uma planta originária da Índia de crescimento rápido, que se adapta facilmente às condições edafoclimáticas do nordeste brasileiro. No entanto, ainda são escassas as informações sobre a produção de mudas desta espécie sob diferentes composições de substratos associados a regimes de irrigação. Desta forma, o objetivo desse trabalho foi caracterizar o comportamento vegetativo de plantas de moringa submetidas a distintas composições de substratos e regimes de irrigação. O experimento foi realizado em ambiente telado (malha 50%), durante o período de setembro a outubro de 2020, na área experimental da Universidade Estadual do Piauí, Campus Cerrado do Alto Parnaíba, Uruçuí. Adotou-se um delineamento experimental em esquema fatorial, sendo, o primeiro fator, dois regimes de irrigação (50 e 100% da ETo) e o segundo fator, cinco tipos de substratos (SB1 = latossolo vermelho; SB2 = substrato comercial; SB3 = solo + esterco; SB4 = solo + cinza vegetal; SB5 = solo + borra de café), com 5 repetições. Aos 45 dias após a semeadura foram analisadas as seguintes variáveis: altura de plantas, diâmetro do caule, número de folhas, área foliar e fitomassa seca total (folha, caule e raiz). Os parâmetros de crescimento inicial da cultura da moringa foram afetados significativamente pela interação entre os fatores (regimes de irrigação x substratos), sendo os melhores resultados obtidos, para as composições de substratos (comercial, latossolo vermelho, solo + borra de café e solo + esterco), mediante aplicação do regime hídrico concernente a disponibilização de 100% da evapotranspiração de referência.

Palavras-chave: *Moringa oleifera Lam.; produção de mudas; déficit hídrico*.

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INTRODUCTION

Moringa (*Moringa oleifera* Lam) is a plant of wide adaptability, growing in regions from dry and humid subtropical, to dry tropical and humid forests. It adapts to various soil types, showing drought tolerance, high flowering and fruit production, however, it shows better development in well-drained soils or clay soils, with a preference for soils with pH close to neutrality (PEREIRA et al., 2019).

Nóbrega et al. (2018) highlight the multiplicity of moringa, which can be used for purposes such as: forage (leaves, fruits, and seeds); medicinal (all parts of the plant); condiment (mainly the roots); culinary; in the cosmetics industry (oil extracted from the seeds); honey (flowers); and as fuel (wood and oil). In Brazil, there is an effort to spread the cultivation of this tree crop characterized by being rich in vitamin A, presenting in the leaves saponins, phytates, and tannins, with low antinutritional factors.

Plants are often exposed to multiple stresses, which limit their growth and development. Among the environmental factors, water deficiency is one of the stress factors that cause the greatest damage to the physiological and metabolic processes of plants, determining the distribution of plant species (LARCHER, 2006).

This happens because all aspects of plant growth and development are affected by water deficiency in the tissues, caused by excessive evaporative demand and/or limited water supply. As a consequence of this deficiency, dehydration of the protoplast occurs, resulting in a decrease in cell volume and an increase in the concentration of solutes. Thus, the growth process, especially in expansion, dependent on cell turgescence is the first affected when in situations of water deficit (TAIZ et al, 2017).

As for the aspects considered in the production of seedlings, the substrate to be used, is another factor that influences the germination and initial development of plants, becoming a determining issue for the seedling producer to obtain a good performance (BARON et al., 2011). Several characteristics and properties of the substrate can influence germination such as structure, pH, aeration, water retention capacity and degree of contamination by pathogens, in addition to the availability of nutrients, oxygen, temperature and light (SILVA et al., 2014). However, for Araújo et al. (2018), the choice of substrate should be made depending on the availability, the cost of the material, the species to be grown and the production conditions.

In the case of native tree species, the agronomic aspects are still little studied, especially those that could better elucidate the behavior of these species in the absence of essential factors for their survival, such as water. Currently, with the growing theme of climate change, evidenced by the reduction in precipitation levels and the increase of dry spells, studies that aim to understand the effects of water restriction and the responses of plants against this limiting factor, can contribute to the management, production of seedlings for reforestation, distribution of the species, and better use of water.

In view of the above, the objective of this work was to evaluate the vegetative behavior of moringa plants cultivated under different substrate compositions associated with two irrigation regimes.

MATERIAL AND METHODS

The experiment was conducted in pots, in a 50% mesh shaded environment, during the period from September to October 2020, in the experimental area of the State University of Piauí, Alto Parnaíba Cerrado Campus, Uruçuí, with local coordinates of latitude 07º 13' 46" S, longitude 44º 33' 22" W and altitude of 167 m, in an area that comprises the cerrado biome.

The region's climate, according to the Köppen classification, is of the Aw type, tropical, with an average temperature of 27.2 °C and average annual precipitation ranging from 750 to 2000 mm.

The rainfall and better regularity of rain distribution occurs between October and March and the dry period, with water deficit, from April to September (MOREIRA NEVES et al., 2015). The pots used for the experiment were made of flexible plastic material, with a volumetric capacity of 5 liters, with holes at the lower end, which aimed to promote the removal of any excess water.

The experimental design was entirely randomized (DIC), in a 2 x 5 factorial arrangement; the first factor was composed of two irrigation regimes (RH 1 = application of a water regime referring to 50% of the ETo and RH 2 = application of a water regimereferring to 100% of ETo) and the second factor was composed of five types of substrates (SB 1 = soil (red latosol); SB 2 = commercial substrate; SB 3 = soil + manure; SB 4 = soil + vegetal ash; SB 5 = soil + coffee grounds), with 5 repetitions, totaling 50 experimental units.

The irrigation management was performed using the reference evapotranspiration (ETo) for the application of irrigation sheets, which were calculated with the help of a spreadsheet where the daily values of reference evapotranspiration (ETo) were recorded, estimated by the Penman-Monteith method using climatic data obtained from the National Institute of Meteorology (INMET), in an automatic agrometeorological station located in Uruçuí, Piauí.

For the application of irrigation water, in mL, a 1000 mL cylinder was used, calculating the volume to be applied according to the area of the pot and the ETo:

$$Vol = 1000 \times Av \times ETo \quad (1)$$

Where,

Vol - Volume of water to be applied, in mL;
ETo - reference evapotranspiration, in mm;
Av - Surface area of the vase, in m2.

To evaluate the vegetative growth of moringa plants, at 45 days after sowing (DAS) the morphological characteristics were determined: plant height, measured by the distance between the soil surface to the apex of the youngest leaf, using a tape measure graduated in centimeters; the stem diameter, measured using a digital pachymeter, with the values expressed in millimeters; the number of leaves, measured by directly counting the fully expanded leaves, with the values expressed in units;

The leaf area was measured using the PETIOLE® cell phone application, with the values expressed in cm². The characterization of the production of total dry phytomass was performed by uprooting the plants, where the leaves, stems and roots were placed in paper bags and then dried in an oven at 65 °C until they reached a constant weight of dry matter, with the values expressed in g plant-1.

The SISVAR software (FERREIRA, 2019) was used for statistical analysis. To interpret the results, analysis of variance was performed, applying the "F" test and when there were significant results, the means of the qualitative variables were compared by the Tukey test at 5% probability.

RESULTS AND DISCUSSION

Table 1 shows that all growth variables analyzed were significantly affected by the interaction between the factors studied (substrates x water regimes) at 1 and 5% probability, by the F test.

Table 1. Summary of the analysis of variance for plant height (A_{LT}), stem diameter (D_C), number of leaves (N_F), leaf area (A_F) and total dry phytomass production (FST) of moringa plants, grown under different substrate compositions associated with two water regimes.

Sourceofvariation	GL	MeanSquares				
		A_{LT}	D_C	N_F	A_F	FST
HydricReg (A)	1	1021,52**	33,43**	115,52**	62849,30**	8,82**
Substrate (B)	4	698,52**	7,89**	7,28*	72948,00**	3,49**

Interaction (A x B)	4	474,52**	4,11**	5,72*	54017,74**	4,42**
Block	4	7,02ns	0,79ns	1,53ns	4289,91ns	0,30ns
Error	36	10,19	0,40	1,99	3470,17	0,33
Total Corrected	49	-	-	-	-	-
CV (%)		6,35	10,98	16,90	19,69	21,60

GL - Degrees of freedom; CV - Coefficients of variation; **, *, ns - significant at 1% probability, significant at 5% probability and not significant by F test, respectively.

In Figure 1 it is possible to observe that for the variable plant height (ALT), the highest result was obtained in the treatment concerning the application of the blade referring to 100% of ETo, with the substrate composition of equal parts (1:1) of soil and coffee grounds, with 69.6 cm. Under the regime of 50% of ETo, the height of moringa plants were negatively affected by the water restriction in all substrate compositions, except the substrate composed of soil and vegetal ash, which had a higher response than those irrigated without water restriction (100% of ETo).

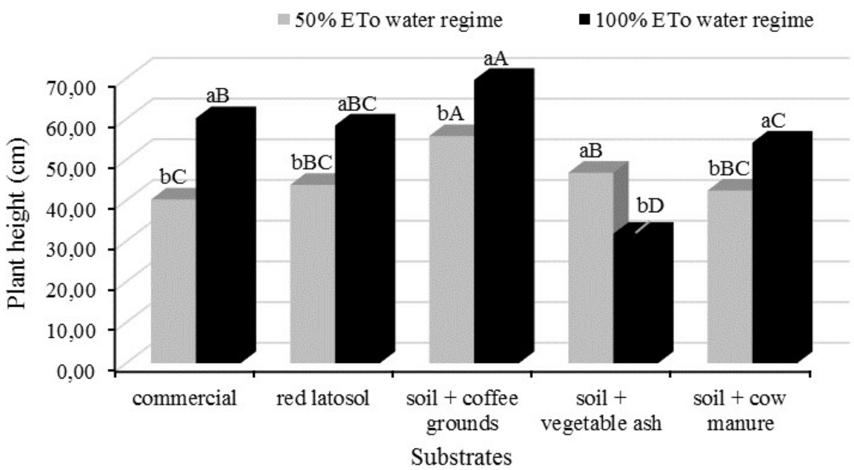

Figure 1. Height of moringa plants cultivated in different substrate compositions associated with two irrigation regimes.

Means followed by the same lower case letter between the hydric regimes within each substrate and means followed by a capital letter between substrates within each hydric regime, do not differ by the Tukey test at 5% probability.

In the comparison between the extreme results, higher and lower respectively, the treatments of substrate compositions (soil + coffee grounds) and (soil + ash), within the hydric regime of 100% of ETo, a percentage difference of 54.31% was observed. This result may have occurred due to the organic material used (coffee grounds), which contributed to a greater retention of water and nutrients, which favors a greater increase in plant height (SANTOS; CASTILHO, 2016). highest results were observed in the treatment concerning the availability of the hydric regime of 100% of ETo, in the compositions of substrates composed of equal parts (1:1) of soil and coffee grounds (7.93 mm); only commercial substrate (7.53 mm) and in the substrate composed of soil - red latosol (6.87 mm). Under the regime of 50% ETo, the stem diameter of moringa plants was negatively affected by water requirement restriction in all substrate compositions.

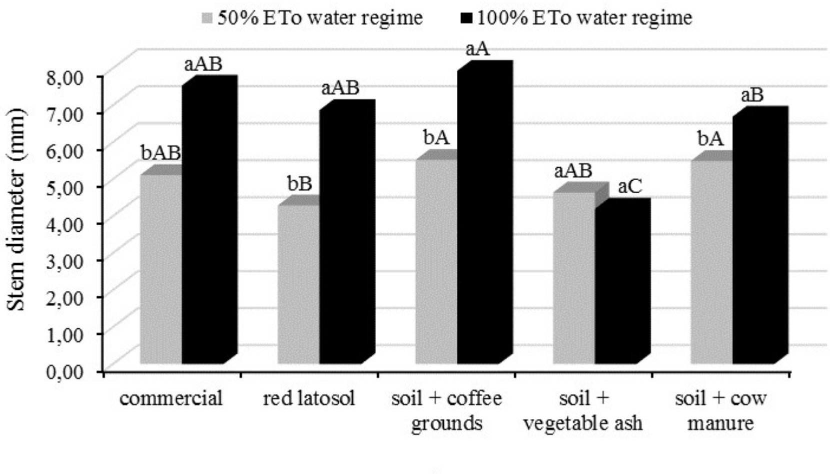

Figure 2. Stem diameter of moringa plants grown in different substrate compositions associated with two irrigation regimes.

Means followed by the same lower case letter between the hydric regimes within each substrate and means followed by a capital letter between substrates within each hydric regime, do not differ by the Tukey test at 5% probability.

Corroborating these results, Nezami et al. (2008) reported that one of the effects of reduced water availability on plant morphology is the reduction of stem diameter, due to the lower growth of stem radius, because under such conditions, the growth of the main stem and lateral branches is suppressed and, consequently, a lower partition of dry matter in the stem is closed. Thus, it is likely that stem growth is influenced by the same principles that govern growth restriction in other plant parts in the face of water deficit.In Figure 3 it is possible to see the results for the variable number of leaves (NF). The highest results were observed in the treatments with a water regime of 100% of ETo, in all substrates used.

The commercial substrate composition, with 11 leaves, was the one that showed the highest result, however, in the substrates composed of soil (red latosol) with 10.2 leaves, soil + coffee grounds with 10.4 leaves and soil + manure with 10.2 leaves, did not differ statistically ($p>0.05$). Under a regime of 50% ETo, it was observed that the number of leaves in moringa plants was negatively affected by water requirement restriction in all substrate compositions.

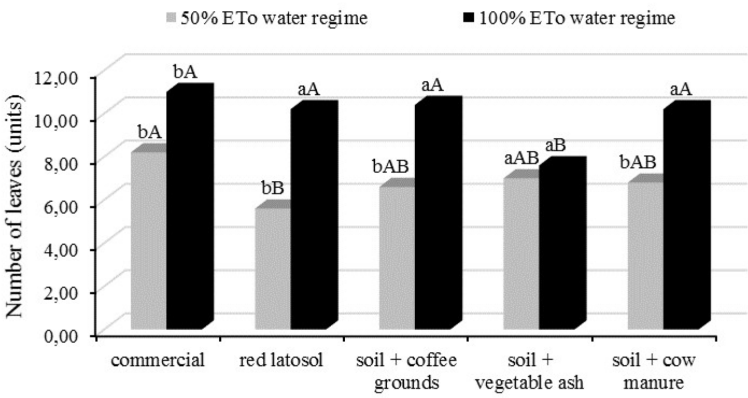

Figure 3. Number of leaves of moringa plants grown in different substrate compositions associated with two irrigation regimes.

Means followed by the same lower case letter between the hydric regimes within each substrate and means followed by a capital letter between substrates within each hydric regime, do not differ by the Tukey test at 5% probability.

The decrease in the number of leaves in moringa plants may be related to the lower growth due to the restriction of the absorption; as a consequence, there is a reduction of water flow in the soil-plant-atmosphere direction, causing morphological and anatomical changes in the plant, which compromised the natural development of the plants (COELHO et al., 2013). In the comparison between the treatments of hydric regimes (100 and 50% of ETo) in the compositions of substrates that obtained greater responses (commercial, soil + coffee, soil - red latosol and soil + manure), percentage differences of 25.45; 36.54; 45.10 and 33.33% were found, respectively, thus highlighting the detrimental effect of low water availability on the emission of leaves in moringa plants. In Figure 4 it is possible to verify the results for the variable leaf area (AF) in which it is observed that in the hydric regime of 100% of ETo the highest results were observed, obtained in all compositions of substrates used, except the substrate composed of soil + vegetal ash, which had the best response of leaf area under a hydric regime of 50% of ETo.

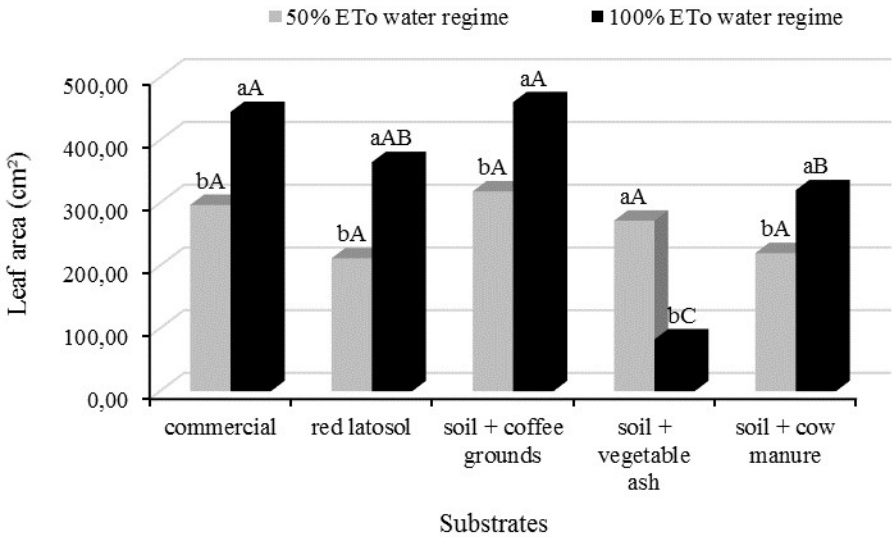

Figure 4. Leaf area of moringa plants cultivated in different substrate compositions associated with two irrigation regimes.

Means followed by the same lower case letter between the hydric regimes within each substrate and means followed by a capital letter between substrates within each hydric regime, did not differ by the Tukey test at 5% probability.

Under the hydric regime of 100% of ETo, the substrate composition soil + coffee, with 460.66 cm², was the one that presented the greatest expansion of leaf area, not statistically different from each other ($p>0.05$), from the substrates composed of soil (red latosol) and commercial substrate, with 364.98 and 445.10 cm², respectively. Under the water regime of 50% of ETo, it was observed that the leaf area of moringa plants did not differ statistically ($p>0.05$), by the restriction of water requirement in the compositions of substrates used.

According to Schwider et al. (2013), leaf area is one of the most important parameters in the evaluation of plant growth and its expansion is related to the interception of photosynthetically active solar radiation (RFAi), photosynthesis and biomass accumulation. The reduction in the number of leaves, along with the decrease in leaf area, in plants under water stress can be considered a survival strategy under adverse conditions, to avoid water loss by transpiration.

Figure 5 shows the results for the variable total dry phytomass (FST) of moringa plants, in which under a hydric regime of 100% of ETo there was a greater accumulation of phytomass, obtained in all compositions of substrates used, except the substrate composed of soil + vegetal ash, which had a greater response of FST production under a hydric regime of 50% of ETo.

The commercial substrate composition, with 11 leaves, was the one that presented the highest result, however, in the substrates composed of soil (red latosol) with 10.2 leaves, soil + coffee with 10.4 leaves and soil + manure with 10.2 leaves, did not differ statistically among themselves. Under a regime of 50% ETo, it was observed that the number of leaves in moringa plants was negatively affected by water requirement restriction, in most of the substrate compositions used.

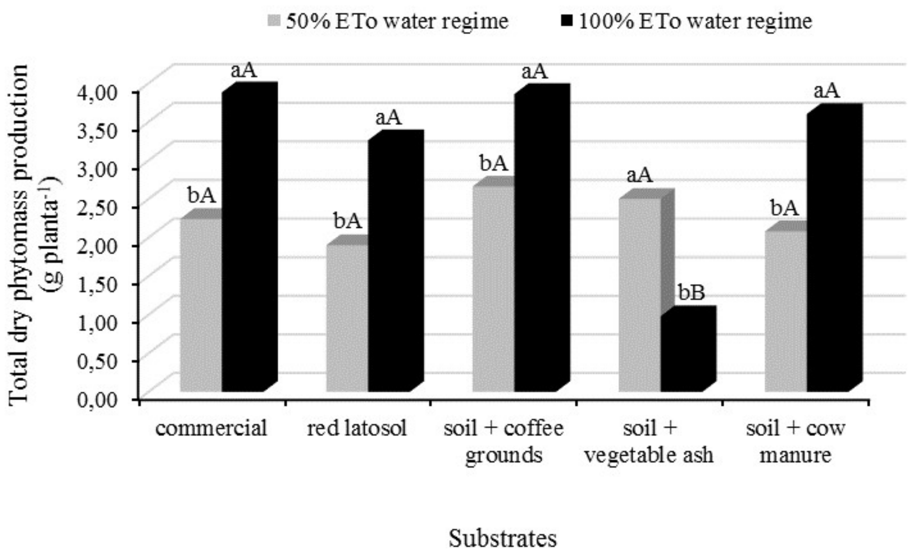

Figure 5. total dry phytomass of moringa plants grown in different substrate compositions associated with two irrigation regimes.

Means followed by the same lower case letter between the hydric regimes within each substrate and means followed by a capital letter between substrates within each hydric regime, do not differ by the Tukey test at 5% probability.

According to Sabonaro (2006), in determining the quality standard of seedlings, the total dry mass is one of the most used characteristics. Thus, it can be inferred that under a hydric regime of 100% of ETo, the moringa plants grown in compositions of commercial substrates, soil (red latosol), soil + coffee and soil + manure, provided the appropriate conditions of growth and development to achieve this standard of quality.

For Wendling and Gatto (2002), the type of substrate used in the production of seedlings is of fundamental importance in determining the frequency and volume to be applied.

In substrates with lower water retention capacity, irrigation should be more frequent than in those with greater retention capacity. Given this fact, it is understood that in the compositions of commercial substrates, soil (red latosol), soil + coffee and soil + manure, the growth and development of moringa plants were more favored, given the higher water retention capacity that these substrates provided, thus reflecting in the best responses of total dry phytomass production.

An important point to emphasize, regarding the results obtained in the treatment of substrate composition composed of soil + vegetal ash, under a hydric regime of 100% of ETo, where in the variables plant height, stem diameter, leaf area and total dry phytomass, the lowest results were observed.

Such results occurred, possibly, due to the composition of the alternative material used (vegetal ash), in this way, the mixture of this material to the soil in equal proportions, caused flooding in the substrate, providing an excess of moisture, creating unfavorable conditions for air circulation, thus affecting the growth and development of moringa plants, reflecting in lower productions of total dry phytomass in this substrate. The results obtained under the hydric regime of 50% of ETo, can be explained by the fact that all aspects of plant growth and development are affected by water deficiency in the tissues, caused by excessive evaporative demand and/or limited water supply.

CONCLUSIONS

The compositions of substrates (commercial, red latosol, soil + coffee and soil + manure) provided the best conditions for the growth of moringa plants when irrigated without hydric restriction (100% of ETo).

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