GROWTH OF SEEDLINGS *Jatropha curcas* L. IRRIGATED WITH SALINE WATER

CRESCIMENTO DE MUDAS DE PINHÃO MANSO, Jatropha curcas *L., IRRIGADAS COM ÁGUA SALINA*

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ABSTRACT: The species *Jatropha curcas* is a rustic plant, adapted to several edaphoclimatic conditions, being constantly explored in marginal conditions, however, ensuring production will be greater with the use of irrigation and fertile soil, when it'll be necessary to research the possibility of its cultivation with saline water. Therefore the present study aims at assessing the effect of the electrical conductivity of irrigation water on the morphophysiological answers of seedlings from *J. curcas* L. The work was conducted in shade with 50% of solar radiation interception at the State University of Goiás. The experiment was set up following a completely randomized design with four treatments and five repetitions. Sowing occurred in four-liter containers containing soil, sand and manure in the ratio of 3: 1: 0.5 respectively. During the seedling stage (60 days), the plants were subjected to four treatments: plants irrigated daily with 150 ml of deionized water containing NaCl, and electrical conductivity of 0.0 dS m^{-1} (T_1), 3 dS m^{-1} (T_2), 6 dS m^{-1} (T_3) and 9 dS m^{-1} (T_4). The high concentration of salt reduced the free energy of the water, making it limiting. The water limitation caused a reduction in the leaf area and in the number of leaves, contributing to the reduction of perspiring area and the maintenance of tissue hydration. The high electrical conductivity of irrigation water reduced the seedling growth *J. curcas*, however, plants of *J. curcas* can be irrigated with saline water of conductivity less than or equal to 3 dS m^{-1} without significant damage to vegetative growth.

KEYWORDS: Acclimation. Development. Tolerance.

INTRODUCTION

The search for alternatives to fossil fuels requires the assessment of renewable sources and of low impact on the natural environment. It's essential the development of appropriate technologies and the search for raw materials for power generation with a minimum or no damage to the environment. (MATOS et al., 2009).

Brazil has high potential for biofuel production in most of its land area, due to its edaphoclimatic characteristics, biodiversity, availability of area and manpower, as well as proven technical expertise in the field of agricultural science (DIAS et al., 2008). Nowadays, the main raw materials used for production of biofuel in Brazil are soybeans, beef tallow and cotton, with contributions of 71.13%, 18.66% and 4.69%, respectively, while the other materials account for only 4.08% of production (FREITAS et al., 2011). There is a need therefore to diversify production of raw materials through the introduction of promising species, for example, *J. curcas*.

According to Dias et al. (2007) *J. curcas* is an oleaginous species originating in Central America, considered a rustic plant and adapted to different edaphic climatic conditions. *J. curcas* is a wild species, devoid of improvement (MAES et al., 2009). This is a species of great economic potential, especially for its seeds constitute raw material for the production of oil for biodiesel. This characteristic has contributed to increasing the exploitation of this species. It is a shrub of rapid development, its production may be started in the seventh month of planting, remaining productive for nearly 40 years. Its climax production occurs from the fourth year in the field.

J. curcas has deciduous leaves, with falling leaves in the dry season, which reappear soon after the first rains and is considered a xerophytic species, with strong resistance to drought (DRUMMOND., et al., 1984; ARRUDA et al., 2004; SATURNINO et al., 2005; POMPELLI et al., 2010; MATOS et al., 2012). However, the guarantee of production will be higher with the use of irrigation, needing to be researched the possibility of its cultivation in saline conditions.

The use of saline water for irrigation becomes important alternative to a shortage of water of good quality throughout the world. The quality of

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many water sources is low, especially the waters of wells and surface reservoirs. Because it contains soluble salts, the water used for irrigation involves periodic addition of salts to soil depth, in the absence of leaching the salt is deposited within the area of the roots and the soil surface as a result of water evaporation (VERAS et al., 2011). The salinity in soils of arid and semi-arid expressed social concern, since millions of hectares worldwide are affected by salts, reducing the productive capacity of these areas (LIMA et al., 2006).

The perennial crops deployment is quite costly and important because it is the production of seedlings and plants remain in the field for several years. Then, obtaining robust seedlings associated techniques appropriate management contributes to achieving uniform crops with higher yields. The lack of good water impairs the growth of plants. Little is known about the biochemistry and physiology of *J. curcas*; there are no defined cultivars and some agronomic aspects still require some research, for example, the stress tolerance to salt and water. However, with the possibility of using the oil of *J. curcas* for biofuel production, new and broad prospects open for increased planting areas. Bearing in mind the better understanding of the influence of saline stress in producing *J. curcas* seedlings, the present study aimed, therefore, at assessing the effect of the electrical conductivity of irrigation water on the morphophysiological answers of *J. curcas* L. seedlings.

MATERIAL AND METHODS

Experimental Design

The study was conducted in four-liter pots on benches in shade was 50% of solar radiation interception at the State University of Goias, unit Ipameri (Lat. 17º 43' 19'' S, Long. 48º 09' 35'' W, Alt. 773 m), Ipameri, Goiás, Brazil. This region has Aw climate according to Köppen. The experiment was arranged following a completely randomized design with four treatments and five repetitions. Seeds *J. curcas* were sown in pots containing soil, sand, manure in the ratio of 3: 1: 0.5 respectively. After analyzing the composition of the mixture was held fertilization and correct the pH of the substrate according to technical recommendations for the crop (DIAS et al., 2007).

Initially, we tested the capacity of retaining water and soil, it was decided that the application volume of 150 ml is suitable for washing and leakage does not occur as shown substratum. During the initial growth period (1st to 60th day after germination), plants were irrigated daily with 150 ml of water to keep the soil at field capacity. The plants were subjected to four treatments: plants daily irrigated with deionized water of electrical conductivity (WEC) equal to 0.0 dS m^{-1} (T_1), 3 dS m^{-1} (T_2), 6 dS m^{-1} (T_3) and 9 dS m^{-1} (T_4). The NaCl was added to deionized water in order to obtain water with different electrical conductivities, the quantity (Q) was determined by the equation proposed by Rhoades et al. (2000), in which the WEC represents the desired value of electric conductivity.

$$Q\ (mg\ L^{-1}) = 640 \times WEC\ (dS\ m^{-1})$$

Q= Salt concentration

WEC= electric conductivity.

At 60 days after germination when the seedlings *J. curcas* are generally suitable for permanent planting in the field, they were analyzed: number of leaves, plant height, branch diameter, relative water content (RWC), leaf area, chlorophyll content, root mass ratio (RMR), stem mass ratio (SMR), leaf weight ratio (LWR), and total biomass.

Relative water content in the leave (RWC)

To obtain the relative water content of leaf discs were removed from five 12 mm diameter, weighed and placed for four hours to saturate in petri dishes with distilled water. Then, the discs were weighed again and dried at 70 °C (158 ºF) for 72 hours, and subsequently obtaining the dry weight in grams and the calculated relative water content.

Growth variables

The number of leaves, leaf area, plant height and stem diameter were measured using graduated ruler and caliper. After, the destructive tests were carried out. Leaves, roots and stems were detached and placed to dry in an oven at 72 ° C until constant dry mass and then weighed separately. With the data of dry matter were calculated leaf mass ratio (LMR), root mass ratio (RMR), stem mass ratio (SMR), shoot / root system (PA/SR) and total biomass

Photosynthetic pigment

Leaf discs were removed from the known foliares areas and they were put in glass material with dimethylsulfoxide (DMSO) to determinate the concentration of chlorophylls**.** Subsequently we performed the extraction in bath at 65 ºC for four hour. Aliquots were removed for spectrophotometric reading at 490, 646 and 663 nm. The content of chlorophyll *a*, chlorophyll *b* and carotenoids were determined following the equation proposed by (WELLBURN, 1994).

Statistical procedures

The variance analysis were processed following the completely randomized design with four treatments and five repetitions. The regression analysis was made for all the parameters using the software proposed by Ferreira et al. (2011).

RESULTS

Growth variables were significantly affected by concentrations of NaCl. The increase in electrical conductivity of water negatively compromised the vegetative growth of *J. curcas*.

The other variables showed no significance at 5% and therefore are not shown. In general, the relative water content decreased linearly with the increase of the WEC. The relative water content in the leaves reduced variation (8%) when the highest and lowest electrical conductivities are compared. The concentration of total chlorophyll showed significant variation, on average, the concentration of this pigment decreased linearly with increasing electrical conductivity, the variation was 27% when the highest and lowest electrical conductivities are compared.

Figure 1 shows statistically significant regressions. The total biomass showed significant variation with increasing conductivity of the water. On average, this variable decreased by 69% when subjected to higher plants is compared with conductivity of lower conductivity. The reasons for foliar and root mass were similar between treatments were not statistically different, but the stem mass ratio showed significant variation when subjected to higher plants is compared with conductivity of lower conductivity.

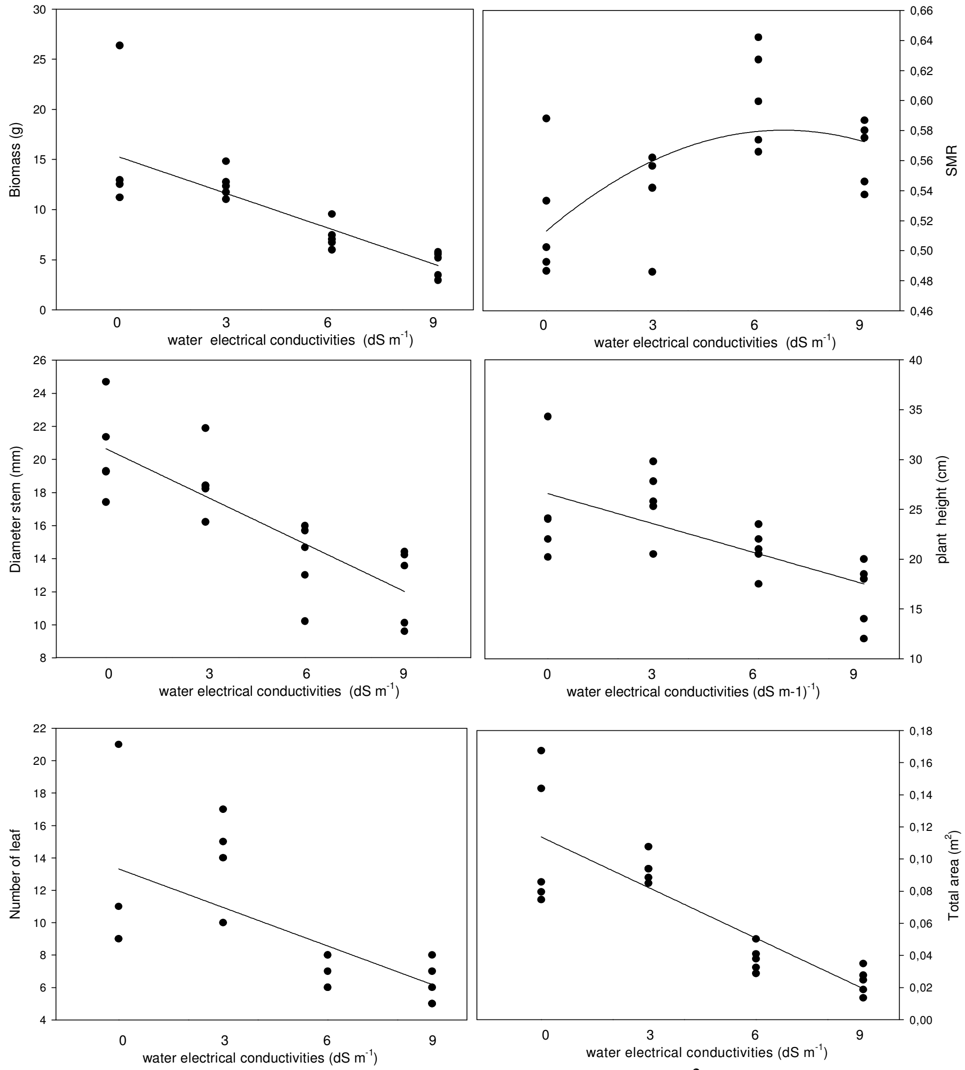

Figure 1. Regression equations for biomass “Y= 15,23 -1,2x, r^2= 0,91*”, stem mass ratios (SMR) “Y= 0,513 + 0,02x – 0,0015x^2, r^2= 0,95* ”, stem diameter “Y= 20,65 – 0,95x”, r^2= 0,98*”, plant height “Y= 26,57 – 1,01x, r^2= 0,97*”, leaf number “Y= 13,32 -0,79x, r^2= 0,90*” and leaf area “Y= 0,114 – 0,010x, r^2= 0,71* of Plants *J. curcas* irrigated with water of different electrical conductivities (0, 3, 6 and 9 dS m^{-1}). * = significant regression (0.01 <p ≤ 0.05); ** = significant regression (p ≤ 0.01).

The diameter of stem, plant height, number of leaves and leaf area were decreased with increasing linear WEC. The diameter of the stem and leaf show variations of 39% and 78 respectively, when the highest and lowest electrical conductivities are compared. The number of leaves and the height variations of plants showed 48 and 26% respectively, when both the electrical conductivity is smaller compared with the two largest.

DISCUSSION

Although the oil *J. curcas* is recognized as ideal for the production of biodiesel and can reach a prominent position in the national program production and use of biodiesel and partially replace conventional diesel sustainably, the species is still lacking scientific information *J. curcas* plants showed significant differences regarding morphophysiological variation WEC irrigation. Plants irrigated with high WEC showed significant changes in vegetative growth, leaf senescence and abscission.

Increasing the salt concentration in the irrigation water reduces the osmotic potential of the water, making it available in various situations to plants. The use of water with electrical conductivity greater than 1.3 dS m^{-1} has hindered the development of different plant species (CAVALCANTE et al., 2005). The irrigation water in this study had much higher electrical conductivities of 1.3 dS m^{-1}, which could potentially affect the hydric status of several species, however, the relative water content showed a shy decrease with the increase of electrical conductivity of the water possibly because this species has succulent stems. The succulent stems functioning as a buffer mechanism of water associated with anticipation of the drought, typical of water plants contributed to maintaining the high water content in the leaf. *J. curcas* has intermediary metabolism C_3-CAM (GRATANI et al., 2006). The succulence of the stem together with the C_3-CAM metabolism confers high tolerance to drought and / or salinity, to keep the leaves hydrated in condition of low water availability in the soil.

The initiation and development of leaves are dependent on plant water status. Excess solutes, especially higher electrical conductivity reduced the free energy of the water, resulting in reduced availability of this solvent for plant metabolism, such as training and development of new leaves. Reducing the number of leaves and leaf area was sharp with increasing conductivity of the water, these reductions are important strategies for salt tolerance by reducing the transpiration surface. The reduction in leaf area and / or loss of leaves by abscission, as well as changes in gene expression are mechanisms of tolerance to salt stress (NERY et al., 2009).

Water stress induced by osmotic effect, which characterizes the physiological drought, causes morphological and anatomical changes in the plants to the point of unbalance in the water absorption and transpiration rate, among the morphological changes, reductions in the number and size of leaves are the most significant (CARNEIRO et al., 2002; SANTANA et al., 2003). The plants subjected to high electrical conductivities showed high levels of leaf senescence and abscission. The reduction in total chlorophyll concentration is indicative of degradation of this pigment, typical of senescent leaves. The degradation of chlorophyll is probably a result of physiological drought and especially the toxic effect of salt in high concentrations in plant tissue.

The reduction of the total biomass on condition of salt stress is a common event in several species (NOBRE et al., 2011). The lowest number of leaves, leaf area, chlorophyll degradation and senescence affect the net assimilation rate of carbon in plants which have been exposed to high levels of electrical conductivity, resulting in lower instantaneous rate and cumulative carbon assimilation and hence less accumulation biomass. The reduced biomass contributes to the formation of less vigorous plants with leaves, roots and inefficient drivers on their roles and, finally, gives plants with a low potential to adapt to field conditions.

The lowest biomass is related to the lower photosynthetic activity on these plants, over time. In addition, the percentage of biomass allocation to stems, leaves and roots were very similar among treatments, but the discrepancy in figures is alarming, as an example, plants subjected to lower and higher conductivity have allocated about 22 and 21% of biomass for the root respectively, however, in absolute values, plants at lower and higher electrical conductivities allocated approximately 3.3 and 1 g of biomass to the root, respectively. Reductions in biomass, plant height and stem diameter are common in plants *J. curcas* irrigated with different WEC (Matos et al., 2012). In a similar experiment (Veras et al., 2011) found no differences in plant height of *J. curcas* under different levels of salt, also reported no significant effects of salinity levels on the stem diameter. These authors analyzed plants *J. curcas* adult WEC irrigated with lower (0.6 to 5.4 dS m^{-1}) to those used in this work.

The drought from the physiological decrease in osmotic potential is the immediate effect of salt stress. Plants irrigated with high WEC showed a reduction in the accumulation of biomass, stem diameter, leaf number and leaf area, resulting in less vigorous seedlings and less capable of acclimation to field conditions, however, plants irrigated with water of low WEC showed a high accumulation of biomass and robust vegetative growth, resulting in plants with vigorous root system and stem can absorb and transport water and nutrients sufficient to meet the demand of the shoot, especially the foliage more numerous.

The reduction in leaf area, leaf number contributed to reducing the area perspirant and maintaining tissue hydration. The seedlings of J. curcas can be irrigated with saline water CEa of less than or equal to 3 dS m^{-1} without significant damage to the vegetative growth of the plant.

CONCLUSIONS

The production of seedlings of *J. curcas* CEa irrigated with water of less than 3 dS $m\text{-}^{1}$ presents vigorous vegetative growth;

The species *J. curcas* can be classified as glycophyte with moderate tolerance to salinity.

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