Notas Científicas

Water relations in physic nut according to climatic seasonality, in semiarid conditions

Bruno Monteiro Rodrigues[1], Gabriela Burle Arcoverde[1], Antônio Celso Dantas Antonino[2] and Mauro Guida Santos[1]

[1]Universidade Federal de Pernambuco (UFPE), Departamento de Botânica, Laboratório de Ecofisiologia Vegetal, Avenida Prof. Moraes Rego, nº 1.235, Cidade Universitária, CEP 50670-901 Recife, PE, Brazil. E-mail: bruno.rafael@gmail.com, gabiburle@gmail.com, mauroguida@pq.cnpq.br [2]UFPE, Departamento de Energia Nuclear. E-mail: acdantonino@gmail.com

Abstract – The objective of this work was to determine the effect of climatic seasonality on physic nut (*Jatropha curcas*), in field, under semiarid climate conditions. Stomatal conductance (g_s), transpiration (E), soluble leaf carbohydrates (SLC), free amino acids (FAA) and total proteins (TP) were measured in leaves, in a commercial plantation in Northeast Brazil, during the summer and autumn. Plants showed high g_s and E, as well as SLC, FAA and TP contents in the summer, which gradually decreased with the lower temperatures and photosynthetically active radiation during the autumn, despite the higher water availability. Even in conditions of adequate water availability, the combination of low temperatures and reduced light drastically decreased foliar metabolism.

Index terms: *Jatropha curcas*, abiotic stress, biodiesel, stomatal conductance.

Relações hídricas em pinhão-manso de acordo com a sazonalidade climática, em condições semiáridas

Resumo – O objetivo deste trabalho foi determinar o efeito da sazonalidade climática em pinhão-manso (*Jatropha curcas*), sob condições de semiárido, em campo. Condutância estomática (g_s), transpiração (E), carboidratos solúveis (SLC), aminoácidos livres (FAA) e proteína total (PT) foram mensurados em folhas, em plantio comercial, no Nordeste brasileiro, durante as estações de verão e outono. As plantas apresentaram altos valores de g_s e E, bem como de SLC, FAA e PT no verão, que diminuíram gradualmente durante o outono, com o decréscimo da temperatura e da radiação fotossinteticamente ativa, apesar da alta disponibilidade hídrica. Mesmo em condições de adequada disponibilidade de água, a combinação de valores reduzidos de temperatura e luminosidade reduz drasticamente o metabolismo foliar.

Termos para indexação: *Jatropha curcas*, estresse abiótico, biodiesel, condutância estomática.

Jatropha curcas L. (purging nut, purge nut, physic nut) is a semi-domesticated species which needs considerable work to achieve high productivity (Achten et al., 2010). Both wild and cultivated, it is widely distributed in tropical areas in Central and South America, Africa, India, Southeast Asia and Australia (Maes et al., 2009).

Semi-arid regions are potentially favorable for biofuel production because they are not in demand for extensive food production. However, their main limiting factor is water availability (Sinclair & Purcell, 2005; Rodrigues et al., 2010; Souza et al., 2010).

The few studies on the ecophysiological aspects of *J. curcas* were done under greenhouse conditions (Maes et al., 2009; Pompelli et al., 2010; Silva et al., 2010; Arcoverde et al., 2011). In Northeast Brazil, *J. curcas* may play an important role in rural development by focusing on small-scale, community-based initiatives for local use. *Jatropha curcas* is cultivated in small plantations or intercropped with other annual crops in systems proved to be effective in the region with other drought tolerant crops. In land-locked or very remote areas, where wood is the main source of fuel and other fuel sources are erratic and very expensive, *Jatropha* offers an interesting alternative (Achten et al., 2010).

The objective of this work was to determine the effect of seasonality on *Jatropha curcas* under the upland field conditions in Northeast Brazil, measured through its stomatal conductance, transpiration and leaf metabolism linked to carbon assimilation.

The field experiment was carried out between April 2008 and March 2009, using three-year-old *J. curcas* plants under dry land conditions in Garanhuns, Pernambuco (8°53'S, 36°29'W, 842 m altitude).

Garanhuns' climate, according to Köppen is As', mesothermal, with an average annual temperature of 20°C, 1,333 mm rainfall, and rainy season between January and June.

The commercial plantation was established in an area of 9 ha, from which ten plants were selected in the middle of the plantation. The soil is a Latossolo (Oxisol) (Santos et al., 2006). During the study period, meteorological conditions were typical for the area; there were heavy rains during the first year, decreasing in the beginning of the second year. Maximum temperatures ranged from 20 to 29°C with minimums between 15 and 18°C (Figure 1). From July to November 2008, rainfall volume decreased, leading to an increase in the average daily temperature. Between October 2008 and March 2009, the highest monthly maximum temperatures were registered. Plants received no chemical fertilizer; soil pH was 6.2 and nutrient levels were adequate, after chemical analysis (Claessen, 1997).

Stomatal conductance (g_s) and transpiration (E) were measured in five plants, with a Li-1.600 porometer (Licor, NE, USA) between 8–9h, in a mature leaf exposed to sunlight. Leaves were collected at 15h, the time of greatest photoassimilate accumulation (Santos & Pimentel, 2009). The plant tissues were immediately wrapped with aluminum foil, frozen in liquid nitrogen and stored at -80°C in a freezer. Total soluble carbohydrates, soluble proteins and amino acids were analyzed according to the methods of Dubois et al. (1956), Bradford (1976), and Moore & Stein (1948), respectively.

The experimental design was completely randomized with five replicates. The data were subjected to analysis of variance, and means were compared and segregated by the Student-Newman-Keuls test, at 5% probability, when significance was detected.

Jatropha curcas plants cultivated in dry land showed different stomatal conductance (g_s) and transpiration rate (E) behaviors under the different climatic conditions during the experiment (Figure 1). In April, in

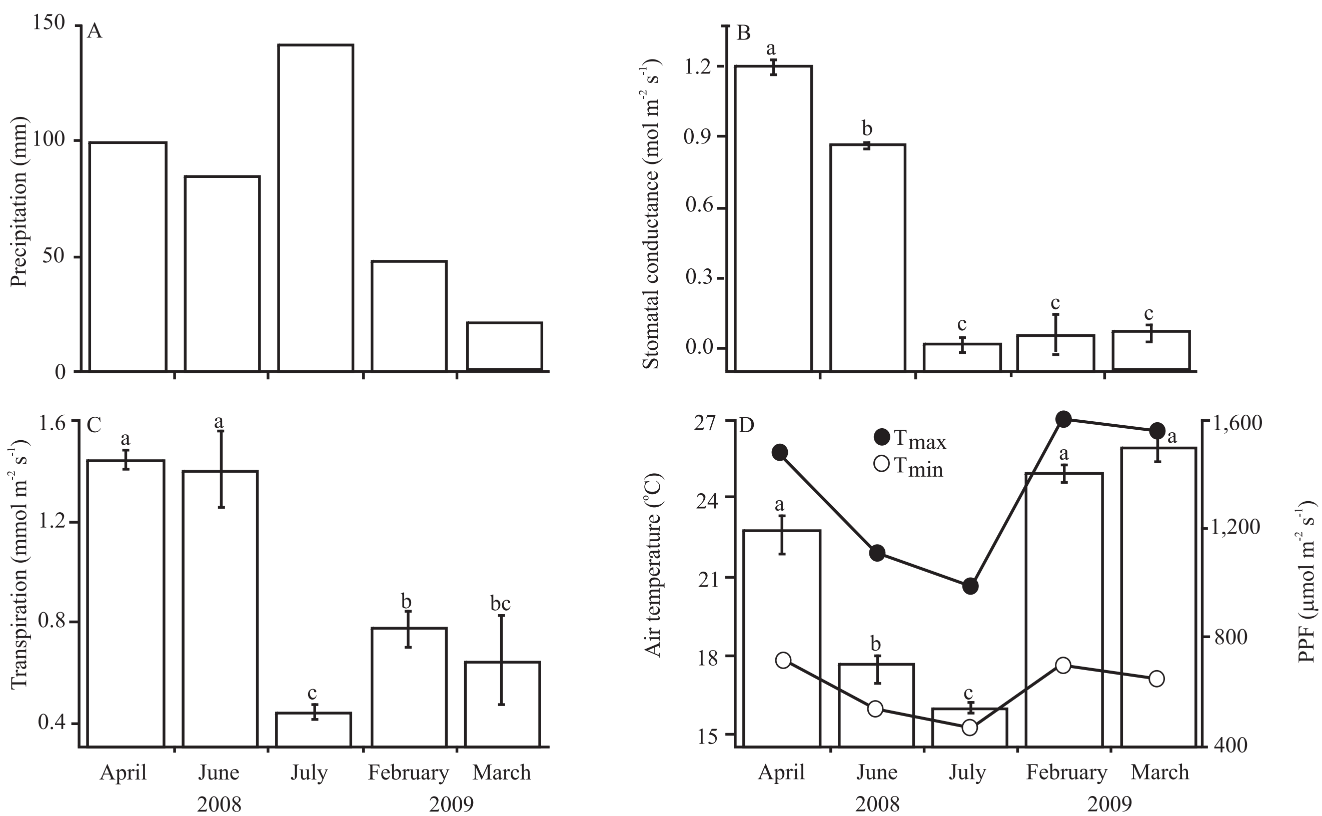

Figure 1. Changes in environmental and physiological variables in Garanhuns, PE, Brazil, during the experiment: A, precipitation; B, stomatal conductance; C, transpiration; and D, air temperature and photosynthetic photon flux (PPF). Values represent the mean±SE of five replicates, for B, C and PPF.

the middle of the rainy season, plants showed higher g_s and E in the mornings than in the afternoons ($p<0.05$). In June, during the latter half of the rainy season, the values of g_s and E decreased. After this date, complete leaf abscission occurred in the plants.

Climate characterization in this study area is essential to understand the behavior shown by *J. curcas* plants under field conditions. The heavy rainy season, which occurs almost every year, maintains low daily average temperatures and low light levels. This causes *J. curcas* plants to gradually lose their leaves. Following the lower metabolic rate due to lower temperatures and reduced light intensity, a gradual reduction in stomatal aperture was observed, resulting in total leaf senescence. Leaf senescence is very sensitive and influenced by several environmental factors including light, drought and nutrient supply (Wingler & Roitsch, 2008), mainly in deciduous plants such as *J. curcas*. However, even plants which remain evergreen throughout the year, such as citrus, show a marked variation in stomatal conductance with lower light intensity and temperature (Ribeiro et al., 2009). In this species, the authors noted that low nightly temperature was the main environmental factor causing decreased photosynthetic and water metabolisms.

Jatropha curcas plants also showed changes in leaf metabolism during the year, such as higher leaf soluble carbohydrate (LSC) content in April and June 2008 and March 2009 (Table 1). Free amino acids showed similar contents throughout most of the year, except during July 2008 and February 2009, when greater accumulation occurred. The protein content in the leaves was similar throughout most of the year, except for March 2009, when the lowest content was observed. These variables manifest the influence of local climatic conditions mainly at lower temperatures and reduced photosynthetic radiation (Figure 1), which led to the decline of leaf metabolism in the plants. Several *J. curcas* genotypes from different climatic origins showed a reduction in photosynthetic metabolism, when the young plants were exposed to five nights of low temperature. Even four days after the cessation of stress, plant metabolism was still decreasing (Zheng et al., 2009). This is typical of an open field plant, which demands sunshine for economically viable production, with at least 700 mm annual rainfall required.

Table 1. Soluble leaf carbohydrate content (SLC, mmol kg^{-1} DW), total free amino acids (FAA, mmol kg^{-1} DW) and total proteins (TP, g kg^{-1} DW) in plants of *Jatropha curcas* in the field, over a year, under semi arid conditions(1).

Variable	2008			2009	
	April	June	July	February	March
SLC	922.94a (20.96)	899.43ab (59.85)	544.85c (6.42)	564.98c (15.24)	851.67b (15.98)
FAA	38.29c (1.43)	29.15cd (2.47)	59.39b (2.81)	77.87a (2.16)	24.68d (1.38)
TP	186.10b (4.88)	236.47a (8.67)	153.00c (6.10)	176.33b (5.36)	95.75d (7.12)

(1)Each value represents the mean±SE (n = 5), followed by equal letters do not differ by Student-Newman-Keuls test, at 5% probability.

The dormancy period under low temperature and drought may have been decisive for the growth of plants under dry conditions, which was reverted in the early spring with adequate water availability.

Acknowledgments

To the Fundação de Amparo à Pesquisa e Tecnologia do Estado de Pernambuco, for grant received; to the Conselho Nacional de Desenvolvimento Científico e Tecnológico, for financial support and fellowship.

References

ACHTEN, W.M.J.; MAES, W.H.; AERTS, R.; VERCHOT, L.; TRABUCCO, A.; MATHIJS, E.; SINGH, V.P.; MUYS, B. *Jatropha*: from global hype to local opportunity. **Journal of Arid Environments**, v.74, p.164-165, 2010.

ARCOVERDE, G.B.; RODRIGUES, B.M.; POMPELLI, M.F.; SANTOS, M.G. Water relations and some aspects of leaf metabolism of *Jatropha curcas* young plants under two water deficit levels and recovery. **Brazilian Journal of Plant Physiology**, v.23, p.123-130, 2011.

BRADFORD, M.M. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. **Analytical Biochemistry**, v.72, p.248-254, 1976.

CLAESSEN, M.E.C. (Org.). **Manual de métodos de análise de solo**. 2.ed. rev. atual. Rio de Janeiro: Embrapa-CNPS, 1997. 212 p. (Embrapa-CNPS. Documentos, 1).

DUBOIS, M.; GILLES, K.A.; HAMILTON, J.K.; REBERS, P.A.; SMITH, F. Colorimetric method for determination of sugars and related substances. **Analytical Chemistry**, v.28, p.350-356, 1956.

MAES, W.H.; ACHTEN, W.M.J.; REUBENS, B.; RAES, D.; SAMSON, R.; MUYS, B. Plant-water relationships and growth strategies of *Jatropha curcas* L. seedlings under different levels of drought stress. **Journal of Arid Environments**, v.73, p.877-884, 2009.

MOORE, S.; STEIN, W.H. Photometric ninhydrin method for use in chromatography of amino acids. **Journal of Biological Chemistry**, v.176, p.367-388, 1948.

POMPELLI, M.F.; BARATA-LUÍS, R.; VITORINO, H.S.; GONÇALVES, E.R.; ROLIM, E.V.; SANTOS, M.G.; ALMEIDA-CORTEZ, J.S.; FERREIRA, V.M.; LEMOS, E.E.P.; ENDRES, L. Photosynthesis, photoprotection and antioxidant activity of purging nut under drought deficit and recovery. **Biomass and Bioenergy**, v.34, p.1207-1215, 2010.

RIBEIRO, R.V.; MACHADO, E.C.; SANTOS, M.G.; OLIVEIRA, R.F. Photosynthesis and water relations of well-watered orange plants as affected by winter and summer conditions. **Photosynthetica**, v.47, p.215-222, 2009.

RODRIGUES, B.M.; SOUZA, B.D.; NOGUEIRA, R.M.; SANTOS, M.G. Tolerance to water deficit in young trees of jackfruit and sugar apple. **Revista Ciência Agronômica**, v.41, p.245-252, 2010.

SANTOS, H.G. dos; JACOMINE, P.K.T.; ANJOS, L.H.C. dos; OLIVEIRA, V.A. de; OLIVEIRA, J.B. de; COELHO, M.R.; LUMBRERAS, J.F.; CUNHA, T.J.F. (Ed.). **Sistema brasileiro de classificação de solos**. 2.ed. Rio de Janeiro: Embrapa Solos, 2006. 306p.

SANTOS, M.G.; PIMENTEL, C. Daily balance of leaf sugars and amino acids as indicators of common bean (*Phaseolus vulgaris* L.) metabolic response and drought intensity. **Physiology and Molecular Biology of Plants**, v.15, p.23-30, 2009.

SILVA, E.N.; FERREIRA-SILVA, S.L.; FONTENELE, A. de V.; RIBEIRO, R.V.; VIÉGAS, R.A.; SILVEIRA, J.A.G. Photosynthetic changes and protective mechanisms against oxidative damage subjected to isolated and combined drought and heat stresses in *Jatropha curcas* plants. **Journal of Plant Physiology**, v.167, p.1157-1164, 2010.

SINCLAIR, T.R.; PURCELL, L.C. Is a physiological perspective relevant in a 'genocentric' age? **Journal of Experimental Botany**, v.56, p.2777-2782, 2005.

SOUZA, B.D.; RODRIGUES, B.M.; MEIADO, M.V.; SANTOS, M.G. Water relations and chlorophyll fluorescence responses of two leguminous trees from the Caatinga to different watering regimes. **Acta Physiologiae Plantarum**, v.32, p.235-244, 2010.

WINGLER, L.; ROITSCH, T. Metabolic regulation of leaf senescence: interactions of sugar signalling with biotic and abiotic stress responses. **Plant Biology**, v.10, p.50-62, 2008.

ZHENG, Y.L.; FENG, Y.L.; LEI; Y.L.; YANG; C.Y. Different photosynthetic responses to night chilling among twelve populations of *Jatropha curcas*. **Photosynthetica**, v.47, p.559-566, 2009.

Received on May 5, 2011 and accepted on August 25, 2011