WATER STATUS AND GAS EXCHANGE OF UMBU PLANTS (*Spondias tuberosa* Arr. Cam.) PROPAGATED BY SEEDS AND STEM CUTTINGS[1]

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ABSTRACT - The experiment was carried out at the Embrapa Semi-Árido, Petrolina-PE, Brazil, in order to study the physiological responses of umbu plants propagated by seeds and by stem cuttings under water stress conditions, based on leaf water potential and gas exchange measurements. Data were collected in one-year plants established in pots containing 30 kg of a sandy soil and submitted to twenty-day progressive soil water deficit. The evaluations were based on leaf water potential and gas exchange data collection using psychrometric chambers and a portable infra-red gas analyzer, respectively. Plants propagated by seeds maintained a significantly higher water potential, stomatal conductance, transpiration and photosynthesis under decreasing soil water availability. However, plants propagated by stem cuttings were unable to maintain a favorable internal water balance, reflecting negatively on stomatal conductance and leaf gas exchange. This fact is probably because umbu plants propagated by stem cuttings are not prone to formation of root tubers which are reservoirs for water and solutes. Thus, the establishing of umbu plants propagated by stem cuttings must be avoided in areas subjected to soil water deficit.

Index terms: water potential, stomatal conductance, transpiration, photosynthesis, root tubers.

ESTADO HÍDRICO E TROCAS GASOSAS DE UMBUZEIROS (*Spondias tuberosa* Arr. Cam.) PROPAGADOS POR SEMENTES E ESTAQUIA

RESUMO- O experimento foi realizado na Embrapa Semi-Árido, Petrolina-PE, Brasil, objetivando estudar as respostas fisiológicas de umbuzeiros propagados por sementes e por estaquia, sob condições de deficiência hídrica. Os dados foram coletados em plantas com aproximadamente um ano de idade, estabelecidas em vasos contendo 30 kg de solo de textura arenosa e submetidas a déficit progressivo de água, durante 20 dias. As avaliações foram realizadas, tomando-se como base o potencial hídrico foliar e as trocas gasosas, monitorados com auxílio de câmaras psicrométricas e um analisador portátil de gás por infravermelho, respectivamente. As plantas propagandas por sementes mantiveram valores de potencial hídrico, condutância estomática, transpiração e fotossíntese significativamente maiores, sob condições decrescentes de disponibilidade de água no solo. Entretanto, plantas propagadas por estaquia foram incapazes de manter um balanço hídrico favorável, refletindo negativamente na condutância estomática e trocas gasosas. Estes resultados estão provavelmente associados ao fato de que o umbuzeiro propagado por estaquia dificilmente apresenta túberas em suas raízes, as quais são reservatórios de água e solutos. Dessa forma, o plantio de umbuzeiros propagados por estaquia deve ser evitado em áreas sujeitas à deficiência hídrica.

Termos para indexação: potencial hídrico, condutância estomática, transpiração, fotossíntese, túberas.

INTRODUCTION

The umbu tree (*Spondias tuberosa* Arr. Cam.) belongs to the Anacardiacae family which grows naturally in the “Caatinga” vegetation throughout the semi-arid Northeast Brazil. The gathering of its fruits is a very important activity for complementing the familiar income of the inhabitants of this ecosystem (Mendes, 1990; Cavalcante et al., 1996). They are rich in carbohydrates and ascorbic acid and are consumed ¨in natura¨ or transformed into preserves, sweets and beverages of pleasant taste (Mors, 1994). During the dry season, the plant sheds their leaves to avoid transpiration remaining in vegetative dormancy until the occurrence of the first rains. The survival of the species under water stress conditions is assured by rigid stomatal control on transpiration (Lima Filho & Silva, 1988) and by specialized root system bearing tubers, whose function is to store water, minerals and other solutes (Lima Filho, 2001). These resources are used during the dry season for maintaining plant normal metabolism and the initiation of the flowering process. According to Lima (1994), the root system of umbu seedlings is formed by a tuberous main root. In adult plants the main root is not present and tubers develop in the adventitious roots. These structures can reach 20.0 cm diameter and can be found from 10.0 cm to 30.0 cm depth. Recently, Calvalcanti et al. (2002) found that the umbu tree can bear about 367 tubers with 683.5 kg mean weight per plant. Lima Filho (2001) studied the internal water relations of this species and suggested that under dry condition the diurnal water balance would be maintained by the consumption of water stored

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in the tubers and by restricted transpiration. Also, it has been stated that umbu plants propagated by stem cuttings are not prone to formation of root tubers (Nascimento et al., 1993), what may imply on low survival when transplanted to the field. These authors verified at 24 month after transplanting that plants propagated by seeds presented 100% survival while only 6% were related to plants from stem-cuttings, due to the luck of tubers.

This paper was carried out in order to study the physiological behavior of umbu plants propagated by seeds and by stem cuttings, under progressive soil water stress, based on leaf water potential and gas exchange measurements.

MATERIAL AND METHODS

The experiment was carried out at the Embrapa Semi-Árido, Petrolina, State of Pernambuco, Brazil. One-year umbu plants propagated by seeds and stem cuttings were established outside in pots containing 30 kg of a sandy soil. The experimental plants were chosen by their uniformity in terms of stem diameter (2,8 cm ± 0,051) and stem height (92,0 cm ± 8,4). Before transplanting, plants were checked for the formation of root tubers in both treatments. It was observed that only seed propagated plants presented tubers in the root system. Such formation was not found in plants propagated by stem cuttings. The experimental design was completely randomized with two treatments and five replicates composed of four plants.

Plants were maintained under well-watered conditions and then submitted to 20 days of progressive water deficit by irrigation withdraw. Soil water status was determined gravimetrically in the beginning and at the end of the experimental period. The results were plotted against the soil moisture release curve giving values around -0.015 MPa and -0.8 MPa matric potencial, respectively. Leaf water potential was obtained in 1.0 cm diameter leaf tissue discs with psychrometrics/hygrometric C-52 chambers connected to the HR33-T micro-voltmeter (Wescor, Inc., USA), using the dew point mode. The description of this technique, as well as the sampling procedures, is presented by Turner (1981).

Leaf gas exchange was monitored with a portable photosynthesis system (LI-6200 - LICOR, USA), using a ¼ liter assimilation chamber. Data were collected on mature sun exposed leaves between 10:00 h and 12:00 h at four days interval, during 20 days. Photosynthetic active radiation, air temperature and humidity were obtained with sensors connected to the LI-1000 datalogger (Licor, USA). Data on temperature and relative humidity were used to calculate the vapor pressure deficit.

RESULTS AND DISCUSSION

The environmental variables recorded during physiological data measurement are presented in Figure 1. It is shown that the photosynthetic active radiation, air temperature and vapor pressure deficit, presented a small variation during the experimental period. Data on photon flux density ranged from 1,297 µmol m^{-2} s^{-1} to 1,630 µmol m^{-2} s^{-1} while air temperature and vapor pressure deficit ranged from 31ºC to 34.8 ºC and from 0.18 kPa to 0.2 kPa, respectively.

Plants propagated by seeds maintained the leaf water potential significantly higher then those from stem cuttings (Figure 2). This difference was more accentuated eight days after irrigation withheld. Leaf water potential of plants propagated by seeds reached -0.56 MPa and -0.88 MPa, respectively, in the fourth and in the twentieth day, meaning a 0.16 MPa drop in the period while values obtained with plants from stem cuttings decreased from -0.72 MPa to -1.3 MPa, meaning a difference of about 0.58 MPa. This result indicates that presence of tubers in the root system of plants propagated by seeds was important for maintaining a steady water balance under decreasing soil water availability. In fact, Lima Filho (2001) observed that during the dry season early morning leaf water potential of adult umbu plants propagated by seeds declined from -0.73 MPa at predawn to about -0.97 MPa at 8:00 h, meaning a 0.24 MPa difference. From this point, a smooth recovery was observed even when the environment was already conductive to greater water loss. Thus, at the end of the day, leaf water potential was – 0.76 MPa, almost reaching the value found at predawn. This situation may have been caused by the fact that the umbu tree, early in the morning, closes their stomata in response to drought, resulting in a drastic decline on plant water loss, thus assuring significant water storage in the tubers (Lima Filho & Silva, 1988).

The importance of root tubers can be emphasized when others *Spondias* species that do not exhibit such adaptation were grafted on umbu plants (Lima Filho & Santos, 2006). These authors verified that the grafted species presented water potential values similar to those obtained by the control umbu plants, after three-month of progressive field water stress. However, plants from stem cuttings presented difficulties to form such adaptation (Nascimento et al., 1993).

The variations between treatments were also evident in relation to gas exchange, due to the leaf water potential influence on stomatal behavior of the umbu tree and consequently on its conductivity to water vapor and carbon dioxide (Lima Filho, 2004). As shown in Figure 3, stomatal conductance of plants propagated by seeds was around 0.26 mol m^{-2} s^{-1} at the fourth day, falling to 0.15 mol m^{-2} s^{-1} by the end of the experimental period. At the same time, leaf transpiration and photosynthesis varied from 5.4 mmol H_2O $m^{-2}s^{-1}$ to 4.1 mmol H_2O $m^{-2}s^{-1}$ and from 9.7 µmol CO_2 m^{-2} s^{-1} to 5.9 µmol CO_2 m^{-2} s^{-1}. Conductance values around 0.14 mol $m^{-2}s^{-1}$ were detected by Lima Filho (2004) on adult umbu plants propagated by seeds in the early afternoon, during the rainy season, while transpiration and photosynthesis reached 5.3 mmol H_2O $m^{-2}s^{-1}$ and 8.6 µmol CO_2 m^{-2} s^{-1}, respectively.

Plants from stem cuttings showed significantly lower stomatal conductance than seed propagated plants. At the fourth day, this variable was 0.19 mol m^{-2} s^{-1} decreasing steadly until reaching about 0.01 mol m^{-2} s^{-1} by the twelfth day. Also, the transpiration and photosynthesis fell from 3.9 mmol H_2O m^{-2} s^{-1} and from 8.7 µmol CO_2 m^{-2} s^{-1}, respectively, to values close to zero. Under dry soil conditions stomatal conductance of adult umbu plants can reach 0.01mol $m^{-2}s^{-1}$ giving minimum values of transpiration and photosynthesis (Lima Filho, 2004).

The results showed that umbu plants from stem cuttings were less efficient than seed propagated plants in maintaining a favorable water status, under low soil moisture, due to the absence of root tubers, reflecting negatively on stomatal aperture and leaf gas exchange.

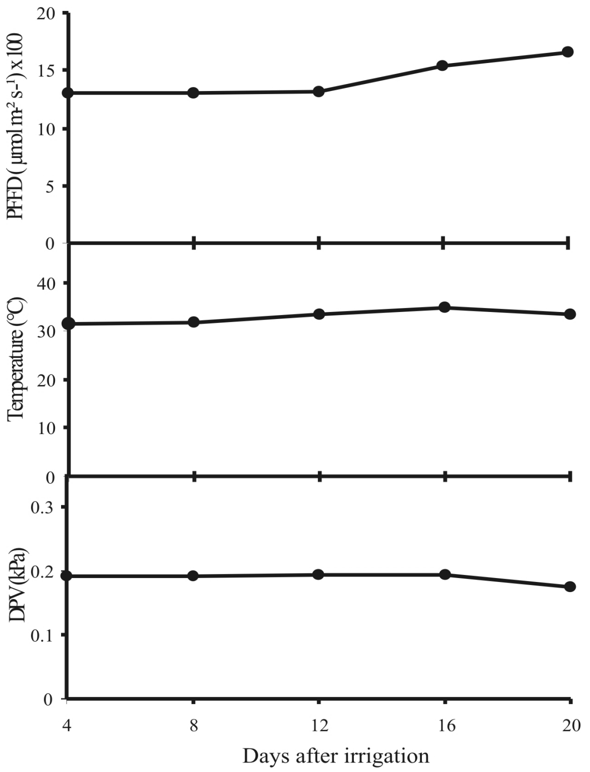

FIGURE 1- Photosynthetic photon flux density (PFFD), air temperature and vapor pressure deficit (VPD) observed between 10:00 h and 12:00 h, during the experimental period.

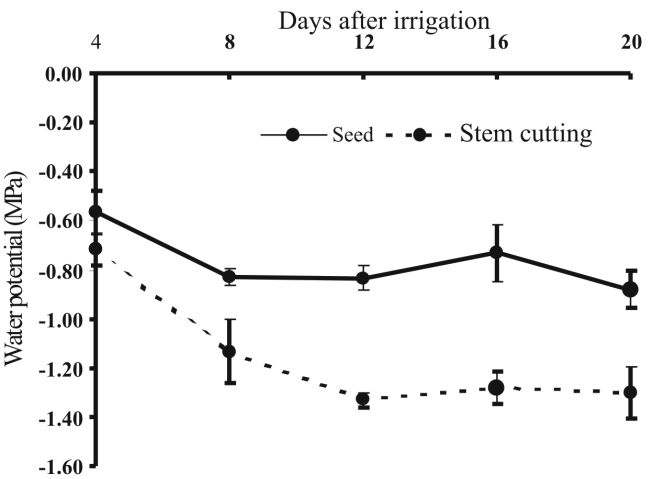

FIGURE 2- Leaf water potential of one-year umbu plants propagated by seeds and stem cuttings observed between 10:00 h and 12:00 h during 20 days progressive soil water deficit. Bars represent the standard deviation.

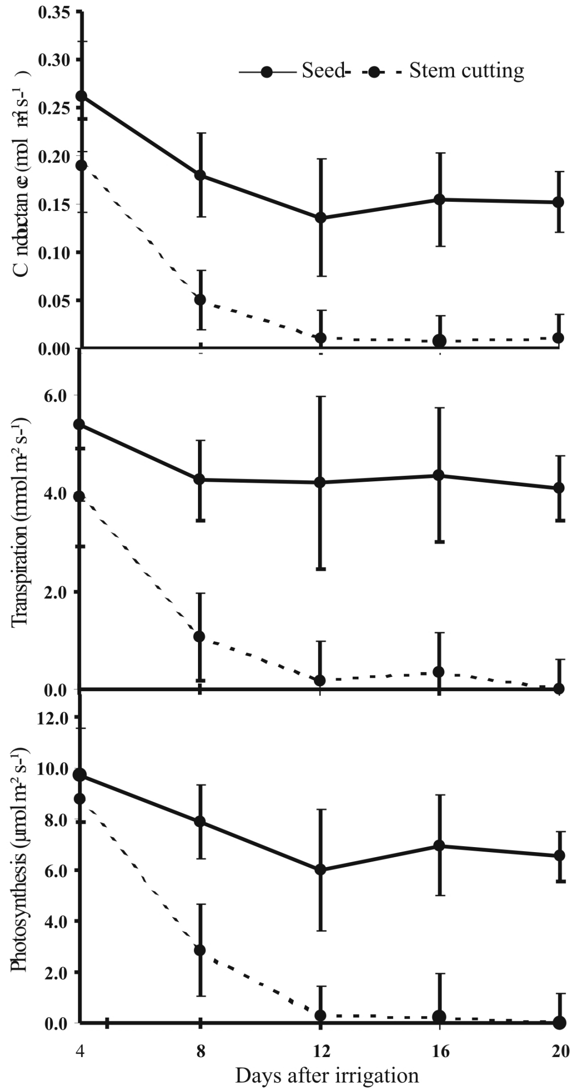

FIGURE 3-Stomatal conductance, transpiration and photosynthesis of one-year umbu plants propagated by seeds and stem cuttings observed between 10:00 h and 12:00 h during 20 days progressive soil water deficit. Bars represent the standard deviation.

CONCLUSION

1-Umbu plants propagated by seeds perform better than plants from stem cuttings under low soil moisture conditions in relation to internal water balance and gas exchange.

2-The planting of the umbu tree propagated by stem cuttings must be avoided in areas subjected to drought.

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