INTERNAL WATER RELATIONS OF THE UMBU TREE UNDER SEMI-ARID CONDITIONS [1]

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ABSTRACT - A study was conducted at the Embrapa Semi-Árido, Petrolina-PE, Brazil, with the aim of understanding the mechanism by which the umbu tree (*Spondias tuberosa* Arr. Cam.) maintains its diurnal internal water balance in dry and wet seasons. The results obtained were based on the measuring of leaf water potential and its components using the pressure chamber and hygrometric chambers / microvoltmeter. Under dry conditions, the lowest values on water potential and osmotic potential were observed around 8:00 h, reaching, respectively, –0. 97 MPa and –1.17 MPa, resulting a turgor pressure of 0.2 MPa. The lowest turgor pressure occurred at 16:00 h when 0.16 MPa was detected but full recovery was not observed by the end of the light period. During the raining season, however, the lowest water potential was –1.55 MPa at 14:00h and -1.57 MPa at 14:00 h giving a turgor pressure of 0.02 MPa. Recovery was fast and, by the end of the day, plant water status was similar to the value observed at predawn. These results suggest the umbu tree presents two strategies for maintaining a favorable internal water balance, regarding the environmental situations studied. Under dry conditions the diurnal balance would be maintained at the expenses of water stored in the tubers and by restricted transpiration. During the rainy season, the diurnal water balance may have been mediated by a short term osmotic adjustment as judged by the observed afternoon range between water potential and osmotic potential.

Index terms: water potential, osmotic potential, turgor pressure, osmotic adjustment, *Spondias tuberosa.*

RELAÇÕES HÍDRICAS INTERNAS DO UMBUZEIRO SOB CONDIÇÕES SEMI-ÁRIDAS

RESUMO - Realizou-se um estudo na Embrapa-Centro de Pesquisa Agropecuária do Trópico Semi-Árido (CPATSA), Petrolina-PE, objetivando identificar os mecanismos, através dos quais o umbuzeiro (*Spondias tuberosa* Arr. Cam.) mantém o balanço hídrico interno durante as estações de seca e chuvosa. Os resultados obtidos basearam-se em observações do potencial hídrico e de seus componentes, utilizando-se da câmara de pressão e câmaras higrométricas / microvoltímetro. Sob condições de seca, os valores mais baixos de potencial hídrico e potencial osmótico foram observados em torno das 8 h, atingindo, respectivamente –0,97 MPa e –1,17 MPa, resultando em uma pressão de turgor de 0,2 MPa. A pressão mais baixa ocorreu às 16 h, atingindo 0,16 MPa. Entretanto, a recuperação hídrica não foi observada, até o final dia. Durante a estação chuvosa, os valores de mais baixos de potencial hídrico foram obtidos às 14 h , quando foram detectados, respectivamente –1,55 MPa. Neste momento, o potencial osmótico atingiu –1,57 MPa , culminando com uma pressão de turgor de 0,02 MPa. Entretanto, até o final do dia, a condição hídrica da planta foi similar à observada no início do dia. Estes resultados sugerem que o umbuzeiro apresenta duas estratégias para manter, durante o dia, um balanço hídrico interno favorável, dentro das condições ambientais estudadas. Sob condições de sequeiro, o balanço seria mantido através da utilização da água armazenada nas túberas e uma baixa transpiração. Durante a estação das chuvas, o balanço hídrico pode ter sido mediado por um ajuste osmótico, a julgar pelas variações observadas à tarde entre níveis de potencial hídrico e potencial osmótico.

Termos para indexação: Potencial hídrico, potencial osmótico, pressão de turgor, *Spondias tuberosa.*

INTRODUCTION

The umbu tree (*Spondias tuberosa* Arr. Cam.) belongs to the Anacardiceae family which grows naturally in the ¨Caatinga¨ areas throughout the semi-arid Northeast Brazil. During the dry season, the plant shed their leaves to avoid transpiration. The flowering process is initiated while under drought, when the first leaves appear at the base of the inflorescence. However, leaf flushing is enhanced after the first rains. The survival of the species in such hash environment is assured by a specialized root system bearing tubers, whose function is to store water, minerals and other solutes. According to Lima (1994), the tubers can reach 20.0 cm of diameter and can be found from 10.0 cm to 30.0 cm depth. These resources are used during the dry season for maintaining plant normal metabolism and the initiation of the flowering process. Its fruits, rich in carbohydrates and ascorbic acid, are consumed ¨in natura¨ or worked into preserves, sweets and beverages of pleasant taste (Mors, 1994). The gathering of fruits is a very important activity for complementing the familiar income of the small farmers (Mendes, 1990; Cavalcante et al., 1996). Due to its social and economic importance, the umbu tree has been studied in relation to dispersion (Santos, 1990), propagation (Oliveira et al., 1989; Nascimento et. al, 1993), morphology (Braga, 1976), root anatomy (Lima, 1994) and fruit chemical composition (Narain et al, 1992). Regarding its physiological behavior and interaction with the environment,

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very few reports are found in the literature. In this context, Ferri & Laboriau (1952) and Ferri (1953), studied the water balance of this specie during the dry season, based on stomatal behavior. They observed that maximum transpiration occurred between 7:00 h and 9:00 h. More recently Lima Filho & Silva (1988), using sophisticated instrumentation showed that the umbu tree exerts a rigid control of transpiration through the stomata, even under good soil moisture conditions, assuring a significant water economy. Despite these considerations, there is a need for new insights on plant water status under distinct environmental situations naturally experienced by the species. Therefore, our objective was to study the water relations of the umbu tree based on the monitoring of leaf water potential and its components in order to understand the mechanism by which this species maintains its internal water balance under dry and wet semi-arid conditions.

MATERIAL AND METHODS

The experiment was conducted at the Research Center for the Semi-Arid Tropic (Embrapa Semi-Árido) during the dry and wet seasons of 1994/1995. Data were collected on four trees grown under natural conditions at the end of the dry season of 1994 (October) and during the wet season of 1995 (March) after an accumulated precipitation of 510 mm. Leaf water potential was monitored using a pressure chamber (PMS Instruments, USA) of the type described by Scholander et al. (1965) on sun exposed leaves located at the canopy midpoint. The osmotic potential was observed with the C-52 sampler chamber connected to the microvoltmeter HR-33T (Wescor, USA). Leaf discs were sampled and stored in 2.0 ml disposable syringe and frozen in liquid nitrogen for 10 seconds. After thawing under laboratory conditions the samples were pressed and the osmotic potential of the exuded sap measured in the dew point mode. Turgor pressure was then estimated by difference between leaf water potential and osmotic potential, as suggested by Turner (1981). Irradiance, air temperature and humidity and precipitation were obtained with respective sensors connected to the LI-1000 datalogger (Licor, USA). All data were monitored from 5:00 h to 18:00 h during three cloudless days, on both seasons.

RESULTS AND DISCUSSION

The environmental variables recorded during physiological data acquisition are presented in Fig. 1. During the dry season, irradiance was higher in the morning but lower in the afternoon than during the wet season as a result of differences in solar inclination between seasons. However, the highest value occurred at noon, reaching around 4.5 Wm^{-2}, in both periods. Despite the small difference in solar radiation, air temperature and vapor pressure deficit were, higher during the dry period. Early in the morning, temperature and vapor pressure deficit were, respectively, 25 ^oC and 0.59 KPa in the dry and 22.5 ^oC and 0.36 KPa in the wet period .The highest values were observed around 14:00 h , reaching 37 ^oC and 2.35 KPa in the dry and 32 ^oC and 1.62 KPa in the wet period, indicating that plants were under higher evapotranspiratory conditions, mainly during the dry period. Due to the environmental differences between seasons, the water relations of umbu plants were significantly affected . In fact, the statistical data analysis detected that the interaction measurement time x periods was significant ($P< 0.01$) for all variables studied. Under dry conditions, leaf water potential and its components presented a very small variation during the day (Fig. 2) . Early in the morning, leaf water potential 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 a drastic decline on plant water loss (Lima Filho & Silva, 1988). Plant recovery may have been sustained by water stored in the tubers.

The osmotic potential data followed similar hourly trend, although lower points had been detected. Values were around - 1.15 MPa from predawn to 8:00 h, increasing until -0.95 MPa, by the end of the day. As it can be seen (Fig. 2), the diurnal range between plant water potential and osmotic potential was rather small and the difference between these variables was narrowed toward the end of the light period. This may mean that during the day there was no solute accumulation in the leaf tissue but a decrease in its concentration due to dilution by water. However, since the osmotic potential was always lower than the water potential, cell turgor pressure was maintained (Tyree & Jarvis, 1982). The maximum pressure occurred at predawn when it reached 0. 41 MPa. From then on, a linear decline was observed until 0.16 MPa at 16:00 h, meaning a 0.25 MPa pressure drop. At 18:00 h, turgor pressure was still around 0.19 MPa, indicating that recovery to predawn values would probably be attained at night.

Because the evapotranspiration conditions during the dry season were more stressing (Fig 1), it was expected the umbu tree to develop a more stable internal water balance during the raining season. However, leaf water potential presented a threefold drop during the day as it declined from - 0.5 MPa at predawn to -1.55 MPa around 14:00h. (Fig.3). In this case, the increasing leaf density may have enhanced plant water loss, not matched by root absorption, causing the water potential to drop significantly. Despite this fact, plants recovered about 1.0 MPa from 14:00 h to 18:00 h. The osmotic potential data decreased less steeply from -1.23 MPa at predawn to –1.58 MPa at 16:00 h. By this time, leaf water potential had already recovered, suggesting an increase in solute concentration in the leaf tissue. This situation may have been caused by a transient osmotic adjustment due to the uptake of additional inorganic salts, or from the accumulation of organic solutes as it naturally occurs (Taiz and Zeiger, 1991). As it can be seen (Fig. 3), the range between water potential and osmotic potential was wider early in the morning and during late afternoon, but significantly reduced around 1400 h. Consequently, turgor pressure, which was about 0.74 MPa at predawn, drastically declined to 0.02 MPa at 1400 h. Full recovery was attained at 1800 h, when pressure reached 0.82 MPa, meaning a 0.08 MPa above the predawn values.

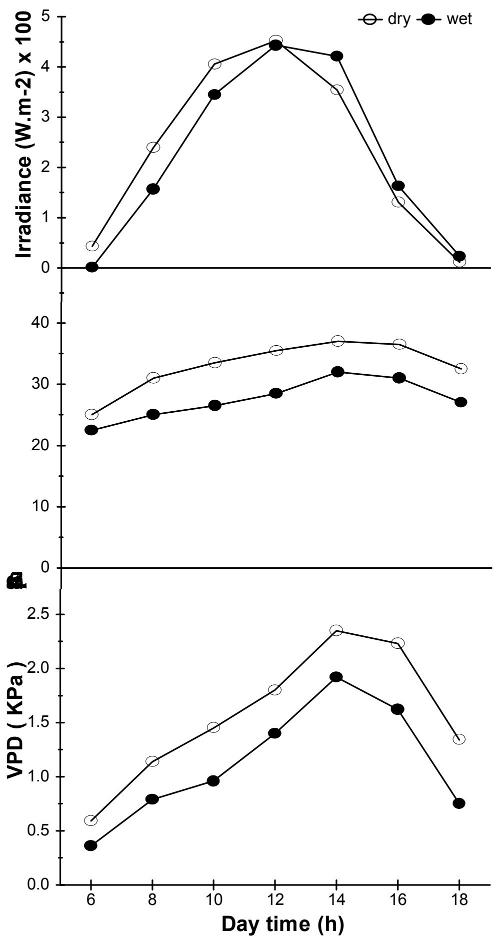

FIGURA 1 – Diurnal fluctuation of irradiance, air temperature and vapor pressure deficit observed at the end of the dry season of 1994 and of the wet season of 1995.

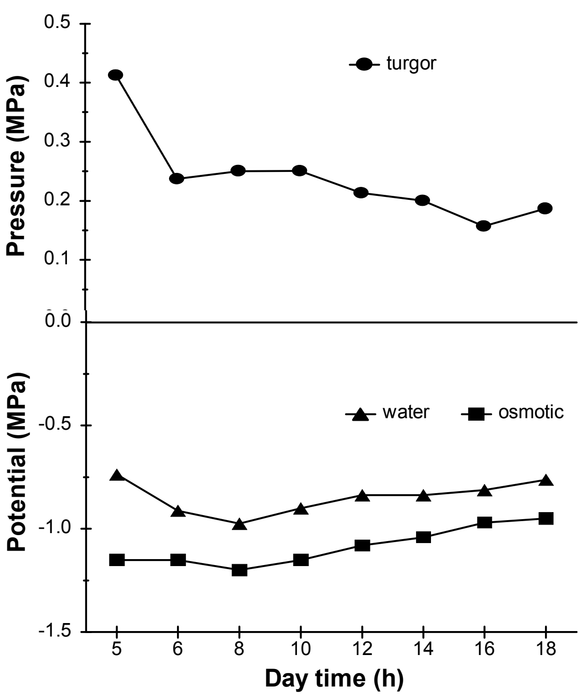

FIGURA 2 - Diurnal fluctuation of leaf water potential, osmotic potential and turgor pressure of the umbu tree, obtained under dry conditions.

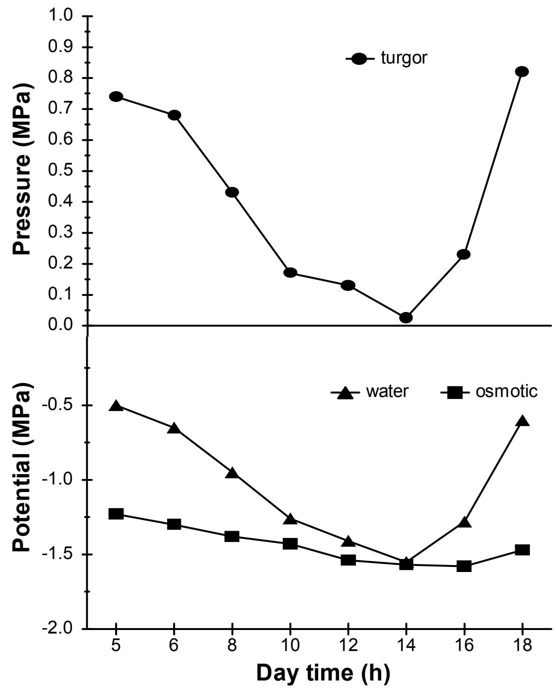

FIGURA 3 - Diurnal fluctuation of leaf water potential, osmotic potential and turgor pressure of the umbu tree, obtained under wet conditions.

CONCLUSIONS

1- During the dry period the umbu tree presents a more stable internal water balance as judged by the diurnal variation observed for leaf water potential and its components. This situation may be attributed to plant control of transpiration under drought and to the presence of tubers in the root system, as a reservoir for water and solutes;

2- During the raining season, despite the better environmental condition observed, the increasing leaf density may have enhanced plant water loss, causing an unfavorable internal water balance at a time of higher evapotranspiration demand. However, the maintenance of lower osmotic potential while plant water potential had already recovered restored the balance and suggests that the umbu tree may express a short term osmotic adjustment.

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