International Journal of Oil Palm, **7(1&2)** : 39-41, June, December 2010

RESEARCH PAPER

Diurnal and Seasonal Variations in Sap Flow in Oil Palm under Irrigated Conditions

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ABSTRACT

The use of sap flow probes in measuring the transpiration of oil palm plantations under irrigated conditions has been attempted. The sap flow in oil palm in response to the environmental variables *viz.,* evapotranspiration and vapor pressure deficit has been studied. Diurnal variations in the sap flow indicated that the sap flow increased gradually from 9.00 AM onwards reaching a peak during 1.00 to 2.00 A.M and then decreased thereafter as the day progressed. This sort of parabolic trend was seen during all the days of the study (January to June). The evapotranspiration calculated based on the Penman-Monteith equation and vapor pressure deficit also showed similar trend as that of the sap flow. Sap flow measurements could give vital leads in developing an approach for monitoring the environmental responses in oil palm.

Key words: Oil Palm, sap flow, transpiration, evapotranspiration, vapor pressure deficit, water dynamics

INTRODUCTION

Oil Palm is being grown in India under non-traditional environments where the temperatures are very high, low humidity and rainfall. Under such conditions, palms experience water deficits and reduce their evapotranspiration below the potential rate by stomatal closure and/or other mechanisms. These responses are accompanied by a reduction in carbon metabolism and dry matter production.

Water relations in plants are considered the most important physiological processes as it often limits growth (Larcher, 2003). Continuous sap flow observations on trees provide a valuable background for the analysis of physiological processes and water balance (Nadezhdina, 1999). Beside transpiration measurements, there is a certain lack of appropriate approaches to interpret the physiological behaviour of trees in relation to the water dynamics *in situ* (Ortuno *et al.,* 2007). Because of the wide availability of sap flow measurements they could be used as a robust tool to analyze tree water dynamics in field conditions, especially under critical soil water availability. Water stress can be characterized by a continuous decrease of the sap flow rate under nearly constant diurnal potential evapotranspiration conditions. The flux in xylem sap through the plant is likely to be closely coupled with whole plant evapotranspiration and measurement of the flux is one of the means of monitoring whether the plants are experiencing stress in responses to changed environmental conditions. As there has not such work on the use of sap flux under Indian conditions, this study was taken up to understand the behavior of the palm under non-traditional environment.

MATERIALS AND METHODS

The study was conducted at Directorate of Oil Palm Research, Pedavegi which is situated in West Godavari district of Andhra Pradesh province in India. The experimental site (Pedavegi) is located at 16^0 43'N and 81^0 09'S with a mean sea level of 13.41 m. The soil is sandy loam with a pH of 6.8 and low organic matter and cation exchange capacity. The climate is characterized with hot and dry summers with an average rainfall is 1,221 mm. The plant material consisted of mature nine year old oil palm *(Elaeis guineensis* Jacq. var. Tenera) plantation, spaced 9 x 9 X 9 m, with an average ground cover of 75%. Four uniform representative palms were selected for the study.

Temperature sensitive probes (TDP 80, ADC Bio Scientific Ltd., Hoddesdon, Herts, England), which are 80 mm long and were inserted into the conducting tissues. One probe was heated by passage of a constant current through a constantan wire, while, the other, placed 150 mm placed below it was unheated. Both probes contained a copper constantan thermocouple wired to a datalogger which recorded the temperature difference between them. The difference in temperature between the probes (dT) served as an inverse measure of the rate of sap flow. The dT readings are converted in to sap flux rates or sap flux density (U) using the empirical formula of Granier (1985; 1987b):

$$U = 119 * 10^{-6} * [(dTo - dT)/dT]^{1.231}$$

Where dTo is the temperature difference between the probes under conditions of zero flow.

Measurements of sap flow was tried by inserting the probes in to the palm trunk, As the trunks are covered by cut frond bases, they are removed to expose the surface area of 30 sq.cm located half way between the soil and point of attachment of the lowest intact frond. The reference evapotranspiration were calculated from the Penman-Monteith equation using the standardized set of input parameters like air temperature, humidity, wind speed, net radiation taken from an automatic weather station (Delta-T, U.K.) installed nearer to the plantation. All the measurements along with sap flow were calculated as averages values for each hour. Sap flow measurements were recorded continuously with the help of a data logger attached to the sap probes.

RESULTS AND DISCUSSION

Sap flow measurements in mature oil palm plantations were made continuously from January to June. The diurnal variations in the sap flow indicated that sap flow increased gradually from 9.00 AM onwards reaching a peak during 1.00 to 2.00 A.M and decreased thereafter as the day progressed (Fig. 1). This sort of parabolic trend was seen during all the days from January to June. The evapotranspiration calculated based on the Penman-Monteith equation also showed the same trend as that of the sap flow, both tending to become zero during nights. Similar results were observed by Henson (1998) in oil palm grown in Malaysia under rainfed conditions. The sap flow in mature oil palm plantations also followed the same trend as that of vapor pressure deficit. This shows that the sap flow in oil palm plantations is closely associated with environmental variables like evapotranspiration and vapor pressure deficit.

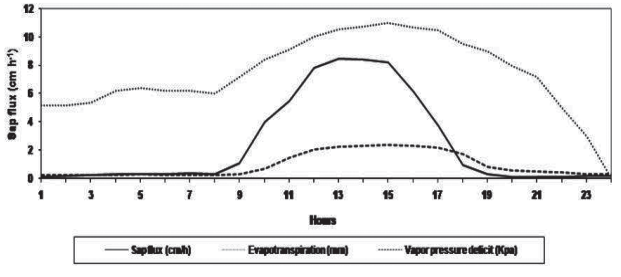

Fig.1 : Diurnal variations in sap flow in relation to evapotranspiration and vapor pressure deficit in oil palm under irrigated conditions

Seasonal variations in the sap flow were also noticed from January to June with the increased sap flow being recorded in the months of January (Fig. 2). The decrease in sap flow during the dry months of May and June could be due to the closure of stomata after mid day as the atmospheric vapor pressure deficit increased (Fig. 3, 4). Even though, this technique of

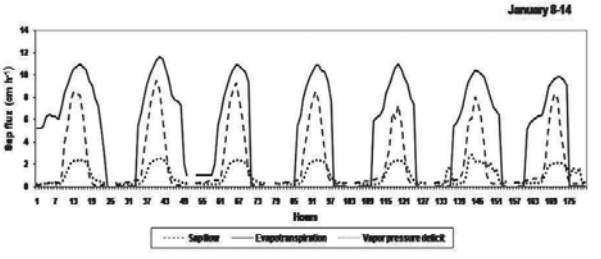

Fig. 2 : Seasonal variations in sap flow in relation to evapotranspiration and vapor pressure deficit in oil palm under irrigated conditions during January

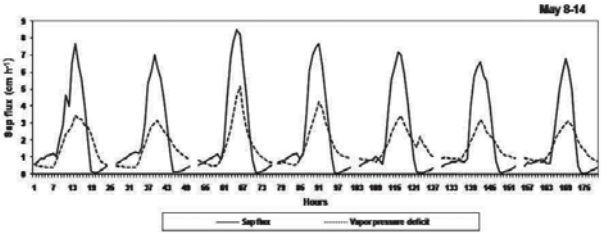

Fig. 3 : Seasonal variations in sap flow in relation to evapotranspiration and vapor pressure deficit in oil palm under irrigated conditions during May

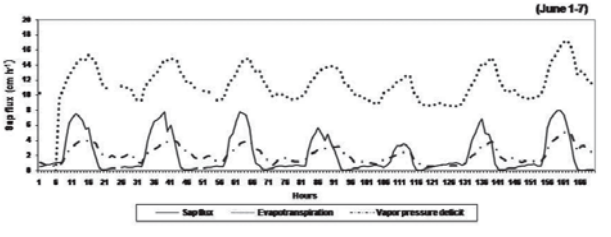

Fig. 4 : Seasonal variations in sap flow in relation to evapotranspiration and vapor pressure deficit in oil palm under irrigated conditions during June

sap flow in oil palm plantations following the pattern of their environmental responses is possible, the total sap flow rates were not determined and it can be determined by multiplying the sap flow with cross sectional area of the conducting tissue. The diffuse nature of the conducting elements in oil palm makes the measurement of conducting tissue very difficult. The flow rates obtained in oil palm plantations under irrigated conditions seems to be similar to that of the findings of Dufrene (1989) and Henson (1988). But the actual flow rates may be higher, suggesting that the probes may fail to fully sense the localized fast flow in the sparsely scattered elements.

In conclusion, studies based on comparisons of sap flow and PET provided information on the palm water status. Further work on these lines have been planned to study the responses of sap flow probes to changes in the soil moisture content and age of the fronds, which may give more lead in developing an approach for monitoring the environmental responses in oil palm.

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