CIGR - International Conference of Agricultural Engineering
XXXVII Congresso Brasileiro de Engenharia Agrícola

Brazil, August 31 to September 4, 2008

SOIL WATER BALANCE AT DIFFERENT DISTANCES FROM A BANANA PSEUDOSTEM UNDER DRIP IRRIGATION BY USING TDR

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Presented at
CIGR INTERNATIONAL CONFERENCE OF AGRICULTURAL ENGINEERING
XXXVII CONGRESSO BRASILEIRO DE ENGENHARIA AGRÍCOLA – CONBEA 2008
Brazil, August 31 to September 4, 2008

ABSTRACT: Crop evapotranspiration (ETc) is the basis for calculation plant water needs. Various methods might be used for determining ETc such as the soil water balance that has the following components: water storage variation (h), precipitation (P), irrigation (I), deep percolation (DP), evapotranspiration (ETc) and run off (R). The way these components are measured affects the accuracy of the method. The objective of work was to determine banana evapotranspiration by using soil water balance method with data collected by a TDR equipment at different distances from the banana pseudostem. Soil water content was monitored at various horizontal distances (R) from a banana pseudostem and soil depths(Z) in a 0.20 m x 0.20 m grid of a vertical plane between two pseudostems along plant row. Results showed that evapotranspiration and deep percolation are not uniform around a banana pseudostem and varied according to water and root distribution in the soil profile. The larger values of deep percolation and smaller values of evapotranspiration occured at zones of the soil of smaller percentage of total root length and vice versa
KEYWORDS: Soil water balance, TDR, irrigation management.

INTRODUCTION: Crop evapotranspiration (ETc) is the basis for calculation plant water needs. Various methods might be used for determining ETc such as the soil water balance that has the following components: water storage variation (h), precipitation (P), irrigation (I), deep percolation (DP), evapotranspiration (ETc) and run off (R). The way these components are measured affects the accuracy of the method. It is commom to use few tensiometers installed at various depths, but at a single distance from plant. The variability of soil water balance components may yield variation coefficient up to 40% in crop ETc calculation (Villagra et al., 1995). The most difficuty calculations regard to water storage and drainage (Libardi, 2000). This difficulty come from the fact that these calculations involve the measurement of distribution of soil water in time and in space (Rogers et al., 1997). The problem increases for crops that are irrigated by drip systems, since water distribution around the emitter affects root distribution and zones of water extraction in the soil (Clausnitzer & Hopmans, 1994; Clothier & Green, 1994;Coelho et al.,2002). As a consequence, the water balance in the soil profile is not uniform around the plant, i.e., the values of its components such as water storage and deep percolation might vary accordind to the distance from the plant. This work was made with the objective of determining banana evapotranspiration by using soil water balance method with data collected by a TDR equipment at different distances from the banana pseudostem.

METHODOLOGY: The work was carried out at Embrapa Casava & Tropical fruits, Cruz das Almas city – Bahia State, (12º48'S; 39º06'W; 225 m), Brazil. The local mean precipitation is about 1.143 mm. The experiment was carried in an area with banana cv. BRS Tropical that was planted at 3,0 x 2,5m and the crop was at fruit development phase. The experiment was set in a silt clay sand soil that is classified as Distrofic Yellow Latossol. Soil water replenishment was made by a drip irrigation system with a single lateral line per plant row. The 4 L h^{-1} were distributed along the lateral lines 0.4 m apart each other in a line source arrangement Soil water content was monitored at various horizontal distances (r) and depths(z) in a 0.20 m x 0.20 m grid of a vertical plane between two pseudostems along plant row. The plane had limits at the pseudostem and at 1.0 m from the pseudostem in the plant row. The limits of depth were the soil surface and z = 1.0 m. TDR probes were inserted horizontally in all grid points in order to get soil water content in all plane to obtain water content in the whole plain according to Figure 1. Soil samples (monoliths) of 500 cm^3 were collected at various r and z locations in the plane during probe instalation in the field in order to evaluate banana root distribution. Roots were separate from the soil by washing (Bohm, 1979) and were digitized in a computer following Coelho et al. (2005). Root lenght (Lr) was obtained by using Rootedge software (Kaspar & Ewing, 1997).

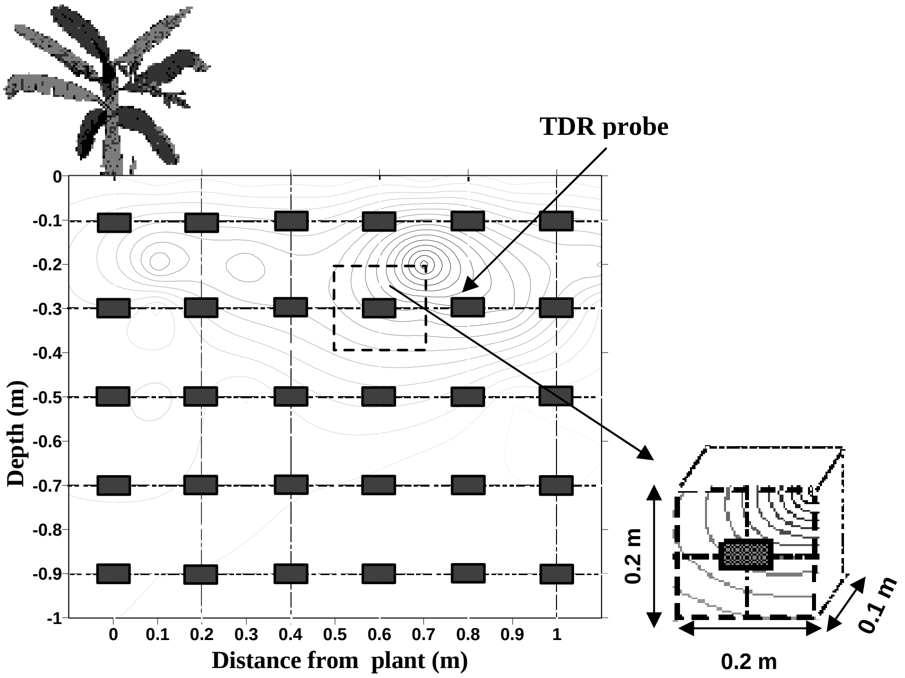

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Figure 1. Vertical plane with TDR probe locations for monitoring soil water content .

Soil water storage was evaluated in the control volume by using Simpson´s method (equation 1) at different horizontal distances (r_i) from pseudostem (0,0), i.e., at 0 m (r_0), 0.2m (r_1), 0.4m (r_2), 0.6m (r_3), 0.8m (r_4) e 1.0 m (r_5) from pseudostem.

$$h = \int_0^L \theta(Z)dz = \frac{\Delta Z}{3}\left[\theta(Z_0) + 4\theta(Z_1) + 2\theta(Z_2) + 4\theta(Z_3) + \theta(Z_4)\right] \quad (1)$$

Water storage (mm) variation in each day was obtained by the equation:

$$\Delta h = h_t - h_{t-1} \quad (2)$$

The effective root depth was defined based upon root distribution as the one that concentrates at least 80% of total roots (Arruda, 1989). Deep percolation was calculated for all r_i distances from pseudostem at effective root depth, using the following equation:

$$DP = \int_{J+1}^{J+2} q dt \quad (3)$$

where:

DP – deep percolation (mm);

$$q = \frac{\theta - \theta'}{t} \cdot \frac{v}{A} \tag{4}$$

where:

V- Representative volume of the soil where TDR probe is inserted (0.2m x 0.2m x 0.10m);
A- Section of the soil where TDR probe is inserted (0,2m x 0,2m);
t- Time interval, considered as 1h.

The depth of water applied to the crop during the experiment was calculated based upon Keller & Bliesner (1992). The infiltrated water depth (LTI) at distance r_i (eq. 5) from the pseudostem was determined by the integration of soil water contents taken after irrigation (θ_{J+1}) before irrigation (θ_j) at all monitored soil depths (z).

$$LTI = \int_0^L \theta_{J+1}(Z) - \theta_J(Z)dz \tag{5}$$

Upward movement of water was disregarded in this work due to large depth of water table. Also, run-off was disregarded since the experiment was carried in leveled soil. Therefore, soil water balance was calculated based upon the equation 6:

$$P + I \pm DP/A \pm \Delta h \pm R - ETc = 0 \tag{6}$$

RESULTS AND DISCUSSION: Figura 2(a) shows soil water distribution (cm^3cm^{-3}) as difference between soil water content obtained immediately before and two hours after the begining of irrigation in each location of the vertical plane. A Figura 2(b) shows banana root length density ($cm\ cm^{-3}$) at the production phase. It was noticed that zones of larger soil water content values were located among distances from the pseudostem (r) of 0.1 and 0.3m and distances (r) of 0.5 and 0.7 m after irrigation. Most of roots have developed at zones of larger soil water content, i.e., at distances from the pseudostem among 0.2m and 0.8m.

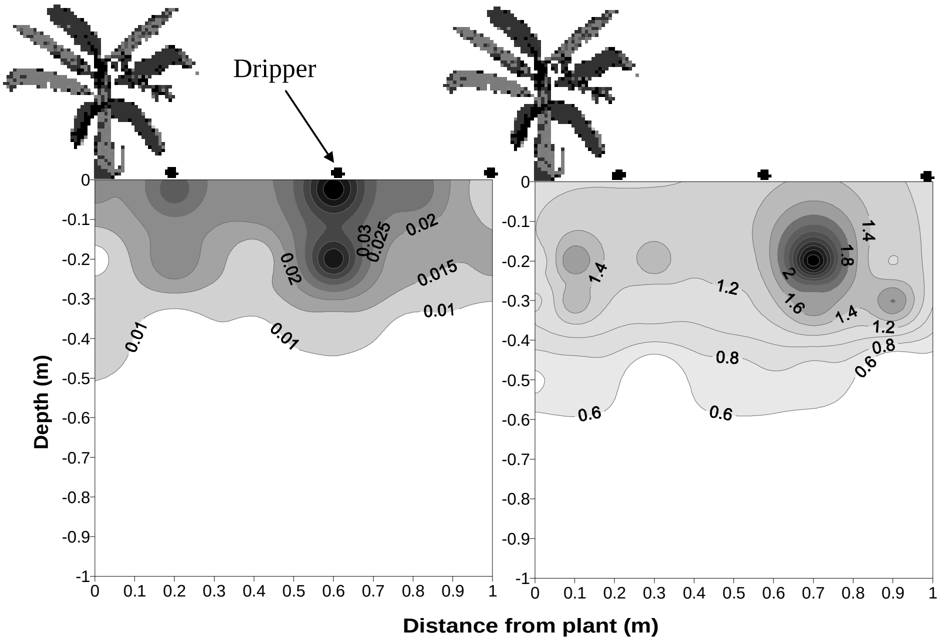

Figure 2. Water distribution 2 hours after irrigation (a) and banana root distribution (b).

Soil water distribution have influenced plant root system distribution, because larger root lenght percentage (17.80 e 22.50%) were found at distances (r) from the pseudostem of 0.2 and 0.7 m, respectively, matching with the wetted volumes below emitters. This result is in accordance with various studies about water and root distribution under trickle irrigation systems (Coelho et al, 2006, Silva et al., 2006, Santos et al. 2005, Coelho & Or, 1999). Assuming the effective distance of roots as the one that contains at least 80% of total roots (Vieira et al., 1996), its was noticed that 80.71% of total roots were found at distances smaller than 0.8 m. The smallest concentration of roots (12.40% of total root length) was found at distance of 0.4 m in the interval of distance from the pseudostem of 0-0.8 m (Figure 3). This was the zone of larger percolation as well the zone of smaller values of evapotranspiration. The largest incidence of roots was verified at 0.8 m (22.50%) where value of percolation was minimum and evapotranspiration has gotten the largest values. Differences up to 59.93% were found among values of Evapotranspiration (ETc) along distance from the pseudostem due to variations of the water balance components.

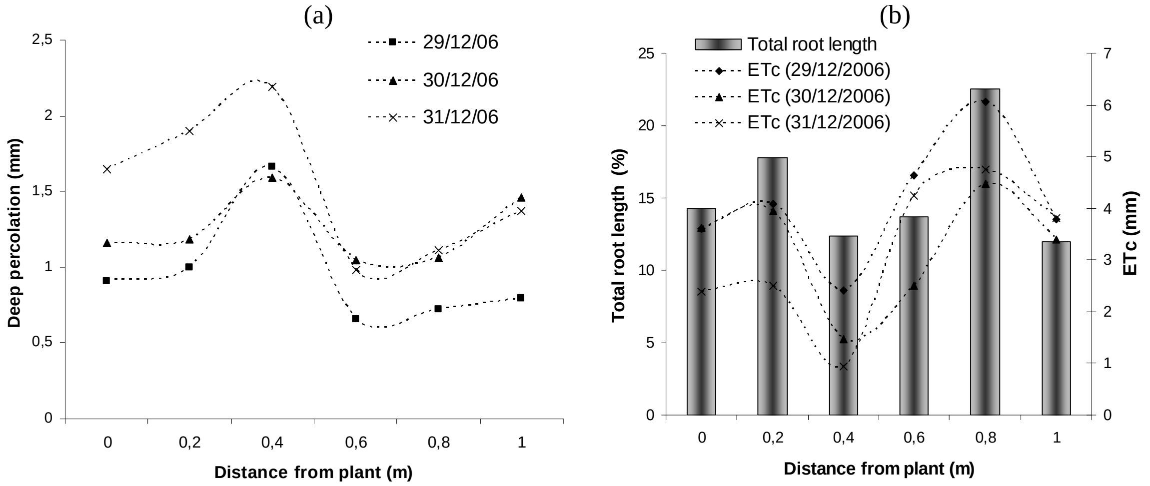

Figure 3. Deep percolation at different distances from the pseudostem (a); total lenght of roots at different distances from the pseudostem (b)

CONCLUSION: Evapotranspiration and deep percolation are not uniform around a banana pseudostem and varied according to water and root distribution in the soil profile. The larger values of deep percolation and smaller values of evapotranspiration occured at zones of the soil of smaller percentage of total root length and vice versa.

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