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WATER APPLICATION EFFICIENCY OF A MICROSPRINKLER IRRIGATION SYSTEM IN BANANA CROP

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ABSTRACT: The food production will be limited in a near future due to the shortening of water resources. The irrigated agriculture must seek for solutions in order to guarantee high yields using water with high efficiency. This work had as objective to determine deep percolation and application efficiency by using TDR technique in the water balance method for banana crop in a trickle irrigation system. The work was carried out at Embrapa Casava & Tropical fruits, Cruz das Almas city – Bahia State. Three different microsprinkler irrigation systems were evaluated: T1 – One 32 L h^{-1}-emitter per four plants (pseudostems) with one single lateral line per two crop rows; T2 – One 60 L h^{-1}-emitter per four plants (pseudostems) with one single lateral line per two crop rows and T3 – One 60 L h^{-1}-emitter per two plants (pseudostems) with one single lateral line per two crop rows. The irrigation systems that applies water at the soil with smaller variations of infiltrated water depths at all distances from the pseudostem are the more efficients. The water application efficiency for the systems with a 32 L h^{-1} microsprinkler per four plants, 60 L h^{-1} microsprinkler per four plants and 60 L h^{-1} microsprinkler per two were 85.01%, 79.72% e 89.54%, respectively.
KEYWORDS: irrigation systems, TDR, microsprinkler, banana crop.

INTRODUCTION: The food production will be limited in a near future due to the shortening of water resources. The irrigated agriculture must seek for solutions in order to guarantee high yields using water with high efficiency. The amount of water that is lost in agriculture per year is about 2.500 km³, (LEMOS, 2003), value that exceeds losses by industry (117 km³) and by domestic use (64,5 km³). The irrigation efficiency may be expressed by specific components such as application efficiency (E_a), conveyance efficiency, water storage efficiency, distribution efficiency, water storage efficiency. Application efficiency is the ratio of the amount of water stored in the soil root zone during the irrigation event and water delivered to the farm (HSIAO et al., 2007). Application efficiency has been assumed according to the irrigation system for water management. The difficulty for obtaining the necessary parameters like deep percolation for Ea calculation has been the reason for assumptions that are usually made. The water balance method may be used for evaluation of deep percolation (ANDREU et al., 1997; CLOTHIER and GREEN, 1993; GREEN et al., 1996 and SMITH et al., 2004) and the use of TDR for measurement of soil water content may be a useful tool to this method. TDR technique has been used for studies that take in account soil water distribution in time and in space, mainly due to its accuracy, repeatability, and possibility for data logging automation (HEIMOVAARA et al., 2004). This work had as objective to determine deep percolation and application efficiency by using TDR technique in the water balance method for banana crop in a trickle irrigation system.

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. Three different microsprinkler irrigation systems were evaluated: T1 – One 32 L h^{-1}-emitter per four plants (pseudostems) with one single lateral line per two crop rows; T2 – One 60 L h^{-1}-emitter per four plants (pseudostems) with one single lateral line per two crop rows and T3 – One 60 L h^{-1}-emitter per two plants (pseudostems) with one single lateral line per two crop rows. The volume of applied water was the same for a all treatments. 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 the plant and the microsprinkler. The plane had limits at the pseudostem and at 1.0 m from the pseudostem towards to the emitter. The limits of depth were the soil surface and z = 1.0 m (Figure 1a). TDR probes were inserted horizontally in all grid points in order to get soil water content in the whole plain according to Figure 1a. 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 and were digitized in a computer following. Root lenght (Lr) was obtained by using Rootedge software. Calculations of the infiltrated and the extracted water depths (LTI after irrigation and LTE, respectively) were made from soil water content data collected in specific times. The vertical lines in Figure 1b indicate these specific times, i.e., time immediately before irrigation (j), time when irrigation water reaches the deepest evaluated depth of the plane (j+1) and time immediately before next irrigation (j+2).

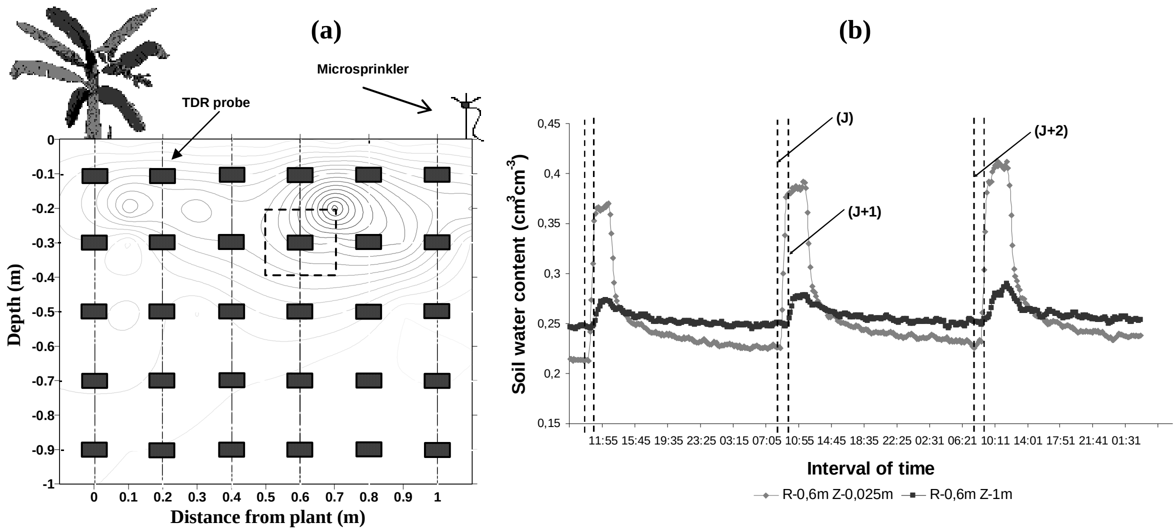

Figure 1. Soil water content readings by TDR probes (a) and times J, J+1 e J+2 during three irrigation cycles (b).

The difference between soil water contents after (θ_{J+1}) and before (θ_j) irrigation allowed the determination of the infiltrated depth of water at time (j+1) – (j), in each location r_i of the grid from the soil surface to the depth of the deepest TDR probe (z = L) (eq.1):

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

where: LTI – infiltrated water depth for each location ri of the grid (mm); $\theta_{J+1}(Z)$- soil water content after irrigation as a function of depth (mm), and, $\theta_J(Z)$- soil water content before irrigation as a function of depth (mm)

The average infiltrated water depth in the control volume of the of banana root system was given by eq. 2:

$$LTI_m = \frac{\sum_{R=1}^{n} LTI}{n} \qquad (2)$$

in which: LTI_m – Total infiltrated water depth (mm); LTI – infiltrated water depth lin each location ri of the grid (mm), and, n – number of points (r_i). The differences among soil water contents after irrigation (j+1) and before next irrigation (J+2) in a location r_i of the grid allowed the determination of the extracted water depth at the same location (eq.3):

$$LTE = \int_0^L \theta_{J+1}(Z) - \theta_{J+2}(Z) dz \quad (3)$$

in which: LTE – extracted water depth in each location ri of the grid (mm). The mean of the total extracted water depth was obtained by eq.4:

$$LTE_m = \frac{\sum_{R=1}^{n} LTE}{n} \quad (4)$$

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 eq.5:

$$DP = \int_{J+1}^{J+2} q dt \quad (5)$$

in which:

$$q = \frac{\theta - \theta'}{t} \cdot \frac{v}{A} \quad (6)$$

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),e, t - time interval, considered as 1h..

Average deep percolation in the plane was obtained as eq. 7:

$$DP_m = \frac{\sum_{R=1}^{n} DP}{n} \quad (7)$$

The mean water application efficiency (E_a) was obtained by eq. 8:

$$E_a = \frac{LTE_m - DP_m}{LTI_m} \quad (8)$$

RESULTS AND DISCUSSION: The effective root system depths for T1, T2 and T3 were observed at 0.4m, 0.6m e 0.6m, respectively. Soil water content observed below these depths indicated deep percolation for all treatments. Water infiltration was more intense near the emitters (Figure 2a). The smaller infiltrated water depths has taken place at the zone limited by the psedostem and the distance from it of 0.4 m, where 45.75% of the total root length was concentrated for T1. This region did not show deep percolation losses. Relevant deep percolation was observed at distances larger than 0.8 m. The mean percolated water depth in T1 was 1.,055mm. The ratio between the water stored in the root system and the water applied by the irrigation system was 0.8501, i.e., the water application efficiency was 85.01%. Water infiltration was not uniform along the distances ri from the pseudostem for T2. LTI was observed as 0.86 mm and 9.24 mm at distances of 0.2 m and 1.0 m, respectively. Deep percolation in this treatment has gotten the largest values (Figure 2b) and Ea the smallest value (79.72%) compared to the others treatments, despite the good horizontal development of the banana root system in this treatment. The smaller differences in the LTI values for all distances ri from the pseudostem was obtained for treatment T3 (Figura 2 c). Deep percolation for this treatment was the smallest one of all evaluated irrigation systems (0.9626mm) and the water application efficiency was the highest one (89.54%).

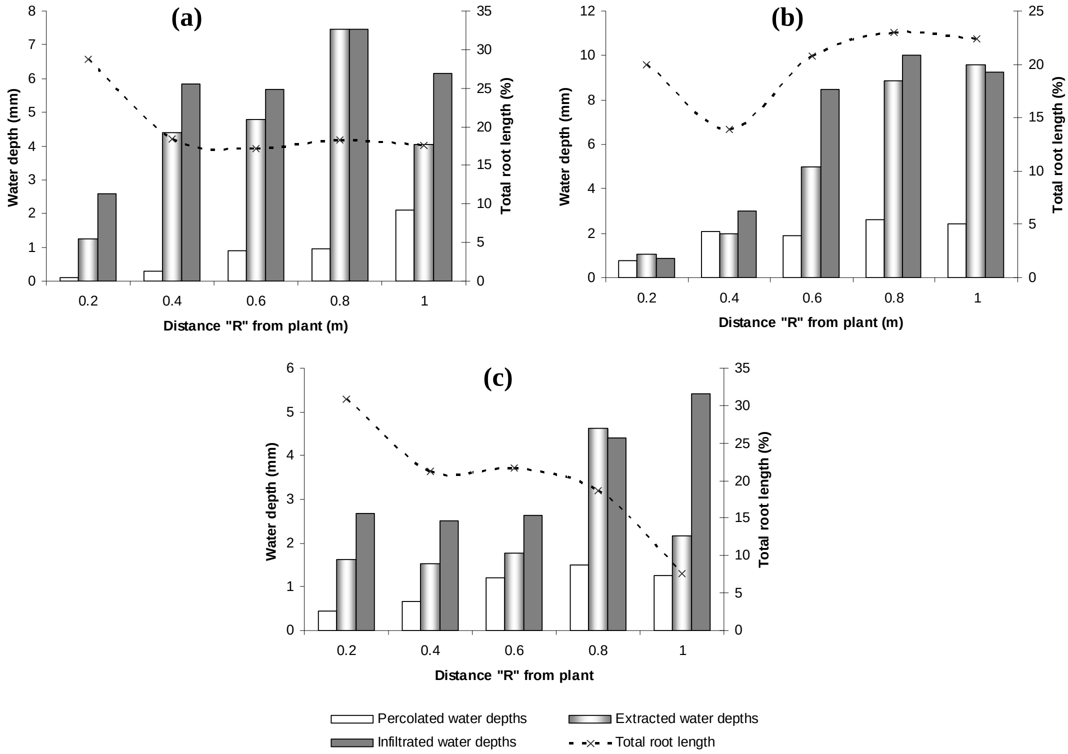

Figure 2. Percentages of total infiltrated, extracted and percolated water depths at different horizontal distances from the pseudostem (R) at treatments T1 (a), T2 (b) e T3 (c).

CONCLUSION: The irrigation systems that applies water at the soil with smaller variations of infiltrated water depths at all distances from the pseudostem are the more efficients. The water application efficiency for the systems with a 32 L h^{-1} microsprinkler per four plants, 60 L h^{-1} microsprinkler per four plants and 60 L h^{-1} microsprinkler per two were 85.01%, 79.72% e 89.54%, respectively.

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