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Evapotranspiration of "Superior" grapevines under intermittent irrigation

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ABSTRACT

This study deals with the effects of intermittent irrigation on actual evapotranspiration (ET) and leaf area index (LAI) of ''Superior'' grapevines grown in a semiarid environment in northeastern Brazil. The field experiments were carried out during two consecutive fruiting cycles (dry season and rainy season) of grapevines (*Vitis vinifera*, L) irrigated by drip at a rate of 2.3 L h^{-1}. Four irrigation time intervals were used as follow: one turn irrigation-time (I-1), two turn irrigation-time (I-2), three turn irrigation-time (I-3), and four turn irrigation-time (I-4). The growing cycles received different amounts of water by irrigation, which for dry and rainy seasons were 470.5 and 243.5 mm, respectively. The ET increased from 5.7 to 7.5 mm day^{-1} when the irrigation time interval changed from I-1 to I-4 and resulted in a higher value of LAI. The values of ET during the rainy-season growing cycle were much lower throughout the phenological stages, reaching a maximum of 6.4 mm day^{-1} for I-4 in the maturation stage. For both growing cycles, an increase in the cumulated vineyard evapotranspiration was observed when changing the irrigation time interval from I-1 to I-4, except I-2, which was slightly greater than I-3. Soil water drainage had a very gradual exponential decrease from I-1 to I-4 in both fruiting cycles. The grapevine coefficient under intermittent irrigation can be described as function of days after pruning by polynomial models.

1. Introduction

The efficient use of irrigation-water has become very important to face the lack of water resources and the high cost of fertilizers and other agricultural expenses. Such evidence has makes the adequate irrigation-water application imperative in the world. The production of grapevines (*Vitis vinifera* L.) has reached economic relevance in the San Francisco River Valley (northeastern Brazil). The application of advanced production technology allows a high fruit quality to different consumer markets.

Several studies have been conducted on vineyards all over the world (Daudet et al., 1998; Tonietto and Carbonneau, 2004; Artés-Hernández et al., 2006; Ramos and Martinez-Casasnovas, 2006; Monteiro and Lopes, 2007). Evans et al. (1993) observed that the soil–crop foliage cover of an adult vineyard is greatly affected by variety, soil structure and depth, crop spacing, crop practices, as well as by climate and soil water management. The authors also found that the most critical factors are spacing, training system and management practices, such as irrigation and thinning. Despite the fact that local growers have been using site–irrigation systems

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with high water application efficiency and grapevine coefficients for seed-grapes adjusted to local climatic conditions, a continuous reduction on grapevine productivity has been observed. The Superior grapevine has been characterized by its precociousness (90–100 days from budbreak harvest) and excellent market acceptance characteristics such as bunch and berry size, low sourness and high sugar grade. However, this cultivar has low and irregular field yield.

Trambouze et al. (1998) obtained evapotranspiration rates between 1.8 and 3.5 mm day^{-1} for an 11-year-old rain fed vineyard planted in southern France using soil water balance and energy balance. These values are similar to those obtained by Yunusa et al. (2004) for an irrigated vineyard in Australia. Trambouze and Voltz (2001) analyzed the within-field variation of vine transpiration in a Mediterranean vineyard of South France using sap flow gauges. They found that when soil water is easily extractable, the transpiration follows the atmospheric demand. Whereas, when the soil dries, transpiration is reduced according to soil water depletion. Valero et al. (2003) related that the main problems with grapevine growing in the province Murcia (Spain) are due to water, climate, soil, sanitary status of the plant material, and the structure of the plantation themselves. Williams and Ayars (2005a) studied the seasonal water use of a vineyard (cv. Thompson Seedless) with a large weighing lysimeter in the San Joaquin Valley of California. These authors noted that the water use of the vines was equivalent to 838, 708 and 936 mm from March 15 until the end of October during the same period in 1994, 1995 and 1996, respectively. Despite all of these studies, there is very scarce information on Superior grapevines under intermittent irrigation management, particularly grown in a semiarid environment. In this study an attempt was made to improve irrigation management in grapevines with different water levels. So, it was assessed what the suitable water level to reduce water losses.

The inadequate use of the irrigation management overestimates the evapotranspiration and may cause loss of water and chemical fertilizers through deep drainage and elevation of soil water table. However, some losses may be beneficial for leaching accumulated salts in soil with a high concentration salt. These factors may interact together at the root zone of the studied region to reduce yield and fruit quality of grapes with serious impacts on the local environment. Therefore, the intermittent irrigation appears as a new approach for fruiting crops water management, mainly under dripping irrigation, in order to minimize the loss of water and chemical nutrients by deep percolation in soils with a sandy physical structure. The water retention capacity is lower for both sandy–clayey and sandy soils under dripping irrigation conditions and it may cause the formation of a wet-soil volume with much lower horizontal than vertical dimensions, as a result of the predominance of gravitational potential over retention soil water.

The purpose of the present paper was for assessing the efficient use of water resources in Superior grapevines grown in a semiarid environment. The effects of intermittent irrigation, soil water content, water drainage, and leaf area development on vineyard evapotranspiration were also investigated.

2. Material and methods

2.1. *Soil, climate and site description*

This study was conducted at the Bebedouro Experimental Station of the Brazilian Company for Agricultural and Animal Research (Embrapa Semi-Árido) in the San Francisco River Valley at Petrolina, PE, Brazil (latitude, 09°09′S; longitude, 40°22′W; altitude, 365.5 m). The region has an irregular rainfall regime with the rainy season occurring from January to April. The soil of the experimental site is classified as Podzolic Red-Yellow Latosol with median texture, flat relief, moderately drained, and a groundwater table that remained constant throughout the study periods at 1.80 m soil depth. A detailed explanation of climatic conditions and physical and hydraulic properties of the experimental site soil is given by Azevedo et al. (2003). Table 1 shows the mean monthly values of some climatic variables during the two experimental periods (dry and rainy seasons). The uniformity coefficient of drippers–water distribution and drippers–water outlet were determined at the beginning of the field experiments, with values of 95.4% and 2.27 L h^{-1}, respectively. It was also observed that the mean variation coefficient of the water applied to the lysimeters was 2.34%.

Table 1 – Monthly values of weather date during the experimental periods (dry season: from July, 2001 to November, 2001) and rainy season: from December, 2001 to March, 2002)

Date	Rainfall (mm)	Mean temperature (°C)	Relative humidity (%)	Pan evaporation (mm)	Wind speed (m s^{-1})	Insolation (h)
Dry season						
July	4.9	23.7	67	5.5	2.4	7.3
August	6.9	23.6	64	6.6	3.1	7.2
September	2.0	25.7	60	7.8	2.9	8.5
October	0.6	27.3	56	8.2	2.7	8.8
November	1.0	28.1	57	8.7	2.4	9.4
Rainy season						
December	75.9	27.7	61)	7.8	2.9	7.5
January	236.5	24.6	85)	4.4	1.4	5.1
February	18.7	25.7	76	5.9	1.6	8.7
March	3.6	26.6	70	6.8	1.7	7.4