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Evaluation of soil moisture levels on growth and productivity of young citrus trees

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ABSTRACT

A citrus orchard (*Citrus sinensis* [L] Osb. 'Rhode Red Valencia') was established at the Agricultural Experiment Substation of Isabela, Puerto Rico in 2001. The predominant soil series at the experimental site is Coto clay (Typic Eutrustox). One hundred-eight Rhode Red Valencia trees grafted on Cleopatra were planted at a distance 4.5 X 6.0 m. Irrigation water was applied at an average rate of 29.07 L/hr using microsprinklers installed on 1.3 cm polytubing line. The experimental plots were arranged in a randomized complete block design with four replications. Plots consisted of six trees; data were recorded on the four middle trees. Two irrigation treatments were scheduled by using tensiometers installed at 30 and 45 cm depth; trees were irrigated when tensiometer reached a low depletion level (10-15 kPa) or a high depletion level (30-35 kPa), there was also a rainfed treatment. Irrigation treatments did not affect orange tree growth or fruit yields during 2004. Tree canopy volume varied from 13.61 to 14.62 m^3, producing an average of 42 fruits. During 2004, Valencia trees were harvested for the first time, therefore an irregular production is expected. Tough drip irrigation is a common practice for fruit orchards at the location; the experimental results obtained during 2004 showed that rainfall distribution was adequate to maintain growth. Older trees or those with a higher fruit load will probably require more frequent irrigations, mainly during the dry season.

RESUMEN

Se sembró un huerto de china (*Citrus sinensis* [L] Osb, 'Rhode Red Valencia') con el objetivo principal de programar las aplicaciones de microriego. Los árboles se regaban cuando la tensión hídrica del suelo alcanzaba los valores críticos predeterminados de 10-15 kPa y 30-35 kPa en dos tratamientos. Se añadió un tercer tratamiento sin riego como testigo. La tensión hídrica en el suelo se monitoreaba utilizando tensiómetros instalados a 30 y 45 cm de profundidad. Las variables utilizadas para determinar la respuesta de los árboles a los tratamientos fueron rendimiento, volumen de la copa, contenido de N total en el tejido foliar, eficiencia y cantidad de riego aplicada. No hubo un efecto significativo de los tratamientos en el rendimiento ni crecimiento de los árboles de Rhode Red Valencia. La producción fue de 42 frutas por árbol en árboles cosechados por primera vez durante el 2004. Tampoco se registraron diferencias significativas para eficiencia de la producción ni contenido de N en el tejido foliar. Un promedio de un riego cada dos semanas es suficiente para mantener la tensión hídrica

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del suelo a capacidad de campo. Aunque el uso de microriego es una práctica común en la zona, los resultados de este experimento demuestran que la distribución de lluvia es adecuada para mantener un buen crecimiento en los árboles jóvenes. Árboles más viejos o con una mayor producción, probablemente requerirán riegos más frecuentes, especialmente durante la época seca.

INTRODUCTION

Although citrus production is presently not a major commodity in Puerto Rico it does have potential for future development. Favorable factors include growing conditions, potential high yield and fruit quality, and motivation to improve citrus production. But, several other factors constrain citrus production. These include diseases, poor orchard management and edaphic problems in citrus production areas. An important problem that citrus growers need to deal with is the lack of information on the proper management of irrigation systems. In 1996, a consultant's report was submitted to the government of Puerto Rico on the potential for local citrus production (Kender, 1995). Among several recommendations the critical need for more research on citrus production and marketing was cited. Information on citrus production under our growing conditions is limited. Improper use of irrigation systems may cause high incidence of Phytophthora, and nitrogen leaching, if an excess of irrigation is utilized. The purpose of irrigation scheduling is to inform the farmers when to irrigate and how much water to apply to increase yield. Through proper irrigation, it should be possible to apply the water that matches crop evapotranspiration thus reducing water and N losses. The use of tensiometers to schedule irrigation has been strongly recommended in Puerto Rico and Florida (Goyal, 1989; Servis, 1990). The University of Puerto Rico has conducted research on citrus production and management in the past (Flores and Orengo, 1995; Román et al., 1997; Toro, 1989; Zamora, 1995). Further research is needed on the amount of irrigation water needed by citrus orchards (Román, 1995). Irrigation research in Puerto Rico has been oriented mostly towards banana and vegetable crops (Goenaga and Irizarry, 1995; Goyal, 1989). Most of the irrigation research on citrus management and production has been conducted in Florida. However, not all the information can be extrapolated to Puerto Rico because of the large differences in soil and temperature. The objectives of this research were to evaluate the effect of water depletion on growth and development of young citrus trees, and to evaluate N uptake in a young citrus tree orchard.

MATERIALS AND METHODS

A citrus orchard was established at the Isabela Agricultural Experiment Substation located on northern Puerto Rico (18°27´ N and 67°03´ W). The predominant soil series at the experimental site is Coto clay, which is classified as very-fine, kaolinitic, isohyperthermic, Typic Eutrustox. One hundred-eight 'Rhode Red Valencia' trees (*Citrus sinensis* [L] Osb.) grafted on 'Cleopatra' rootstock were planted on 10 April, 2000 at a distance of 4.5 x 6.0 m, resulting in a tree density of 370 trees/ha. In two of three treatments trees were irrigated when tensiometers reach a low depletion level (10-15 kPa) and high depletion level (30-35 kPa). Microsprinklers installed on 1.3 cm

polytubing line were used fo irrigating at an average rate of 29.07 L /hr of water. The sprinkler water reached a diameter of 3.8 m giving a wetted area of approximately 11.8 m^2/tree. Irrigation was applied based on tensiometer readings at 30 and 45 cm depth installed approximately one meter from the trunk. Tensiometers were read three times per week. Water applied per treatment was measured by an industrial flow meter. The third treatment consisting on rainfed trees was included as a check. Orange trees were submitted to two different soil water regimes during a four-year period.

The experimental plots were arranged in a randomized complete block design with four replications. Plots consisted of six trees and data was recorded from the middle four. Climatic data were obtained from a nearby weather station. The orchard was divided into three fields and soil samples were taken to determine water retention curves in the laboratory and thus to estimate volumetric water content from saturation to a soil water tension of 100 kPa. Tree canopy volume was calculated by using the method of Román et al. (1997).

To study the effect of water depletion on N uptake, leaf samples were taken from four quadrants of each tree within the plot. The response variables measured were canopy volume, fruit number, efficiency, and total N in the foliar tissue.

RESULTS AND DISCUSSION

Long-term soil water tension data of the citrus orchard are shown in Figure 1. The solid straight lines represent the upper soil water tension threshold for each microirrigation treatment (15 and 35 kPa). Soil water tension dropped rapidly after each irrigation event. During a four-year period orange trees suffered a high stress (75 to 95 kPa) on two or three occasions between 726 and 817 days after planting. Data for the rainfed treatment were omitted because the tensiometer water column breaks after a few days without irrigation or rainfall.

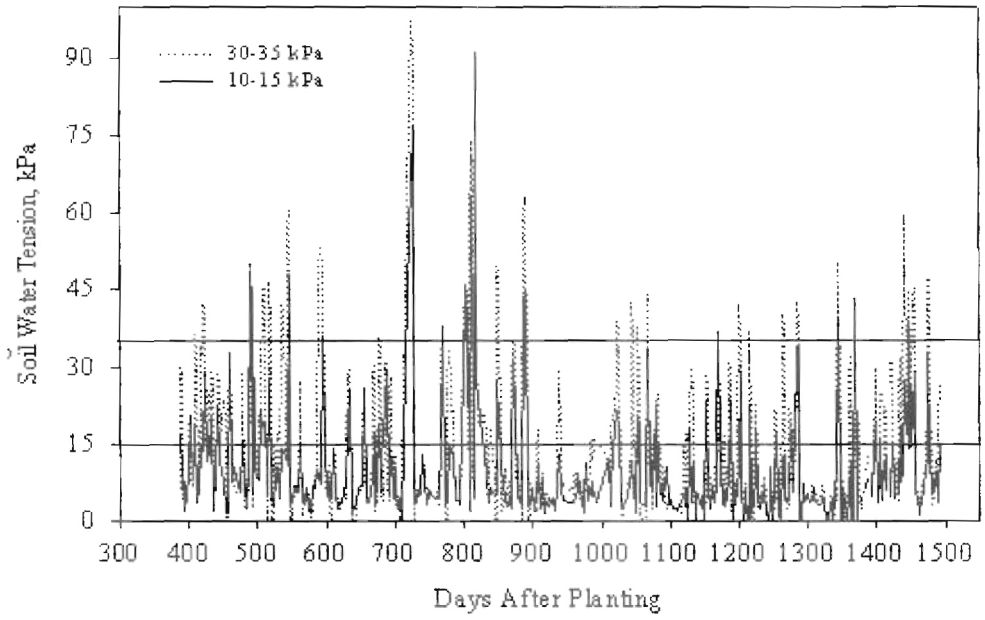

Figure 1: Soil water tension per microirrigation treatment scheduled by tensiometers in a Coto clay (Typic Eutrustox) in a 'Rhode Red Valencia' orchard at Isabela, Puerto Rico.

There was no difference in tree growth among irrigation treatments. Canopy volume varied from 13.61 to 14.62 m^3 during 2004 (Figure 2), when a tendency for greater growth, expressed by canopy volume, was observed among irrigated trees; however, this difference was not significant.

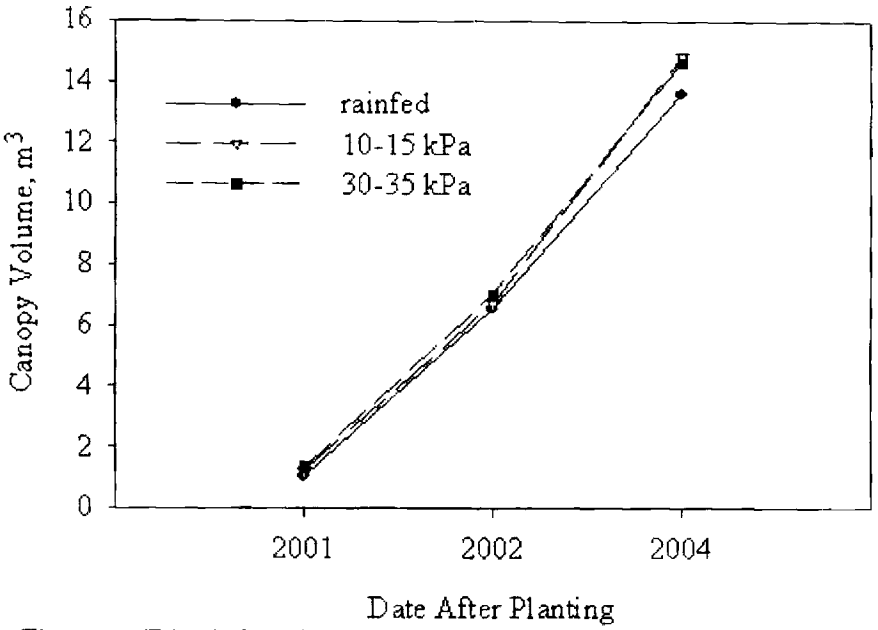

Figure 2: 'Rhode Red Valencia' mean canopy volume response to microirrigation treatments scheduled by tensiometers in a Coto clay (Typic Eutrustox) at Isabela, Puerto Rico.

Microirrigation did not affect any of the response variables measured (yield, efficiency, and total N in foliar tissue). The orchard produced an average of 42 fruits per tree (Table 1). A low production is expected for trees harvested for the first time. The total N content in the foliar tissue is interpreted as being optimum to high (Hanlon et al., 1995).

Table 1: Yield, efficiency, and total N concentration response of young orange trees (*Citrus sinensis* [L] Osb 'Rhode Red Valencia') to microirrigation treatments scheduled by tensiometers at Isabela, Puerto Rico.

Irrigation Treatment	Yield Fruits/tree	Efficiency fruits/m^3	Total foliar N %
Rainfed	41.9	2.72	2.65
10-15 kPa	39.6	2.66	2.62
30-35 kPa	45.8	3.97	2.56
	NS	NS	NS

In a one year period, orange trees submitted to the 10-15 kPa treatment required a total of 29 irrigation events to maintain soil moisture near field capacity (Table 2). From a practical standpoint one irrigation event every two weeks is enough to maintain the soil water tension near field capacity (10-15 kPa). Trees needed more frequent irrigations during January to March and July to September, which are periods corresponding to dry seasons. Even though drip irrigation is a common practice for fruit orchards at the location, the present results showed that rainfall distribution is adequate to maintain tree growth (Table 2). Water retention curves were estimated for Coto clay

at the experimental site. The volumetric water content (Θ) to field capacity corresponded to 42.3% and for permanent wilting point, Θ=27.6%. In addition to rainfall distribution observed during 2003-2004, a possible explanation for the lack of response to microirrigation treatments is that Θ @ 15 kPa = 41.7%, whereas @ 35 kPa, Θ=39.1% (a difference of 2.6%). Data gathered during a four-year period indicate that there is no need to maintaining soil water content at field capacity (10-15 kPa). Maintaining the soil water tension around 35 kPa only reduces the available water by 2.6%, but the number of irrigation events are reduced by half (Table 2). Older orange trees with a higher fruit load probably will require more frequent irrigations, mainly during the dry season to maintain soil water tension near 30-35 kPa. The experiment will be continued for at least two more years. Soil water depletion levels (soil water tension) will be revised to increase the difference in Θ between treatments to at least 5%.

Table 2: Rainfall, number of irrigations and irrigation amount (L/tree) applied to 'Rhode Red Valencia' trees per microirrigation treatments scheduled by tensiometers at Isabela, Puerto Rico.

Time Period	Rainfall cm	Soil Water Tension, kPa			
		10-15		30-35	
		Number of irrigations	Irrigation amount	Number of irrigations	Irrigation amount
January to March 2003	17.7	7	957	3	410
April to June 2003	65.4	3	410	0	0
July to September, 2003	42.8	6	820	4	547
OCTOBER TO DECEMBER 2003	75.9	5	684	2	273
January to March 2004	26.9	8	1094	3	410
TOTAL	228.7	29	3967	12	1641
Average/week	-	0.48	66	0.20	27

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