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Leaf gas exchange and growth response of juvenile 'Valencia' orange trees to dry season irrigation in south western Nigeria

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Abstract

Between January and April 2007 at Abeokuta southwestern Nigeria, 18-month old budded seedlings of 'Valencia' sweet orange (Citrus sinensis L. Osbeck) spaced 3.5 m apart were irrigated with 7.5, 30 and 60 L water/plant/week. The aim was to determine if juvenile sweet orange trees respond to dry season irrigation, the critical volume of water for growth and the mechanism by which irrigation exerts its influence on vegetative growth. Compared with 7.5 or 30 L water/plant/week, irrigation with 60L water /plant /week significantly increased height of the juvenile sweet orange seedlings. The effect of 7.5 or 30L water/plant/week did not differ significantly. Application of 30Lwater/plant/week significantly enhanced leaf production compared with application of 7.5 water/plant week but it did not differ significantly from that of 60Lwater/plant/week. The effects of irrigating with 7.5L or 60L water/plant/week on leaf area did not differ significantly. Nonetheless, irrigation with 30L water/plant/week produced significantly larger area than plants irrigated with 7.5L or 60L water/plant/week. Transpiration rates (E) in the morning and evening did not differ significantly. But in the afternoon, plants irrigated with 7.5Lwater/plant/week had significantly lower E than plants irrigated with 30 or 60 L water/plant/week did not differ significantly. Net photosynthesis (A) values were negative throughout the study. Based on its effect on leaf area development, 30L water/plant /week is recommended for dry season irrigation of juvenile orange plants in southwestern Nigeria.

Key words: Growth, irrigation, organic agriculture, sweet orange,

Introduction

Sweet orange (Citrus sinensis L. Osbeck) is one of the most important fruit crops in south western Nigeria (OLANIYAN AND FAGBAYIDE, 2007). Hitherto grown mainly for the fresh fruit market, there has been a recent increased demand for citrus fruits by the local fruit juice processing industry. To exploit this market opportunity, citrus production has to be intensified by increasing the area cultivated and improving the management of existing orchards. More than 70% of the citrus fruits consumed in Nigeria come from scattered trees in croplands or tree crop plantations (AIYELAAGBE ET AL., 2001). The trees undergo 3 - 6 months of drought stress annually during the dry season November - April/May. Nonetheless, they are not irrigated. Previous studies elsewhere have shown that drought stress impairs photosynthesis, growth and yield of citrus (AIYELAAGBE ET AL., 2005, KOSHITA AND TAKAHARA, 2004, HUTTON ET AL., 2007). Nonetheless, citrus trees in Nigeria are not irrigated. Our study was designed to

determine whether dry season irrigation would enhance the vigour of juvenile plants in south western Nigeria, the mechanism by which irrigation exerts it influence and the critical amount of water required to sustain growth of plants during the dry season.

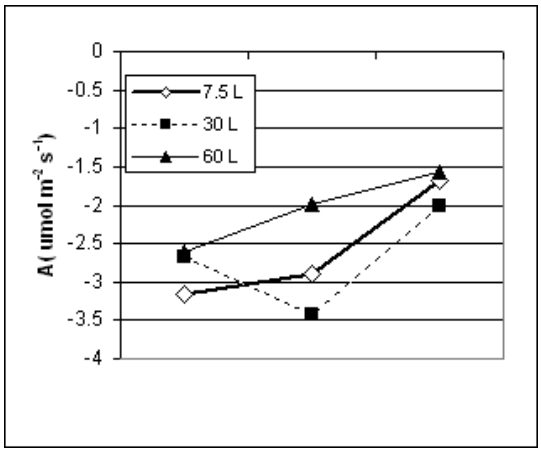
Materials and methods

In August 2006 mid rainy season, 18 month old budded seedlings of 'Valencia' orange scion on Cleopatra root stock were transplanted 3.5m apart in a single row on a sandy loam in the experimental plot of the University of Agriculture Abeokuta, south western Nigeria. Diurnal light intensity and leaf temperature ranged between 50 and 1750 µmol m-2 s-1 and 23 and 38oC, respectively. The plants received a dose of poultry manure applied at 10t/ha. Insect pests were controlled by hand picking and weeds were controlled by hoeing. In January 2007 mid-dry season a second dose of poultry manure was applied at 10t/ha. Thereafter, irrigation was applied using a simulated drip irrigation system to deliver 7.5, 30 and 60 L water /plant/week The irrigation rates were assigned following a randomised complete block design with six replicates. Vegetative growth was assessed by measurements of plant height, number of leaves and leaf area at 4-week intervals. Leaf gas exchange was determined on two clear days using the CIRAS-1 porometer (PP Systems, Herts UK). Photosynthesis and transpiration rates were measured on one tagged fully expanded leaf per plant in the morning, afternoon and evening (8.00, 14 and 18 hours, respectively). Plotted values are averages of eight readings. The study was terminated in May 2007 when the steady rains resumed and irrigation was no longer necessary.

Results

Leaf gas exchange

Transpiration rates (E) of plants ranged between 0.2 and 1.7 mm water m-2 s-1. E of the irrigated plants did not differ significantly in the morning or evening (Fig.1). However, in the afternoon, E of plants irrigated with 30 or 60 L water/plant/week was significantly higher than those of plants than those irrigated with 7.5L water/plant/week. Net photosynthesis rates were negative throughout the study. Thus, no useful inferences can be made from them



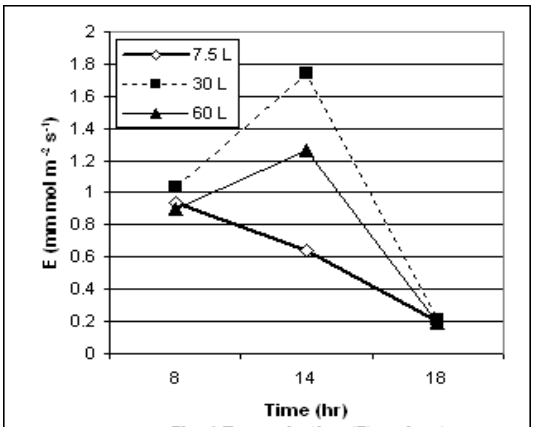
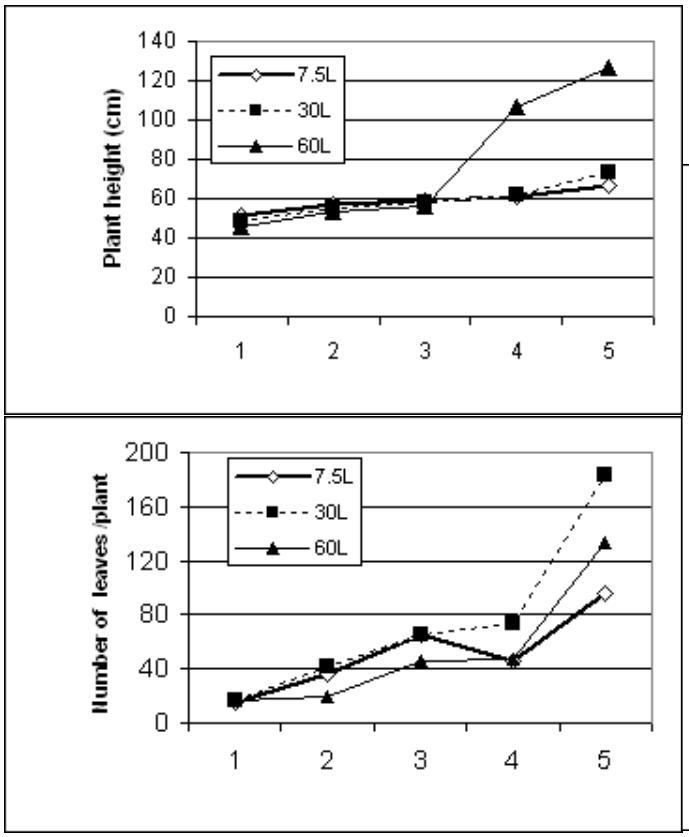


Fig. 1 Transpiration (E) and net photosynthesis (A) of juvenile 'Valencia' orange plants inresponse to dry season irrigation

Vegetative growth

Irrigation did not significantly influence vegetative growth of the orange plants until 3 months after irrigation commenced (Fig.2). Plant organs exhibited different sensitivities to irrigation. Plant height was significantly enhanced by irrigation with 60L water/plant per week, compared with those irrigated with 30 or 7.5 L water/plant/week. The effects of 30 or 7.5L water/plant/week did not differ significantly. Irrigation with 30L water/plant/week produced the largest number of leaves (twice as many leaves as those irrigated with 7.5L water/plant/week). Plants irrigated with 60Lwater/plant/week produced fewer leaves which were not significantly different from those produced by plants irrigated with 7.5 L water/plant/week. Similarly, irrigation with 30L water/plant/week significantly enhanced leaf area compared with 60 or 7.5L water/plant/week, compared with 60 or 7.5 L water/plant/week. The effects of 60 or 7.5 L water/plant/week on leaf area did not differ significantly.



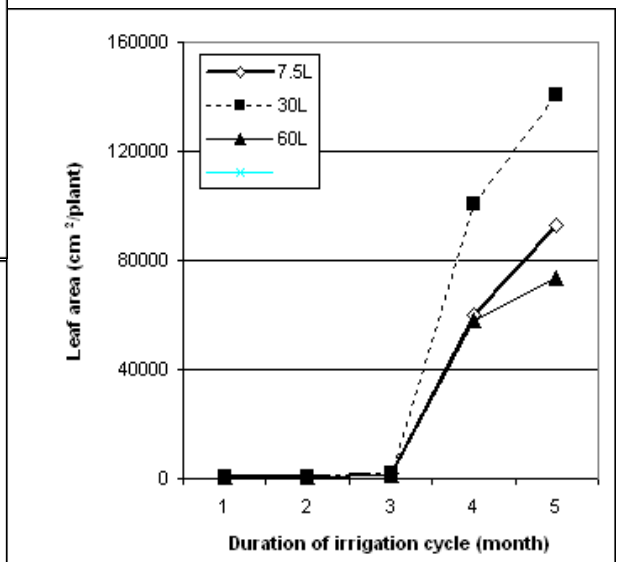


Fig.2 Plant height, number of leaves and leaf area of 'Valencia' orange in response to dry season irrigation

Discussion

The reason for negative net photosynthesis of the plants during the study is not clear. Nonetheless, the trends of transpiration clearly indicate that irrigation influenced internal plant water status and growth of the orange plants. Growth of plants irrigated with 7.5 L water/plant/week was curtailed due to water stress caused by a difference between transpiration and hydraulic conductivity. This must have adversely affected evaporative cooling and nutrient uptake of plants. Plants irrigated with 60L water/plant/week performed almost as poorly as those irrigated with 7.5L water/plant/week, probably because they were water logged. Flooding produces similar effects in citrus as water stress (GRACIA-SANCHEZ ET AL., 2007). Leaf area is a vital organ in the plant since it has a strong input into light capture for photosynthesis of plants. Since irrigation with 30Lwater/plant/week gave the largest leaf area, it is recommended for dry season irrigation of young orange plants in south western Nigeria.

Acknowledgement

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