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Energy balance measurements and a simple model for estimating pecan water use efficiency

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ABSTRACT

Plant water use efficiency (WUE) is defined as the net dry matter production (DM) per unit of consumptive water use. It is a vital variable for plant growth, yield, and irrigation-management models. Pecan [*Carya illinoensis* (Wangenh.) C. Koch] WUE has been estimated for above ground biomass growth using evapotranspiration (ET) and DM data measured separately in different experiments. The WUE for whole pecan trees (including above and below ground parts), a direct measurement (ET and DM measured in one experiment), and a simple model for WUE based on weather conditions, are currently lacking. A 16.5 m walk-up tower in a flood irrigated pecan orchard, located in the Mesilla Valley of NM, was instrumented with energy budget and eddy flux sensors. Continuous, above canopy measurements of vertical fluxes of sensible heat, H₂O vapor, and CO₂ were made by the eddy covariance technique in growing seasons from 2002 to 2005. ET was calculated from vapor flux. DM production was calculated from CO₂ flux assuming that dry matter of pecan trees was 46.4% carbon.

During the growing seasons (May through November), the mean ET was 122.7 cm (48 inch) per season; the mean dry matter production for the whole trees was 22082.3 kg ha⁻¹ (19684.4 lb acre⁻¹) per season. The average seasonal water use efficiency for the whole trees was 179.7 kg ha⁻¹ cm⁻¹ (406.5 lbs acre⁻¹ inch⁻¹). In 'on' years (high-yield years) 13.8% of the dry matter produced was allocated to the harvested nut crop, while in 'off' years only 8.0% was so allocated. Similarly, the nut WUE as nut yield per unit water used (as cm depth) was higher in 'on' years, at 26.2 kg nuts ha⁻¹ cm⁻¹ versus 14.9 kg nuts ha⁻¹ cm⁻¹. A simple model for monthly WUE (kg ha⁻¹ cm⁻¹) as a function of vapor pressure deficit (VPD) and relative humidity (RH) was obtained. It is anticipated that the measured WUE, the simple WUE model, and other data obtained in this study will be useful in developing and validating pecan growth, yield, and irrigation-management models.

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1. Introduction

WUE has generally been defined as units of plant growth per unit of evapotranspiration (ET) or consumptive water use. It has been

expressed as units of dry matter produced (DM) per unit of water used (Jensen et al., 1981; Begg and Turner, 1976) and as photosynthesis per unit of water transpired (Fischer and Turner, 1978; Sinclair et al., 1984). The term WUE has also been used to

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