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Front Cover: Images on the cover are examples of the history and breadth of research activity in agricultural and forest meteorology at the University of California, Davis (UC Davis). The upper left photograph, taken in 1962, shows W.O. Pruitt standing inside the 6.1-m diameter drag-plate floating lysimeter prior to installation in the field. This second large lysimeter supplemented the 6.1-m weighing lysimeter installed in 1958-59 and was designed and constructed by F.A. Brooks (project leader), W.B. Goddard, F. J. Lourence and Pruitt under sponsorship of the U.S. Army Electronics Command, Fort Huachuca, Arizona. The upper right photo taken in 1963 shows the floating lysimeter in place with Lourence (standing) and Goddard back-filling the lower 30 cm of soil covering the suction-drainage system. This unit provided a measure of evaporation rate along with the weighing lysimeter, and in addition, an absolute measure of surface drag for the 1960s micrometeorological studies at UC Davis. Both lysimeters have provided basic measurements for the testing and calibration of numerous Bowen ratio and eddy flux systems developed in the USA and other countries. They have provided important information regarding the water requirements of many crops, and their data have been used in a large number of major publications worldwide. Both the floating and the weighing lysimeter are still in use some 40 years after construction.

The lower image is recently constructed from the output of a large-eddy simulation (LES) of the flow through and over a horizontally uniform forest canopy. This simulation computes a time-dependent representation of the turbulent flow within a three-dimensional grid array. Shown here is a contour plot of static pressure perturbations over an x,z (streamwise, vertical) slice through the domain at a single time step. Flow is from left to right, and solid and dashed contours represent positive and negative perturbations, respectively. The horizontal dashed line represents treetop height. Of particular interest is the positive pressure perturbation in the center of the domain with peak at the canopy top. Such a zone of positive pressure is a regular feature of canopy flow and is coincident with a sloping scalar microfront separating a downwind ejection of air from the canopy and an upwind sweep of air from aloft. Large-eddy simulation is proving to be a valuable tool in the investigation of canopy aerodynamics, and is an active area of research in biometeorology at UC Davis today.

Lysimeter photos are courtesy of W. O. Pruitt. The contour plot created by R. H. Shaw is from a simulation performed by E. G. Patton.

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2.10 EVAPOTRANSPIRATION OF A MANGO ORCHARD IN A SEMIARID SITE OF NORTHEAST BRAZIL

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1. INTRODUCTION

The use of adapted citrus crop coefficient for water management of mango trees plantations and grapevine crop in the irrigated areas of the Submédio São Fracisco river region has increased costs of production and reduced the quality of the fruits. Also, the expansion of mango trees irrigated areas in that region has caused several problems of mango fruits illness. The works by Evans *et al.* (1993) and Castel (1994) are among the few researches related to fruit plantations water requirements.

Above canopy Bowen ratio energy and soil water balance methods have been applied by several authors (Lhomme *et* al., 1994; Phersson & Petterson, 1996) for estimating crop evapotranspiration. In semiarid regions, factors like topography, wind speed regime and local microclimate, make the surface energy fluxes measurements very difficult. The objective of this study was the determination of daily evapotranspiration throughout the productive cycle of a mango tree orchard (Mangifera indica L.) variety 'Tommy Atkins', grown in the soil and climate conditions of the Submédio São Francisco river region.

2. MATERIAL AND METHODS

From June 10 to November 09, 1999 the mango orchard was daily irrigated with a water volume, V_a (litters/plant) of:

$$V_a = \frac{E_v \cdot K_t \cdot K_c \cdot A_p}{E_i} \quad (1)$$

Where E_v is "Class A" pan evaporation; K_t = 0.75 is pan coefficient; K_c = 1.0 is constant crop coefficient; A_p = 40m^2 is the maximum surface area occupied by plant root system; E_i = 0.926 is the irrigation system efficiency. Then, the daily irrigation was obtained by $I = V_a/A_m$ where A_m is the irrigation soil wetting area.

The soil water balance (SWB) was obtained by:

$$Pr + I \pm D_d \pm \Delta h \pm R - ET_c = 0 \quad (2)$$

Where Pr is rainfall; Δh is soil water storage change; D_d is soil deep drainage; R is runoff; ET_c is crop evapotranspiration.

Assuming equality between the turbulent diffusion coefficients of sensible (K_h) and latent (K_w) heat and $(\partial T/\partial Z)/(\partial e_a/\partial Z) \approx \Delta T/\Delta e_a$, the latent heat flux (LE), based on Bowen ratio ((β = H/LE $\cong$ $\gamma \Delta T / \Delta e_a$), was obtained by:

$$LE = -\left(\frac{R_n + G}{1+\gamma \Delta T/\Delta e_a}\right) \quad (3)$$

Where R_n (W/m^2) is the net radiation; G (W/m^2) is soil heat flux; γ (KPa/°C) is the psychometric constant; $\Delta T = T_2 - T_1$ (°C) and $\Delta e_a = e_2 - e_1$ (KPa) are the temperature and vapor pressure gradients of air above trees canopy, respectively.

The reference evapotranspiration (ET_o) was obtained by the Penman-Monteith model for a stomatal resistance and grass height of 70s/m and 0.12m, respectively (Allen et al., 1994):

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma\left(\frac{900U_2}{T+273}\right)(e_a - e_s)}{\Delta + \gamma(1+0.34U_2)} \quad (4)$$

Where R_n and G are given in MJ/m^{2}day; Δ is the saturation vapor pressure curve tangent (KPa/°C); U_2 (m/s) is the average daily wind speed at 2m above soil surface.

3. RESULTS AND DISCUSSION

For the selected phenological phases of the mango productive cycle, the average daily evapotranspiration rate is presented in table 1. For the whole study period the mean daily evapotranspiration estimated by SWB (3.5mm/day) was lower than that obtained by the BREB (4.2mm/day). It was also observed that, for all phenological phases the SWB underestimated ET_c as compared to the BREB, possibly due to the simplifying assumptions made in the BREB. These results are compared to those obtained by Malek & Bingham (1993) and Phersson & Petterson (1997).

TABLE 1

Phenological Phases	Time Periods	ET (BREB) (mm/day	ET (SWB) (mm/day)
Flowering	10/06-30/06	3.5	2.3
Fruits fall	01/07-09/08	3.8	3.2
Fruits formation	10/08-30/09	4.5	4.0
Fruits maturation	01/10-09/11	4.9	4.6
Mean	-	**4.2**	**3.5**

Observed differences between the methods used for estimating mango orchard evapotraspiration were supposed to be a consequence of the simplifying assumptions made in the application of the BREB method, such as: (1) small fetch in the micrometeorological tower; (2) similarity between sensible and latent heat turbulent diffusion coefficients; (3) no consideration about within canopy and soil storage heat flux.

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The mango orchard evapotranspiration by the SWB increased from 2.4mm/day in the beginning of flowering to 7.9mm/day in the fruits formation phase, decreasing after that to reach 3.5mm/day at fruits harvest (table 2).

TABLE 2

Weekly periods	ET_c (BREB) mm/day	ET_c (SWB) mm/day
Jun 18 to 29	3.7	2.4
Jun 30 to Jul 12	3.9	2.8
Jul 13 to 19	3.9	3.1
Jul 20 to 26	4.3	3.0
Jul 27 to Aug 02	4.2	4.5
Aug 03 to 09	3.3	3.5
Aug 10 to 16	4.1	4.0
Aug 17 to 23	3.8	3.8
Aug 24 to 30	5.2	3.3
Aug 31 to Sept 06	4.6	5.9
Sept 07 to 13	4.6	4.0
pt 14 to 20	4.3	4.5
Sept 21 to 27	4.1	4.8
Sept 28 to Oct 04	5.5	3.6
Oct 05 to 11	4.9	7.9
Oct 12 to 18	4.4	5.7
Oct 19 to 25	5.1	5.7
Oct 26 to Nov 01	3.2	5.5
Nov 02 to 08	4.6	3.7
Nov 09 to 15	5.2	3.5
Weekly average	**4.4**	**4.1**
Total	643	612

The water consumption throughout mango orchard productive cycle was 612mm and 643mm while the week average daily evapotranspiration was 4.1mm/day and 4.4mm/day by the soil water balance (SWB) and Bowen ratio energy balance (BREB) methods, respectively. Similar results were obtained by Papakyriakou & McCauchey (1991) above forest.

The values of the mango orchard crop coefficient, obtained by the SWB method is presented in figure 1 as a function of the days after flowering. This figure shows that the mango orchard water requirements is not constant throughout the productive cycle and can be estimated by the crop coefficient (K_C) obtained as a function of the days after flowering.

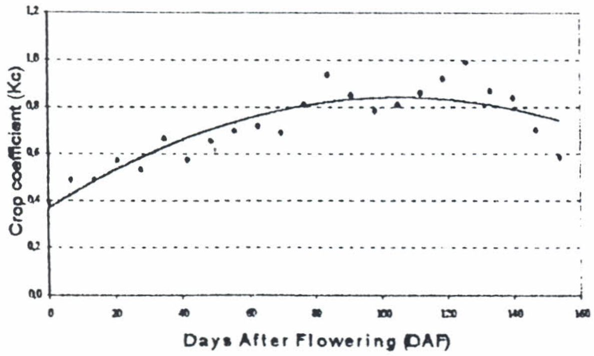

FIGURE 1 – Behavior of the productive mango cycle crop coefficient for Petrolina, Brazil.

4. CONCLUSIONS

A. The productive cycle mango evapotraspiration is affected by the available atmospheric energy and by the level of soil humidity;

B. In the experiment soil and climate conditions, the soil water balance method is more efficient than the Bowen ratio energy method for estimating the mango orchard evapotranspiration;

C. In the soil and climate conditions of the San Francisco river region, the mango orchard water requirements is not constant throughout the productive cycle and can be estimated by the crop coefficient (K_C) obtained as a function of the days after flowering (DAF) as: $K_C = 0.36 + 0.009\,(DAF) - 4 \times 10^{-5}\,(DAF)^2$.

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