1.2 ENERGY BALANCE IN A COTTON CROP IN NORTHEAST OF BRAZIL

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1. INTRODUCTION

The energy balance has been recognized as an efficient approach when applied to the exchange of energy and mass into the boundary layer. In Brazil, important studies have applied the Bowen ratio energy balance for determining crops evapotranspiration (Villa-Nova, 1973; André and Viswanadham, 1986; Silva et al.,1997; Siqueira and Leitão, 1998; Oliveira and Leitão, 1998; Silva et al., 1999; Lopes, 2002). Many researchers have also used that approach abroad, such as those conducted by Brakke et al. (1978), Angus and Watts (1984), Gay (1988), Dugas et al. (1997), and Prueger el al.(1997).

The main objective of this research was the determination of the energy balance components in order to obtain the actual evapotranspiration of a new variety of cotton crop in Northeast of Brazil and to offer support for a remote sensing assessement of actual evapotranspiration in irrigated areas of Cariri region of Ceara State.

2. MATERIAL AND METHODS

A field experiment was conducted at the Experimental Station of the National Center for Cotton Research of the Brazilian Coorporation of Agricultural and Animal Research – Embrapa, located in Barbalha, CE, Brazil (7^o 19´ S; 39^o 18´; 409 m), from August to December, 2001, with a cotton crop (Gossypium hirsutum) BRS-201 variety, furrowed irrigated. The soil of the experimental site was classified as Red-Yellow Latossoil. The cultural practices such as fertilization, weed and plagues control, followed local technical recommendations. The local climate type is BSwh' according to Koppen classification. A micrometeorological tower was installed over a crop row in which several instruments were attached in order to asess atmospheric and plant variables. One net radiometer was installed at 1 m above the canopy of the cotton crop. The incident (Rs) and reflected (Rr) solar radiation were measured with two radiometers (Eppley star model), installed in the same position as the net radiometer. Dry and wet bulb temperatures, and wind speed were measured by copper-constantan thermocouple thermometers and Young anemometers, installed at 0.5 m and 1.5 m above the crop canopy. The soil heat flux was measured with two heat flux plates burried at 0.02 m deep in the soil. All the analog signals were recorded every one second and averaged every 10 min using a datalogger (21X Campbell Scientific Ing, Logan, USA). Weekly, height of 20 plants, fresh and dry matter of three plants and the correspondent leaf area were measured in order to avaluate throughout the growth period. The Bowen ratio energy balance, was used for calculating the latent heat flux density, according to the following equations:

$$LE = \frac{-(Rn + G)}{1 + \beta} \quad (1)$$

where

$$\beta = \frac{H}{LE} = \frac{p_O . c_P}{L.\varepsilon}\left(\frac{Kh}{Kv}\right)\frac{\partial T / \partial Z}{\partial e / \partial Z} = \gamma\left(\frac{Kh}{Kv}\right)\frac{\Delta T}{\Delta e} \quad (2)$$

is the Bowen ratio and H, LE, Rn and G are the flux densities of sensible heat, latent heat, net radiation, and soil heat, respectively, all in $W.m^{-2}$; p_o is the atmospheric pressure (kPa); c_p is the specific heat of air at constant pressure ($J.kg^{-1}.{}^oC^{-1}$); L is the latent heat of vaporization ($kJ.kg^{-1}$); ε is the molecular weights ratio of water (M_w) to dry air (M_a); Kh e Kv are the turbulent exchange coefficient for sensible heat and water vapor, respectively; ΔT and Δe are the above canopy air temperature and vapor pressure gradients, respectively; and γ is the psycrometric constant. A basic assumption of the method is the equality of the turbulent exchange coefficients (Kh = Kv) supported by previous investigations made under non advective conditions. Additionaly, two lysimeters with 1.8 m x 1.5 m x 1.2 m, were operated in order to measure the actual evapotranspirations of the cotton field.

3. RESULTS AND DISCUSSION

The values of the reference evapotranspiration, ETo, were derived from the weather measurements taken into a shelter installed at the experimental site following the FAO-Penman-Monteith model. The ETo values presented a clear tendency to raise with time, reflecting the atmosphere behavior. The minimum value of ETo in the study period was 3.8 mm, registered on the day after plantation, DAP, 18. The maximum value of 10.3 mm occurred on DAP = 108.

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The ETo accumulated from August to December reached 756 mm. The total irrigation water applied in the cotton field was 523.2 mm, while the accumulated rainfall wa s 37.8 mm. During the study period two rainy days occurred.

On the Julian day, JD = 276, corresponding to the flowering phase, the sensible and latent heat fluxes represented 11.8 % and 83.5% of the net radiation (considering only the time interval where the Rn-G was greater than zero). On the other hand, on the maturity phase the sensible and latent heat fluxes represented 16.0 % and 77.0 % of the net radiation, respectively. The soil heat flux (G) was lower in the maturity and higher in the flowering phases, representing 2.1 % and 8.9 % of Rn, respectively. In the growing phase G was about 5 % of Rn. The actual evapotranspiration on JD = 240 was equal to 3.9 mm, and that occurred on the flowering phase. On the maturity phase (JD = 285), that value reached 7.1 mm. On JD = 305 the ETc was equal to 6.8 mm, and the sensible heat flux represented 16.5 % of the net radiation. The oscillations of the ETc values followed the variation of the ETo values, which are very dependent of daily solar radiation.

These results are preliminary, since the data set has been analysed and the final harvest occurred on January 2002. The data set has, also, been submited to consistency analysis. It is important to register here that these results will offer an important tool to the local cotton growers which have been encouraged to plant the cotton crop under irrigation systems. In this sense the informations about the behavior of the water requirements of the cotton crop are very important.

The crop coefficient (Kc = ETc/ETo) values showed an high seasonal variation with a clear increasing tendency. The minimum and maximum values were 0.18 and 1.17, respectively.

The final harvest occurred in the midle of January and the final yield was equal to 5,167 kg/ha, which is much greater than that obtained by local growers with other varieties.

4. CONCLUSIONS

According to these preliminary results we conclude that the latent heat flux represents about 80 % of the net radiation. On the other hand, the preliminary results of the actual evapotranspiration and reference evapotranspiration, will offer a great tool for the local growers of Cariri Cearense.

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