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CANOPY RESISTANCE AND LATENT HEAT EXCHANGE IN A CORK OAK STAND

Abel M. Rodrigues***** and Gabriel P. Pita**.
*E.F.N.,Instituto Nacional de Investigação Agrária, Oeiras, 2780, Portugal,
**DEM, Instituto Superior Técnico, Lisboa, Portugal

1. INTRODUCTION

Cork oak stands in Portugal are sparse and located mainly in the southern county of Alentejo. Those canopies exert a protective environmental role, needed by the prevalent conditions of Mediterranean climate with harsh hydric and micrometeorological stresses, derived of the high Summer temperatures, water vapor deficits and associated to soil erosion.

The Penman-Monteith equation allows a quantification of contributions of some key factors that control canopy evaporation, mainly available energy, canopy and aerodynamic resistances and the atmosphere humidity deficit. The inversion of Penman-Monteith, using values of evaporation obtained by eddy covariance is also a common method for calculating canopy resistance, r_c. Eddy covariance data of friction velocity and wind velocity are used for calculation of the aerodynamic resistance, r_a.

An algebric manipulation of that equation by Jarvis *et al*. (1986) resulted in the introduction of the decoupling dimensioneless coefficient W, representative of the coupling between vegetation communities and the atmosphere, defined as:

$$W = (D/g + 1)/(D/g + 1 + (r_c/r_a))$$

The equilibrium evaporation LE_{eq} is defined as a limit situation of Penman-Monteith evaporation theory. Vogt *et al*.(1990) write LE_{eq} as:

$$LE_{eq} = \frac{Ä}{Ä + ã}(R_n - G)$$

where D is the slope between saturation vapor pressure and temperature and g is the psychrometer constant.

2. SITE DESCRIPTION

The experimental site(38.8N e 9.1W) was located at Rio Frio, Montijo, Portugal. The site was located at a 70 year old cork oak stand (*Quercus Suber* L.) with a mean canopy height of 8m, a tree diameter at the 1.3m of 41cm, and a tree density of 65 trees/ha, planted in Podzol type soil with a deepness of 1.3m. The cover located in a flat terrain extending for at least 2-3Km in all directions. The understory was short (50cm high), patchy and constituted mainly by rock-rose (*Cistus Ladanider* L.).

3. MEASUREMENTS

The experimental sensors were installed at a 16m tower. Latent and sensible heat fluxes were measured by eddy covariance method at the top of the tower. Measurements were made for several days, between July and October during two years,1998 and 1999. Eleven days were selected. The eddy covariance equipment consisted of a three-dimensional ultrasonic anemometer (Solent Research, A 1012R, Gill Instruments, Ldt.), and one Krypton hygrometer (Campbell Scientific Inc., Model K2O). A coordinate rotation was made to cancel the wind mean vertical $\bar{w}$ and lateral $\bar{v}$ components. The sensible heat flux was obtained with sonic anemometer calculation of air temperature corrected for cross wind and humidity effects (Kaimal *et al*., 1991). The latent heat flux was corrected for the variations in air density, due to humidity and/or temperature (Tanner *et al*., 1993). Supporting measurements of net radiation, wind velocity and direction, air temperature and relative humidity and soil heat flux were also made.

4. RESULTS AND DISCUSSION

Table 1 shows the daytime values of eddy fluxes of latent and sensible heat, Bowen and $(H+LE+G)/R_n$ ratios. The averages of LE and H are 127.8 and 267.1W/m^2. Those positive values of ascendant eddy fluxes, competing for the available energy are typical of unstable conditions.

The average sum of eddy fluxes, not shown, was 77% of the net radiation. That value is of the order of the reported results in forest ecosystems of Lee *et al*.(1993) and Blanken *et al* .(1997), respectively of about 77% and 85%. By Table 1, the daytime average sum of eddy fluxes with soil heat storage was 96% of net radiation. That value is a bit high when compared with the reported results the cited references, respectively of about 79% and 90%. The sparseness of the stand was accountable for a larger exposure of soil to radiation, enhancing in that way the fraction of soil heat storage, comparatively to other kinds of heat storage

Also by Table 1 it can be noticed that Bowen ratio greater than 3 occur under conditions of higher net radiation and sensible heat flux. Inversely, Bowen ratio values below 3 may occur at days corresponding to daytime means of net radiation below total daytime average of 501.8W/m^2 or at days corresponding to daytime means of net radiation above total daytime average. On the other hand Figures 1 and 2 show that canopy resistance is more dependent on saturation deficit than on net radiation. That information is expressive of some indirect coupling between daytime latent heat flux and net radiation(Lindroth,1985), with air humidity and physiological factors being the main controllers of atmosphere evapotranspiration.

The canopy resistance, r_c =319.74s/m, is far greater than the aerodynamic resistance, r_a =15.15s/m, fact that, according to Baldocchi *et al*.(1997), occurs when Bowen ratio exceeds 1. The average value of 0.47 for the ratio LE/LE_{eq} is typical of dryness or high Bowen ratios and rough canopies (Baldocchi *et al*.1997).

The average daytime value of the decoupling coefficient of 0.18 indicates a strong coupling condition between the aerodynamic rough canopy and the convective boundary layer. In such a condition, the so called imposed transpiration by trees follows closely the atmospheric saturation deficit and is controlled by the canopy resistance.

To conclude we can say that the results obtained showed a pattern of dry conditions, aerodynamic roughness of the cork oak stand, coupled to the convective boundary layer (Blanken et al. 1997) with the evapotranspiration being controlled mainly by restricted stomatal opening. In this way the results contribute to emphasize the protective role of cork oak in water conservation in a dry ecosystem.

5. REFERENCES

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Table-1 Daytime values of: net radiation (*Rn*), eddy fluxes of latent (λE) and sensible (*H*) heat, Bowen ratio (β) and $(H+LE+G)/R_n$

Day	*Rn* (W/m^2)	*λE* (W/m^2)	*H* (W/m^2)	*β*	*(H+LE+G)/* R_n
98/05/08	523	102	286	2.8	0.96
98/05/15	434	98	215	2.19	0.90
98/05/27	321	114	213	1.87	1.07
98/06/05	560	148	280	1.89	0.84
98/06/17	558	170	254	1.49	0.95
98/09/16	459	115	229	2.00	0.97
98/10/01	439	141	212	1.5	0.95
98/10/22	352	119	160	1.34	0.98
99/06/16	645	170	341	2.00	0.90
99/06/30	596	101	354	3.49	1.00
99/07/28	634	129	393	3.04	1.07
total daytime means	501.8	127.8	267.1	2.15	0.96
std.dev.	109.1	26.1	71.5	0.68	0.06

Figure 1- Global results relative to variation of canopy resistance and mean saturation deficit, (*10Pa)

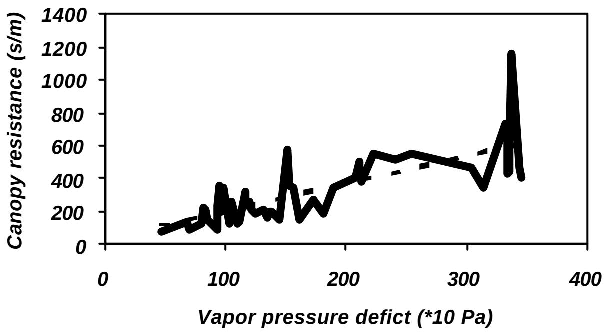

Figure 2- Global results relative to global variation of canopy resistance and net radiation