Ⅲ－A233

Field Investigation on The Bare Soil Resistance Parameters to Evaporation in Greenhouses

By Ali Abdel-Rahman MOHAMED and Kunio WATANABE *

Introduction

Actual evaporation is an important quantity in climatology, hydrology and agronomy, but its characterization at regional scale has not been clarified yet. Models of the evaporation from both bare soil and vegetated surfaces may be formulated as proportional to the difference in vapor pressure between the evaporating surface and the atmosphere divided by the sum of the resistance parameters to the movement of the water vapor. These resistance parameters are generally specified as the surface resistance and the aerodynamic resistance. In situ measurements were carried out to study the effect of the soil moisture content in the thin top layer of the bare soil in greenhouses on these resistance parameters.

1. Measuring Apparatus

The measuring apparatus mainly consists of two parts. A new equipment for measuring evaporation has been proposed by Watanabe and Tsutsui (1994) and six thermistors (See Fig. 1). During measurements the relative humidity and temperature for both the injected and extracted air are measured and they are used to calculate the absolute humidity of the air. Also, the volumetric air flow rate and the soil temperature just beneath the surface are measured. The ventilation box of this equipment represents a model of the simple pattern of a greenhouse shown in Fig. 2.

3. Field Experiments

An experimental place was selected inside the campus of Saitama University. The soil was described as silty sand soil. The place was saturated first and the experiments were begun after a few days to allow the settlement of an equal soil moisture distribution. During the drying period of the place eleven experiments were carried out under different soil moisture conditions.

4. Description and Analysis

Some of the observed data were plotted as shown in Figs. 3 and 4 (Under saturation ratio of 22.1 % as an example). As shown from these figures that all of these parameters change considerably during the time of the experiment and also from one experiment to another.

From the air flow rate and the absolute humidity of the injected and extracted air the evaporation rate can be calculated (See Fig. 5 as an example). The total resistance to evaporation can be calculated from the values of the vapor pressure at the soil surface, water vapor pressure of the air in the box, air density, evaoration rate and the total pressure of the air.

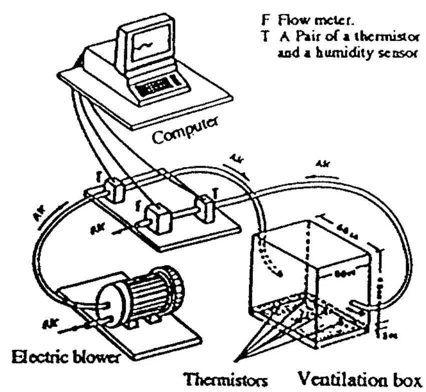

Fig. 1. Schematic view of the evaporation measuring technique equipped with six thermistors.

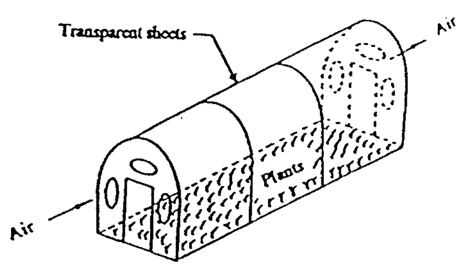

Fig. 2. Definition sketch of a simple pattern of greenhouses.

Keywords: Bare soil, Aerodynamic resistance, Surface resistance, Evaporation, Greenhouses.

* Faculty of Eng., Saitama University, 255 Shimo-Okubo, Urawa, saitama 338. Fax: 048-855-1378.

Assuming that the aerodynamic resistance to water vapor and sensible heat flux to be the same , the aerodynamic resistance can be calculated from the soil surface temperature, inflow and outflow air temperature, volumetric air flow rate and the covered area in the box. The surface resistance to evaporation can be calculated by subtracting the aerodynamic resistance from the total resistance (See Fig. 6 as an example). The average values of the resistance parameters were plotted against the different values of the saturation ratio in the thin top layer of the soil as shown in Figs. 7 and 8.

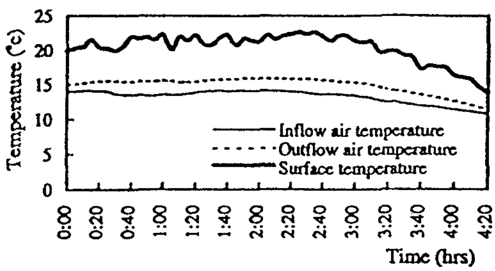

Fig. 3. Transient changes of the temperature of the soil surface, inflow and outflow air.

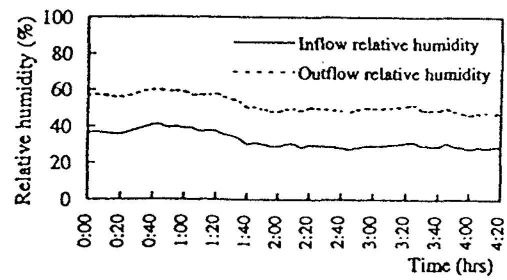

Fig. 4. Transient changes of the relative humidity for both inflow and outflow air.

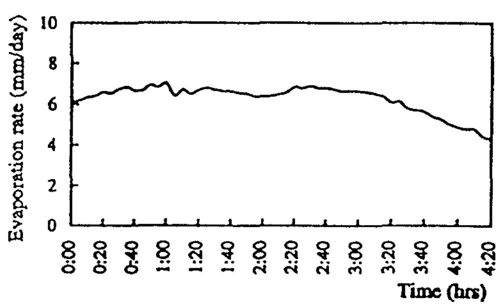

Fig. 5. Transient changes of the evaporation rate.

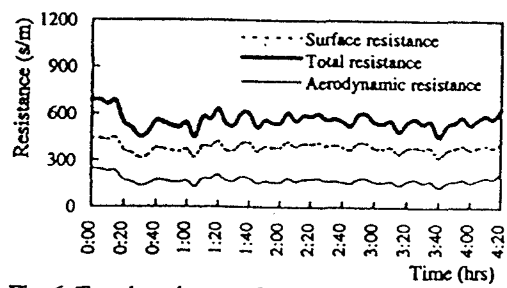

Fig. 6. Transient changes of the total, aerodynamic and surface resistance parameters to evaporation.

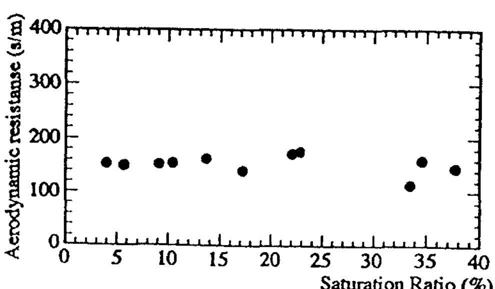

Fig. 7. Effect of the saturation ratio in the thin top layer of the soil on the aerodynamic resistance.

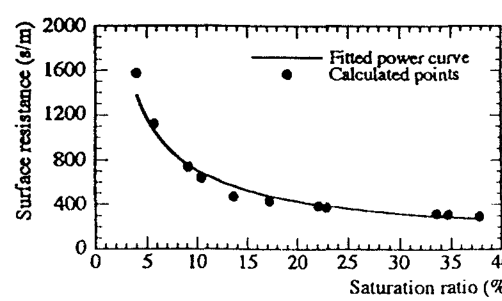

Fig. 8. Relationship between the saturation ratio in the thin top layer of the soil and the surface resistance.

Conclusions

The surface resistance to evaporation is small at saturation but increasing in highly nonlinear way when the soil becomes dry. The surface resistance can be modeled quite well as a power function of the soil saturation ratio in the thin top layer of the bare soil in greenhouses. However, the aerodynamic resistance to evaporation is independent of the moisture conditions in the thin top layer of the bare soil.

References

Watanabe K., Y. Tsutsui (1994): A new equipment used for measuring evaporation in a field. Proc. 7th Congr., IAEG: 309 - 313.