Transpiration measurement from plant leaf by using two-sensor type evaporation meter

Saitama University	Member of JSCE	KYI MYINT THWIN
Saitama University	Member of JSCE	KUNIO WATANABE
Saitama University	Member of JSCE	AYE AYE THANT
Thammasat University		KHANCHAI CHAICHAN

1.Introduction

Water shortage problems have become very severe during the last decades over the world. In agricultural practice, evaporation alone is not enough to determine the sufficiency of the amount of water supply. Transpiration is also a very important factor in determining the amount of necessary water. Accurate estimation of transpiration is indispensable in this regard. This paper describes the use of sensors for transpiration measurement from plant leaf and the accuracy of the measurements that was carefully checked under both laboratory and field condition.

2.Equipments and method

The shape of the sensor part of the equipment used (Tokyo Keisoku ETH 2101) is shown in **Figure 1**. An evaporation sensor comprises of two pairs of humidity sensor and thermistor. As shown in **Figure 1b**, the humidity sensor is plate-shaped and its size is about 5mm x 5mm. The thermistor is of spherical shape with 2mm diameter. Humidity and thermistor are shielded by a protection cover. The size of the protection cover is 6mm thick, 1.5cm wide and 2cm long. The humidity and the temperature at the center height of the protection cover (3mm from the bottom of the cover) can be measured. Absolute humidity can be calculated from the measured values of temperature and the relative humidity. The distance Δn between two pairs of the humidity sensor and a thermistor can be arbitrarily fixed. In this study, Δn was fixed as 5mm. Absolute humidity from surface can be obtained when the sensor is correctly put on the surface. Absolute humidity gradient is calculated from the absolute humidity values. Then the transpiration is estimated with multiplying vapor diffusion coefficient to the gradient.

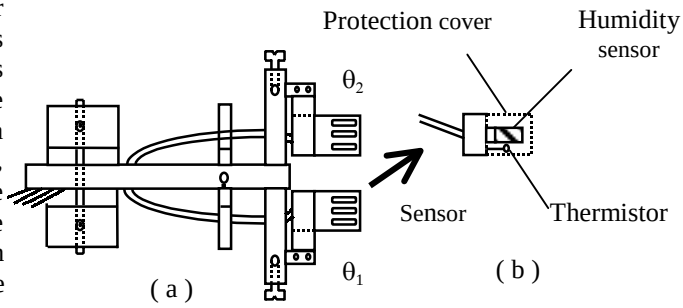

Figure 1 Shape of the evaporation sensor (Sensor is composed of two pairs of a humidity sensor and a thermistor)

Data measured by each sensor are sent to a microcomputer to calculate the absolute humidity gradient and the transpiration rate from the plant. All data obtained are stored in the floppy disk. The response time of the sensor is about 20 second and finally 5 minutes average values were stored in the floppy disk.

3.Accuracy of the measurement

Before applying the equipment for actual measurement of transpiration, the accuracy of the measurement was checked in the laboratory by comparing the measured evaporation with weight losses recorded by a balance as shown in **Figure 2**. A cup filled with wet soil was prepared. The weight of the specimen decreases if the water from the specimen evaporates. The weight increases when the specimen sucks the vapor in air. The evaporation rate is evaluated from the weight changes of the specimen. At the same time, the sensors also measured the vapor fluxes just above the upper surface of the specimen. **Figure 3** shows the results of transient change of evaporation rates from a specimen measured by using the equipment and rate calculated from the change in weights recorded by the balance. It illustrates the results of accuracy check carried out in the laboratory for a period of 6 hours.

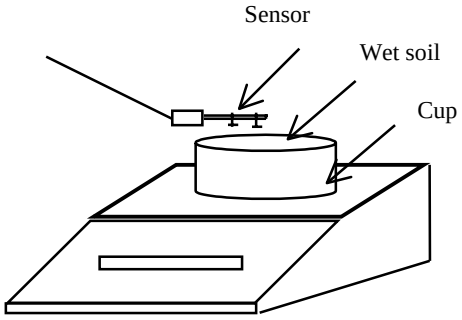

Figure 2 Experiment for checking the accuracy of the measurement

A field check was carried out in the campus of Saitama University to investigate the accuracy of the equipment under natural conditions. Transparent plastic sheet was used to cover the plant carefully to protect it against the wind. **Figure 4** shows the transpiration rate compared with weight losses recorded by a balance under laboratory and natural conditions. The evaporation rates measured by equipment showed good agreement with the evaporation rates measured by a balance both in the laboratory and in the field. It can be seen that sensors can be well used under natural conditions.

4.Actual test in the laboratory and field

After checking the accuracy, the two-sensor type evaporation meter is used to measure transpiration rate from both sides of the strawberry leaf. Sensors were placed on the both sides of the strawberry leaf and measurement was taken under wind protection

Key words: two-sensor type evaporation meter, transpiration, and accuracy check
Address: Geo-sphere Research Institute of Saitama University, Graduate School of Science and Engineering.
255, Shimo-okubo, Urawa-shi, Saitama ken, 338-8570, Japan.

condition. Transpiration rate from both sides of the leaf was shown in **Figure 5**. It was found that the backside of the leaf transpirates more than the front side. Then the transpiration from 18 leaves of rubber tree was measured is illustrated in **Figure 6**. The average values of transpiration from backside and front side are plotted in this figure. The distribution of transpiration from leaves is shown in **Figure 7.** It can be clearly seen that different leaves have different transpiration rates due to age of leaf and solar radiation conditions.

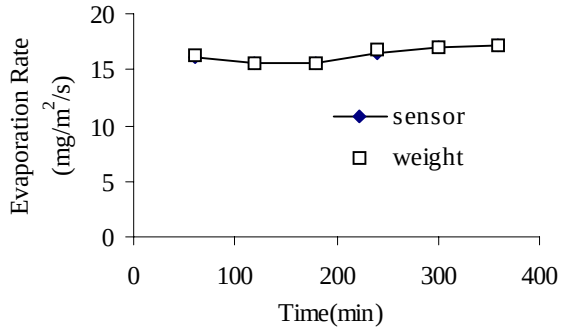

Figure 3 Accuracy check of the sensors with wet soil

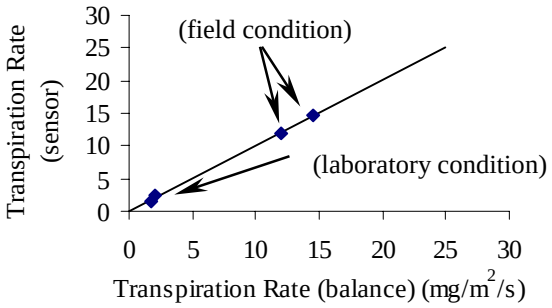

Figure 4 Accuracy check of the sensors with plant

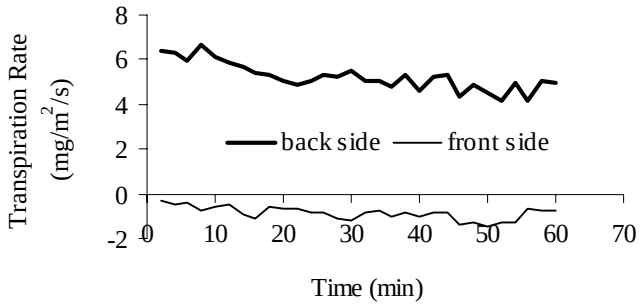

Figure 5 Transpiration rate from both sides of the strawberry leaf

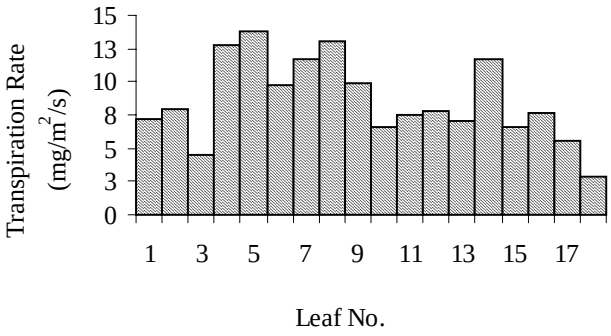

Figure 6 Average value of backside and front side transpiration rate of the rubber tree from different leaves

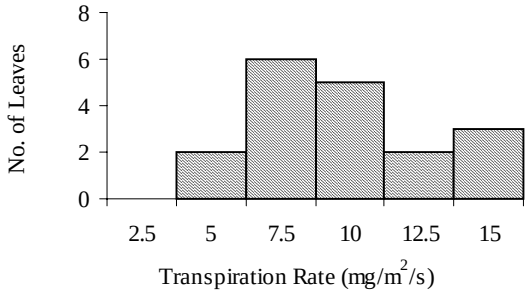

Figure 7 Transpiration distribution

5.Conclusion

Both laboratory and field-tests show the high accuracy of two-sensor type evaporation measuring technique. It can be concluded that, this measurement technique can be applied to an irrigated area and transpiration results can be used as a useful tool for planning irrigation water requirement.

Reference

1) Watanabe, K.et.al; Evaporation measurement for mapping the groundwater discharge on tunnel wall (part 1), Jour.JSGE, vol. 30, pp. 189-196, 1989