Water Balance of a Cucumber Field in a Chinese Style Greenhouse

○ BAI Yanmei*, INOSAKO Koji*, INOUE Mitsuhiro**, LIANG Yingli*** and TAKUMA Katsutoshi*

1. INTRODUCTION

A Chinese style greenhouse is a typical energy-saving greenhouse widely used in the north China. It enables cultivation in winter without any heating facilities. Therefore, since the introduction of such cultivation in 1992, the area of cultivation in the Yan’an district has been increasing. Such a greenhouse has a unique structure and high heat retaining ability. So far, some studies have been conducted about suitable structure design, building materials, heat properties, and radiation conditions. However, there have been few studies on the water balance of fields in the greenhouse. This study analyzed water balance of a cucumber field in a Chinese style greenhouse by using water balance model.

2. SITE AND EXPERIMENT GREENHOUSE

In this study, Yan’an district was selected as a research site. Yan’an city is located between north latitude 35°21' - 37°31' and east longitude 107°41' - 110°31' in northern China, as shown in Fig.1. Experiments were conducted in a 502 m² solar plastic house. Figure 2 illustrates a vertical cross-section of the greenhouse. The north side of the greenhouse has an earthen wall (2.6 m high, 64.4 m long and 0.8 m thick). The internal dimensions of the greenhouse are 62.8 m long and 8.0 m wide. Cucumbers were cultivated during the measurement. Soil water content was measured by PR1/4 under cucumber in the greenhouse of Yan’an city.

Fig.1 Location of Yan’an district

Source:http://www.lib.utexas.edu/maps/China.html

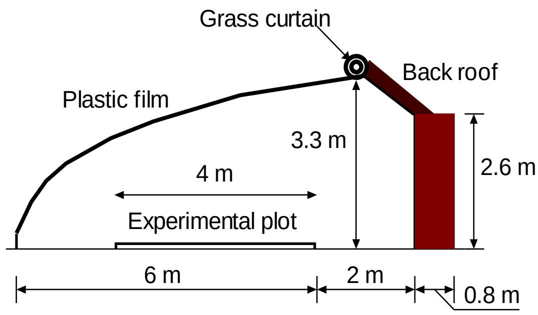

Fig.2 Vertical cross-section of Chinese style greenhouse

3. WATER BALANCE MODEL

An equation describing water balance of a field in a greenhouse can be written as

$$SW_{i+1} = SW_i + I_i - ET_i - G_i \quad (1)$$

, where *SW* is soil water storage in a root zone, *I* is the applied irrigation water, *ET* is evapotranspiration, and *G* is root zone gravitational water, Subscript denotes the day of *i*. *ET* and *G* are estimated by the Makkink method and a power function model.

The Makkink method is presented as follows,

$$ET = \alpha \frac{\Delta}{\Delta + \gamma} \frac{Rs}{l} + \beta \quad (2)$$

* Faculty of Agriculture, Tottori University, ** Arid Land Research Center ,Tottori University, *** Institute of Soil and Water Conservation, CAS., Key words irrigation, water management, evapotranspiration

,where Δ is the slope of the saturation vapor pressure curve (hP_a/K), γ is a psychrometric constant (hPa/K), *l* is the latent heat of the vaporized water (MJ/kg), and *Rs* is global solar radiation (MJ/m^2). α and β are empirical parameters.

Gravitational water in the equation of (1) can be estimated by the following equation:

$$G = g_1 (SW_i - SW_{\max})^{g2} \quad (3)$$

where g_1 and g_2 are empirical parameters, and $SW_{\max}$ is the soil water in the root zone at conditions of field capacity. If *G* value is less than zero, *G* equals zero.

Five model parameters (α, β, g_1, g_2 and SW_{max}) are optimized to minimize error between observed and estimated soil waters by using a genetic algorithm (Inosako eyal.,1998). The model error is assessed by using a root mean square error (RMSE). Data measured from Dec.1, 2004 to May 31, 2005, was used for this analysis.

4. RESULT AND DISCUSSION

Figure 2 shows the result of estimation by using water balance model.. Estimation of soil water was in good agreement with observation. The RMSE was 3.32 mm. This result suggests that this water balance model can be used for simulation of soil water. The mean daily evapotranspiration was 1.44mm. The total amount of irrigation water, evapotranspiration, and gravitational water were 313 mm, 262 mm and 38.5 mm, respectively. From middle March, the interval of irrigation became shorter. The mean daily evapotranspiration was less than 1mm from December to February, and increased gradually from March. However, the soil water also increased gradually from March. That is, applied water was slightly remained in the root zone. Therefore the balance of the frequency and the amount of irrigation was inadequate for this field under on-going irrigation scheduling.

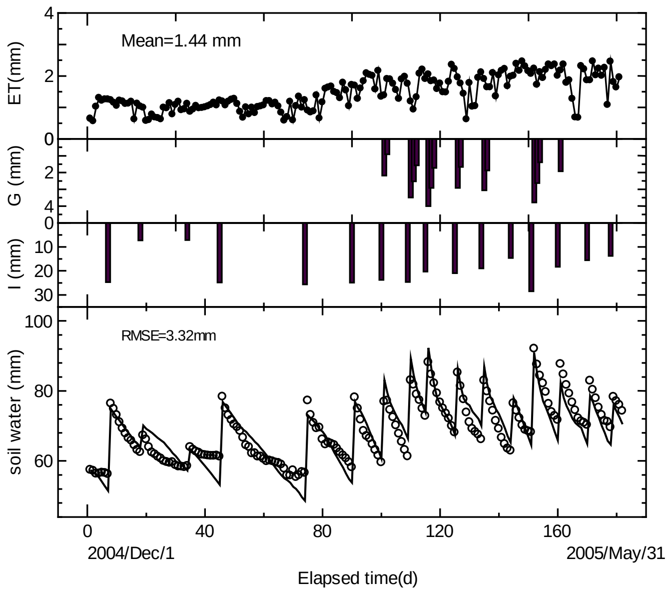

Fig.3 The change of water balance of a crop field in the greenhouse

5. CONCLUSION

In this study, an empirical water balance model was used for analysis of water balance of the cucumber field in the Chinese greenhouse in Yan'an district. According to the analysis the balance of the frequency and the amount of irrigation was inadequate for this field under on-going irrigation scheduling.

ACKNOELEDGEMENT

This research was supported by JSPS Core University Program.

REFERENCE

INOSAKO Koji, NAKANO Yoshisuke, KURODA Masaharu and YOSHIDA Isao (1998): A Scheduling Model for a Line Source Irrigation System, Trans.JSIDRE,66, pp.975-983.