Evaluation of the Effect of Irrigation on the Environment

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Introduction

Irrigation practice for modifying soil moisture condition affects the crop response to the transfers of water vapor. This response occurs by mean of the changes of crop resistance to the evapotranspiration.

The use of electrical analogy in modeling the crop micrometeorology had been disclosed by many researchers (Waggoner and Reifsnyder, 1968; Lhomme, 1988; Mohan and Srivastava, 2001). By using the model the crop environment can be simulated.

The objective of this study is for evaluating the effect of irrigation application to upland field to the environment.

Methods

A two layers upland crop energy balance model was used to simulate the effect of irrigation on the upland crop environment. The crop system is assumed to have leaf area index of 5, experiencing dry condition and wet condition due to the irrigation practice. Air temperature, humidity, wind velocity and soil temperature were estimated using one dimensional diffusion models. A simple two-layer model, following Nakano and Cho (1985), was used for the simulation. In this model the crop canopy can be treated as one big leaf as shown in Figure 1.

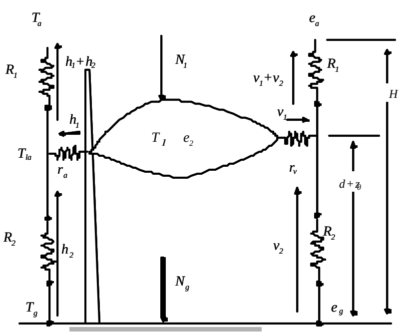

Figure 1. Resistance model.

Where, T_a, T_l and T_g are air, leaf and soil surface temperature; $e_s(T_a)$ and $e_s(T_g)$ are saturation vapor pressure at T_a and T_g; e_a and e_g are vapor pressure above plant canopy surface and at soil surface; h_1, h_2, v_1 and v_2 are sensible and latent heat transmitted from leaf surface and soil surface; R_1 and R_1 are resistances of the canopy's layer, r_a is boundary resistance, r_v is latent heat transfer resistance. N_l and N_g are net radiation on the canopy surface and soil surface. The resistance occurs in latent heat transfer is obtained with taking into account the stomatal resistance r_s, which is influenced by environmental condition, especially it is strongly affected by solar radiation and soil moisture. The relation is expressed

$$r_s = r_{min} + b / [I + b / (r_c - r_{min})] \qquad (1)$$

Here, r_{min} is the minimum stomata resistance to soil moisture changes, r_c is cuticle resistance and b is a constant. In our case r_{min} is assumed 100 sm^{-1} for irrigated condition at pF 2 and 500 sm^{-1} for unirrigated condition at pF 6. These values are due to plant response in water vapor transmission to wet and dry condition. When a different r_{min} occurs, latent heat flux density will also change which will affect sensible heat flux density compensating the surface energy balance equilibrium. The changes in sensible heat flux density consequently affect T_l, T_{la}, and T_a.

Result

The simulation results show that the changes in soil moisture condition, which changes crop resistance, affect the environment. The decreasing of air, leaf and air above the canopy top temperature are noticed, depicted in Figures 2a and 2b. These figures are the results of simulation using summer climatology data in the month of July.

In unirrigated condition, temperature tends to increase. In the other hand, when soil moisture is increased by irrigation, temperature is decreasing. The temperature difference reaches more than 2°C.

This condition takes place because of the shifting of energy balance component, mainly sensible heat flux and latent heat flux. Figure 3a and 3b shows the surface energy balance fluctuation.

From these figures we can notice that if the soil moisture increase, the latent heat flux is also increasing which is compensated by sensible heat flux.

Keywords : upland irrigation, energy balance, crop micrometeorology
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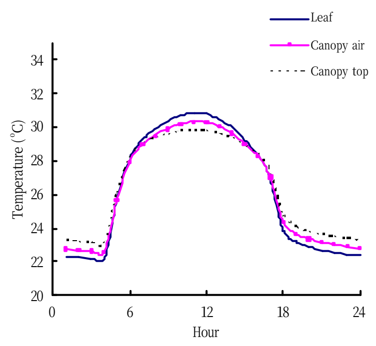

Figure 2a. Temperature fluctuation in unirrigated condition.

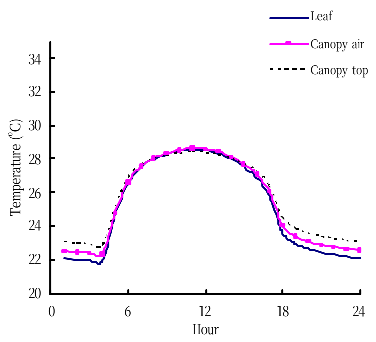

Figure 2b. Temperature fluctuation in irrigated condition

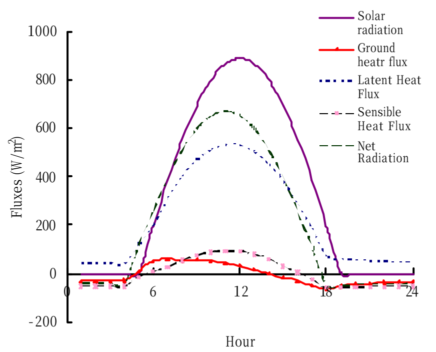

Figure 3a. Energy balance in unirrigated condition

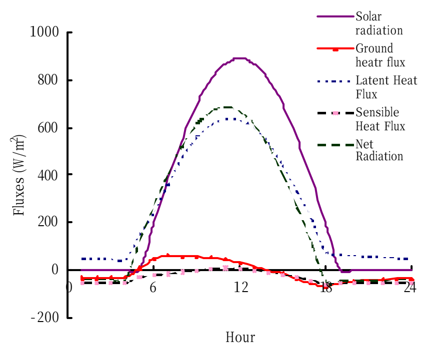

Figure 3b. Energy balance in irrigated condition

The decrease of sensible heat flux causes less energy released to warm the temperature of leaf and air. Consequently when soil surface is wet the environment temperature will be lower than if it is dry. The maximum decrease of temperature when the land is irrigated is depicted in Figure 4 for every season. Figure 5 shows the daily sensible heat flux and latent heat flux in every season, in unirrigated and irrigated condition.

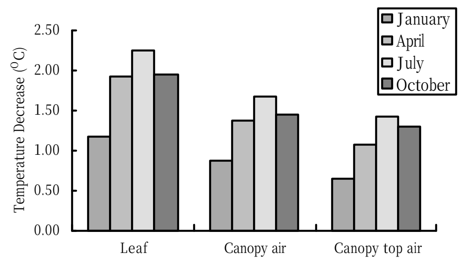

Figure 4. Maximum temperature decrease

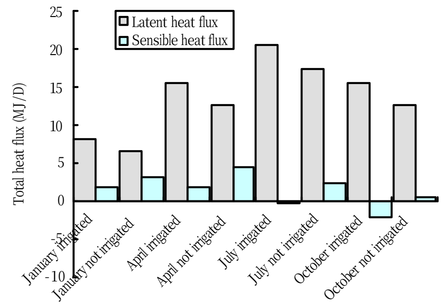

Figure 5. Daily sensible heat flux and latent heat flux

Conclusion

Soil moisture condition affects the crop response by mean of crop resistance change, which will affect the surface energy balance and temperature. When irrigation is applied to a crop field, soil moisture condition is increase, and the crop resistance is decrease and less sensible heat flux is released, which cause the lower temperature than in the dry condition. In this paper the effect of irrigation practice to the environment is shown as the lower temperature that occurs when irrigation is applied.

Refferences

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