Enhancement of Soil Moisture Preservation by Date-Palm Mulch

Chao HE*, Teruyuki FUKUHARA**, Jie SUN*** and Weimin FENG***

(Received February 6, 2009)

New use of as mulch is proposed to improve the soil moisture preservation capacity from a viewpoint of the application of unused materials to agriculture in the Middle East. This paper describes the mulch performance of the date-palm, i.e. evaporation control and suppression of soil-temperature rise associated with incoming short-wave radiation through heat and moisture transfer experiments that were conducted using soil columns and date-palm chips. One of important conclusions is that the mulch covered soil can maintain low temperature and less evaporation flux for a long time than the bare soil.

Key words: Soil-Moisture Preservation, Heat and Moisture Transfer, Evaporation

1. Introduction

In order to actually reconcile economical agriculture and securement of water resource in the Middle East, the use of soil-moisture preservation materials, which can be easily acquired in the local area, will become the key of a success for sustainable agriculture. A date-palm tree represents a botanical resource, but may have not been frequently used in an agricultural field in the Middle East and the surrounding area. In the present study, we prepared soil columns and date-palm chips as a mulch and conducted the heat and moisture transfer experiments in a constant temperature and humidity room to examine the performance of their mulch effects, i.e. evaporation control and suppression of soil-temperature rise associated with incoming

The purpose of the present study is to describe the performance of date-palm mulch effects, obtained from the heat and moisture transfer experiments.

2. Indoor radiation evaporation experiment

Dry Toyoura standard sand was packed in a column with the bulk density of about 1600 kg/m^3. An infrared lamp (125W) was emitted from a height of 0.3m on the soil surface (See Figure 1). Three kinds of mulch columns, DP1 (mulch density = mass of mulch/mulching area: 0.25kg/m^2), DP2 (0.7kg/m^2), and DP3 (1.0 kg/m^2), and other two kinds of columns, i.e. a non-treated (bare soil) column and a water column were also prepared for the experiment (See Table 1). Starting radiating the lamp and the soil temperature were measured by a thermo-couple every 15 minutes for 18 hours, and

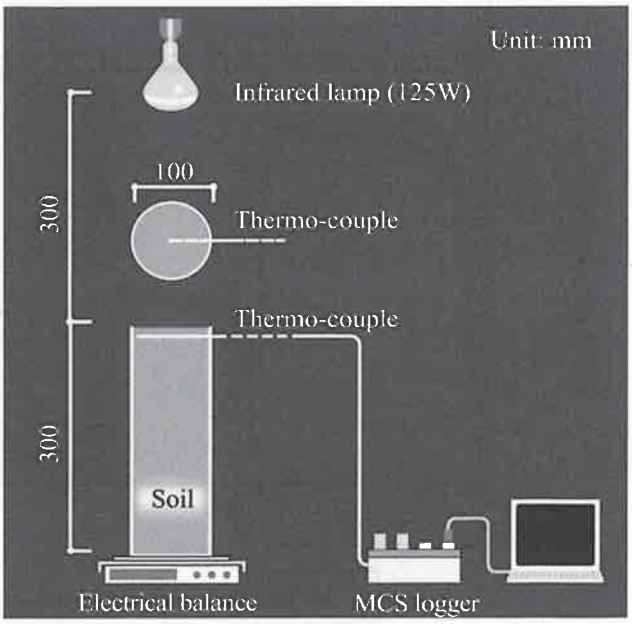

Figure 1 Experimental scheme

* Zhejiang College of Construction
** Architecture and Civil Eng. Course,
Graduate School of Engineering
*** Wuhan University of Science and Technology

Table 1 Mulch column prepared for the present experiment

Non-treated	DP1	DP2	DP3	Water
				
Mulch density of date-palm (kg/m^2)				
0	0.25	0.7	1.0	–

then watering on the soil surface was performed for 8 minutes (the amount of watering per unit soil surface area: 12.7 kg/m^2). Lighting and turning off the lamp were repeated every 12 hours for three days after watering. During this experimental period, soil temperature was measured at a depth of 5mm by a thermo-couple every 15 minutes, Each column weight was measured by an electric balance (minimum reading : 0.1g) every 1 to 6 hours to obtain the evaporation mass.

3. Results and discussions

3.1 Soil temperature control

Figure 2 shows the time variation of soil surface temperature (1cm below the soil surface). Although the mulch covered soil temperature was 2 to 3°C higher than the bare soil one before watering, all temperature levels suddenly fell down after watering, because of the sensible heat associated with watering and the latent heat of vaporization. As a result, the temperature difference among all soil columns disappeared for the first radiation and non-radiation period. In the second radiation period, however, the soil temperature became high in order of the bare, DP1 and the reminder, i.e. DP2, DP3. The bare soil temperature rose about 6°C, compared with that in the first radiation period, but the mulch covered soil temperature of DP2 and DP3 was the same as that in the first radiation period. This temperature difference between the bare soil and the mulch covered soil was attributed to the latent heat of vaporization acting on the mulch covered soil surface.

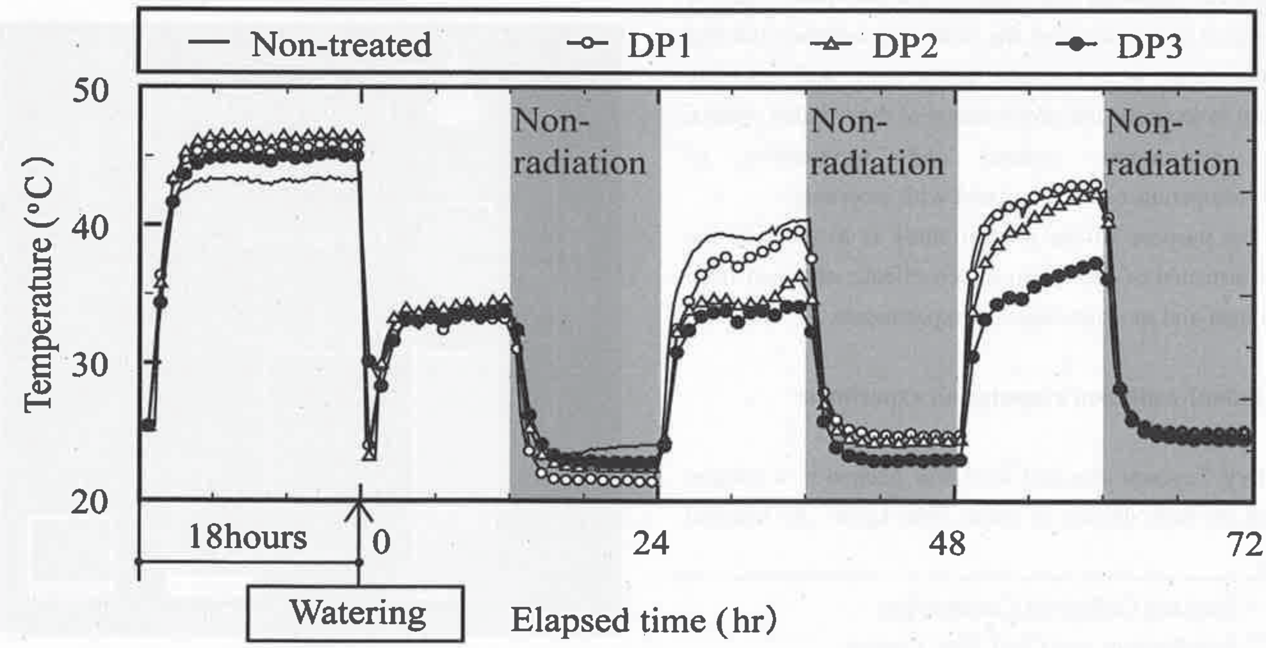

Figure 2 Time variation of soil surface temperature for different mulch columns

In other words, the bare soil surface was not wet any longer, while the mulch covered soil surface still maintained wet. In the third period, it suggested that the dryness of soil surface advanced further except the highest mulch density, DP3.

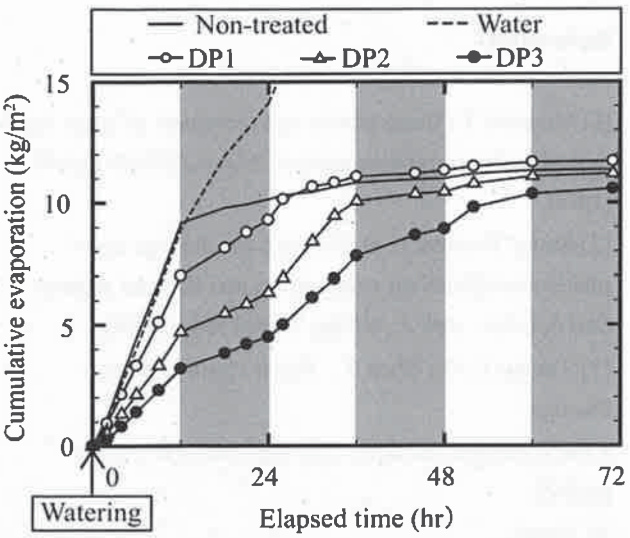

Figure 3 Time variation of cumulative evaporation for different mulch columns.

3.2 Evaporation control

Figure 3 shows the time variation of cumulative evaporation per unit soil surface area. Comparing the cumulative evaporation from the bare soil with that from the mulch covered soil, the rate of evaporation reduction due to the date-palm mulch over the first radiation period was 24% for DP1, 49% for DP2 and 65% for DP3. As the mulch density increased, the evaporation control became clear. There is almost no difference in the cumulative evaporation between the bare soil surface and water surface. The evaporation flux, i.e. time rate of the cumulative evaporation was higher for the radiation period than the non-radiation period.

Figure 4 shows the time change of the mean evaporation flux during the radiation period. In the first radiation period, the evaporation flux became small in inverse proportion to the mulch density. The evaporation flux for the bare soil and water column was higher than that for the mulch covered soil column. In the second radiation period, the evaporation flux of the bare soil fell sharply and then gradually decreased in the third radiation period. This transition implies that the

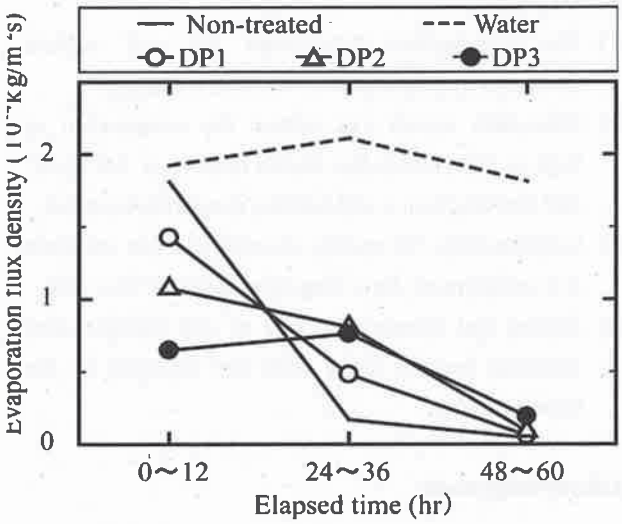

Figure 4 Time change of mean evaporation flux for different mulch columns

bare soil surface becomes desiccated. Comparing the evaporation flux of DP1 with DP2, the time rate of the diminution of the evaporation flux is higher for DP1 than DP2. However, the evaporation flux of DP3 keeps constant (steady evaporation stage) until the second radiation period. From this fact, it is implied that only the soil surface of DP3 was still wet. In the third radiation period, the transition from the constant-rate to the falling-rate evaporation stage appeared for DP3.
From the above results, drying and temperature rise of the soil surface after watering become early with the decrease in the mulch density.

4. Conclusions

We have paid attention to date-palm chips as mulch from a viewpoint of the application of unused materials to agriculture in the Middle East. Heat and moisture transfer experiments using soil columns were, therefore, conducted in a constant temperature and humidity room to examine the evaporation control and sunshade effect by mulching the date-palm chips. Four kinds of mulch density (= mass of mulch / mulching area) were designed for the experiments, i.e. 0 (bare soil surface), 0.25, 0.7 and 1.0 kg/m^2, and the evaporation flux and soil temperature were measured to examine the mulch performance.

The following conclusions can be drawn from the present study.

(1) The evaporation flux from the soil surface decreases in proportion to the mulch density.
(2) Date-palm mulch can reduce the evaporation as high as 65% when the mulch density is 1.0 kg/m^2 and can lengthen a soil surface evaporation period.
(3) Consequently, the mulch covered soil can maintain low temperature for a long time than the bare soil.
(4) Drying and temperature rise of soil surface after watering become early with the decrease in the mulch density.

Acknowledgement

The authors thank the Natural Science Foundation of Hubei for supporting this research under the grant 2009ABA290.

References

[1] Miyazaki T.: Condensation and movement of water vapor in sand under temperature gradient, *Trans. JSIDRE*: pp.1-8. (1976).

[2] Sauer Thomas J., et al.: Corn residue age and placement effects on evaporation and thermal regime, *Soil Sci. Soc. Am. J.*, 60: pp.1558-1564, (1996).

[3] Tanner C. B., Shen Y.: Water vapor transport through
a flail-chopped residue, *Soil Sci. Soc. Am. J.*, 54: pp.945-
51, (1990).