Effect of soil crust on evaporation and water infiltration

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1. Introduction

Soil water cycle plays an important role in the water cycle as the hydrologic cycle. Soil water evaporation and infiltration into the soil significantly affect the soil moisture content, soil temperature, substances in soils, soil chemical and physical properties, etc. Chemical and physical crusts are inorganic features such as a salt crust or platy crust, often formed by desiccating or trampling. Soil crusts such as a stiff thin layer on the soil surface may change soil properties and control evaporation from the soil surface and infiltration into the soil. Many studies have reported the effects of soil crust on evaporation from the soil surface. For example, Wang S et al.[1)] showed that the soil crust enhanced evaporation flux. On the other hand, Eldridge and Greece[2)] pointed out that the soil crust possibly reduced evaporation flux.

In order to make a reliable heat, mass and solute transfer model, it is important to study about the effects of soil crust on evaporation and infiltration across the soil surface.

The objective of this study is to describe and show whether soil crust has a significant influence on the evaporation and infiltration rate through an indoor experiment using soil columns.

2. Experimental equipment and method

2.1 Evaporation experiment

Fig. 1 shows the schematic view of evaporation experiment. The experimental equipment consists of a soil column made of vinyl chloride with 0.079m in diameter and 0.05m in height, an infrared heat lamp (250W) and an electric balance with a minimum reading of 0.01g. An evaporation experiment was conducted by the following procedure: (1) Chao soil was packed in a column (Column A) with the dry soil bulk density of 1550kg/m³ then the soil column was filled with fresh water. (2) Radiative energy from the heat lamp was emitted from a height of 0.3m above the soil surface. (3) The soil crust was identified with a microscope and removed after 31hours of radiation exposure. (4) After that, the evaporation experiment was continued for 129hours until the soil was completely dry.

The evaporation flux was calculated from the time decrement of the weight of the soil column measured with the electric balance. The thickness of the crust was measured by means of the microscope with 200×magnification. The density of soil crust, ρ_{crust}, was calculated using a specimen removed from the soil surface.

2.2 Infiltration experiment

In addition to the column A, another column (Column B) with 0.06m in height was used in an infiltration experiment. The column was filled with fresh water and Chao soil, and then the same evaporation experiment described in **2. 1** was

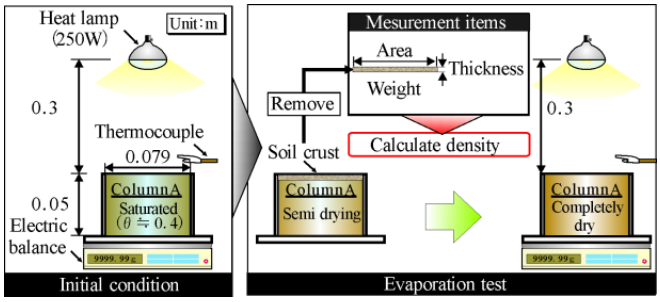

Fig. 1 Schematic view of evaporation experiment

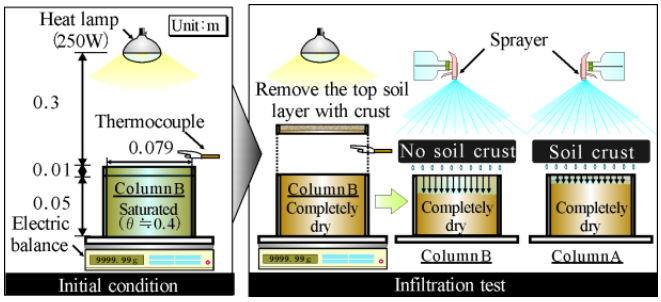

Fig. 2 Schematic view of infiltration experiment

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carried out until Chao soil was completely dry. The soil crust was formed on the soil surface at the end of the experiment. Thus, the infiltration experiment was started by the following procedure: (1) The surface layer with soil crust was removed flatly. (2) Watering on the new soil surface (no crust) was performed with a sprayer for thirty-five minutes. The same watering was also carried out on the soil crust (soil surface) in the column A used in the evaporation experiment, simultaneously. (3) The depth of infiltration, D_i, was measured by means of a digital video camera with high resolution every two minutes.

3. Results and discussions

3.1 Schematic views of soil crust

Fig. 3 shows the schematic soil surface and an enlarged views of the soil crust for the column A at elapsed time of 31hours (t=31hours). The thickness of the soil crust, H_{crust}, was 0.5mm on average and ρ_{crust} was 1430kg/m^3.

3.2 Evaporation

Fig. 4 shows the time variation in the cumulative evaporation per unit soil surface area $\sum Q_v$ (kg/m^2). The evaporation flux, q_{ev} ($=d\sum Q_v/dt$), increased by 13% due to the removal of the soil crust at t =31hours (compare the gradients of the two straight lines in the enlarged view). It is seen that the soil crust with 0.5mm of H_{crust} reduces the evaporation from the soil surface.

3.3 Infiltration

Fig. 5 shows the time variation in D_i. The triangle and circle plots express D_i for the column A, D_{iA} (soil crust) and D_i for the column B, D_{iB} (no soil crust), respectively. Both of D_{iA} and D_{iB} increased linearly during $t \leqq$ 35minutes. The beginning of infiltration for the column A was four minutes later than that for the column B due to the soil crust.

4. Conclusions

The experimental results showed that the soil crust with 0.5mm in thickness has a weak resistance to the evaporation and water infiltration from the soil surface.

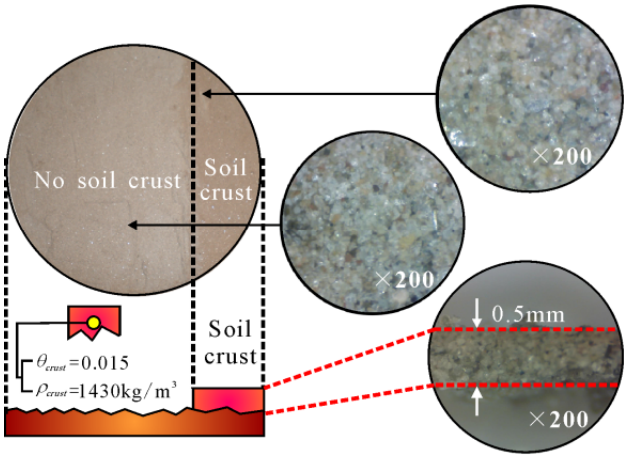

Fig. 3 Schematic and enlarged views of soil surface and soil crust

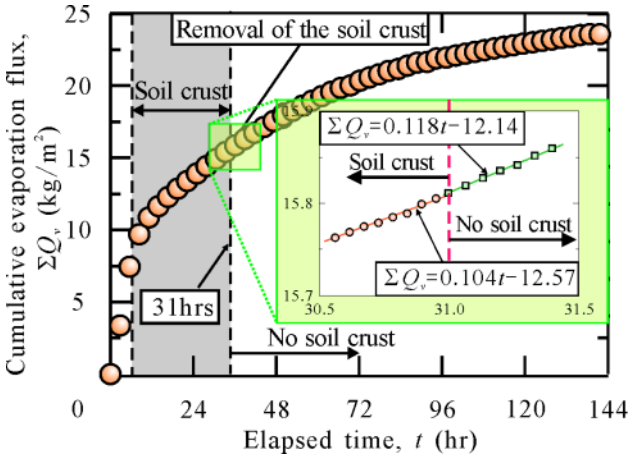

Fig. 4 Time variation in cumulative evaporation flux

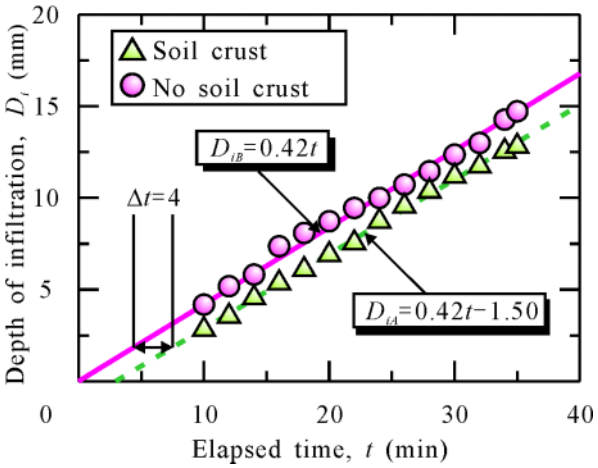

Fig. 5 Time variation in depth of infiltration

References

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