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EFFECTS OF THE CROP ROOT ON THE SOIL PHYSIC PROPERTIES AND SOIL WATER TRANSPORT ENVIRONMENT

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ABSTRACT The objectives of this study are to clarify the effects of the crop root on the soils physical properties and soils water transportation environment. The water retention and conductivity of soil samples which contain the crop roots are clarified by estimating the soil moisture characteristic curves by a one-step method. The water retention and conductivity of the soil can be quantified with crop root content. The experimental results indicate that the saturated water content increases with the crop root content because of the porosity generated by the crop root. The soil water transport is simulated considering the crop root effect on the soils physical properties. To verify the simulation models accuracy, field observations were conducted. The simulated matrix potential has good agreement with the measurement. Using this model, the soil moisture content distribution was simulated. The simulation results indicate that the soil moisture content in the plot with high crop root content is quite high. After irrigation, high water content in the plot around crop root is maintained. The simulation result indicates that the crop root is effective at retain the soil water around crop root zone.

Keywords: soil water retentivity and conductivity, soil water conductivity, simulation model, soil surface evaporation

INTRODUCTION The soil water retentivity and the hydraulic conductivity affect the soil water transport in the crop field. In the soil of the crop field, the pores are generated by root physiological activities, including the growing, water absorption, and so on. The change of the soil structure affects the soil physic properties, including the soil water retentivity, and the hydraulic conductivity. The changes of the soil physic properties bring changes of the mechanism of the soil water transport. The studies to clarify the soil water movement in the crop field have been conducted to quantify the water consumption in the crop field (Yuge *et al*.:2005a, 2005b). However a method to evaluate soil water movement considering the root effect on the soil physic properties has not established yet. The objectives of study are to clarify the effects of the crop root on the soil physic properties and soil water transport environment

METHODOLOGY To estimate the soil water transport considering the crop root effect on the soil water retentivity and the hydraulic conductivity, a simulation model is introduced. The governing equation describing the soil water transfer can be described as follows:

$$\rho_w \frac{\partial \theta}{\partial t} = \frac{\partial}{\partial z}\left[k_z \left(\frac{\partial \psi}{\partial z} + g\right)\right] + \frac{\partial}{\partial x}\left[k_x \frac{\partial \psi}{\partial x}\right] + r_w \qquad (1)$$

where g is the gravity acceleration, k_x is the hydraulic conductivity at x direction, k_z : the hydraulic conductivity at z direction, t is the time, γ_w is the sink, θ : is the volumetric water content, ρ_w is the water density, Ψ is the matric potential.

Figure 1 shows the simulation model describing the water transfer in the soil. To solve the two-dimensional transfer of water, the finite-differential method is used. As the bottom boundary condition, the soil water potential is set as constant. The matric potential and hydraulic conductivity are set considering the root content for an interior node. The sink is set using the transpiration rate.

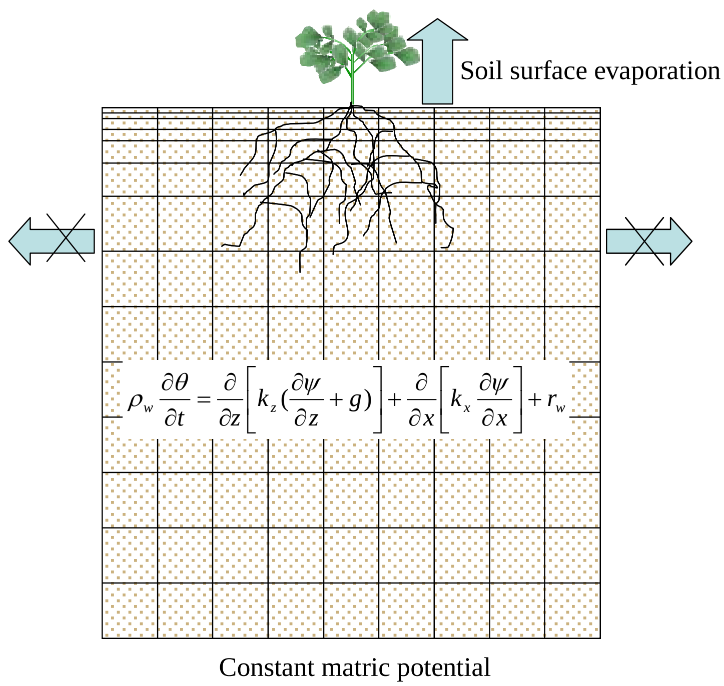


Figure 1. Schematic view of the simulation model.

EFFECTS OF THE CROP ROOT ON THE SOIL PHYSIC PROPERTIES To evaluate the effect of the crop root on the soil water retentivity and conductivity, the field observation is conducted. Fugure 1 shows the condition of the field experiment. A soybean is planted in the acrylic slit pot, at the size of the 0.45m × 0.6m × 0.1m. The ballasts are paved at the bottom of the acrylic slit pot, and the weathered granite soil is filled at the depth of 0.48m. After plant growing, the soil containing the root is sampled at the depth shown in Figure 3. Using these samples, the soil water retention curves are estimated by suction plate method, and the root content are measured.

Figure 4 shows the relationship the soil water retention curves and the crop root content. This figure indicated that the soil water retentivity vary with the root content of the soil sample. The soil water retention of the sample containing the root is high in the high volumetric water content zone. The differences of the soil water retentivity become smaller when the matric potential is over 10 cm.

Figure 5 shows the hydraulic conductivity estimating by the one-step method. This figure indicates that the difference of the hydraulic conductivity is relatively small comparing the soil water retentivity.

Figure 2. Field experiment condition.

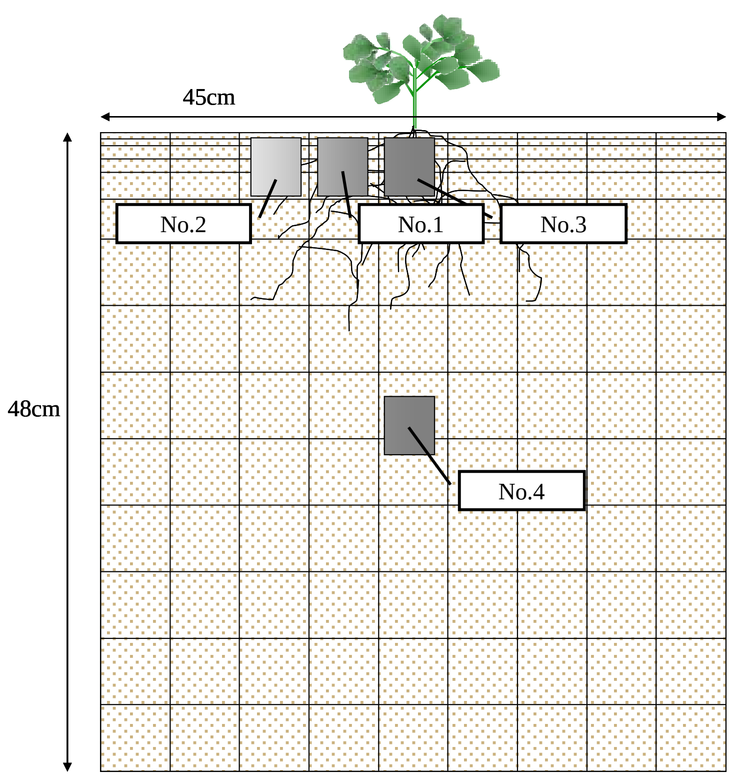


Figure 3. Soil sampling.

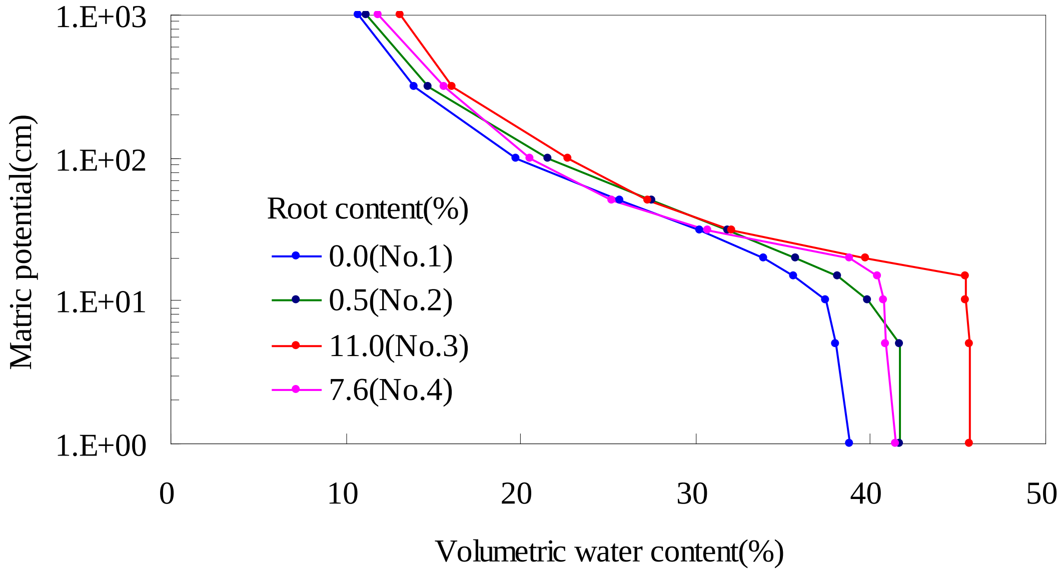


Figure 4. Relationship between the soil water retentivity and the root content.

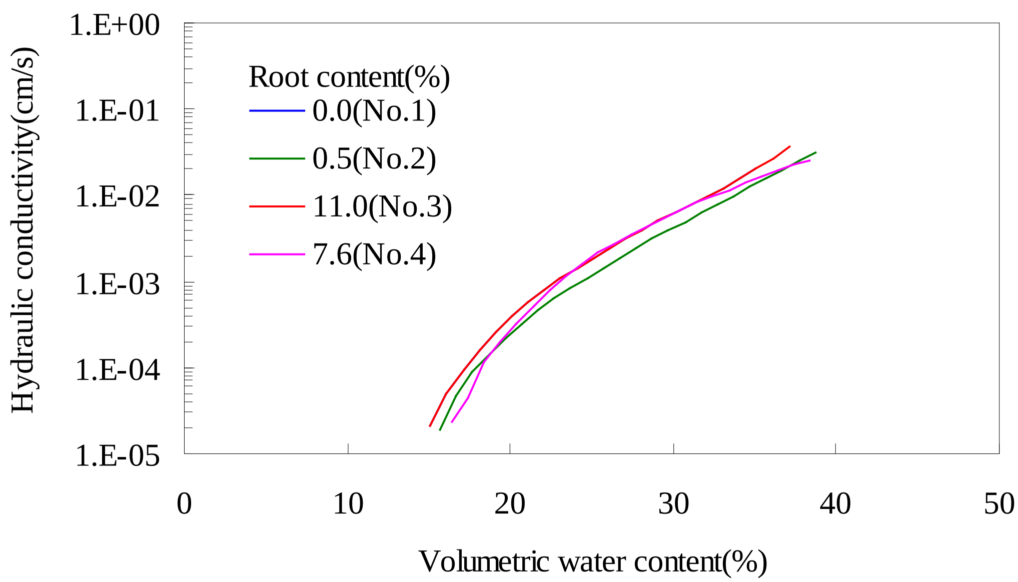


Figure 5. Relationship between the hydraulic conductivity and the root content.

MODEL ACCURACY To verify the accuracy of the simulation model shown in Figure 1, an experiment is conducted using the slit shown in Figure 2. Matric potentional is measured at 5cm, 15cm, and 35cm depth using tensiometers. The root content is estimated using the photograph shown in Figure 6. The root content is quantified in 10cm ×10cm meshes. Figure 7 shows the distribution of root content. Using this result, the matric potential and the hydraulic conductivity at the nodes shown in Figure 1 is determined using the Figure 4 and Figure 5, considering the root content. After 5 minute irrigation, 44mm/h, the matric potential is estimated using the simulation model. Figure 8 shows the comparison of the simulated and observed matric potential. The simulated result has good agreement with the measurement.

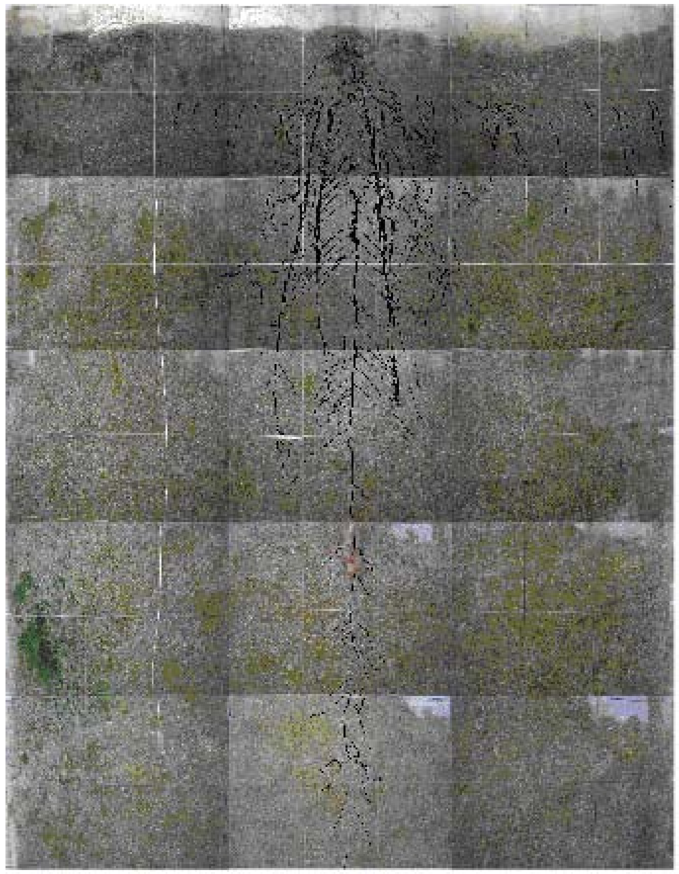


Figure 6. Condition of the root zone in the slit

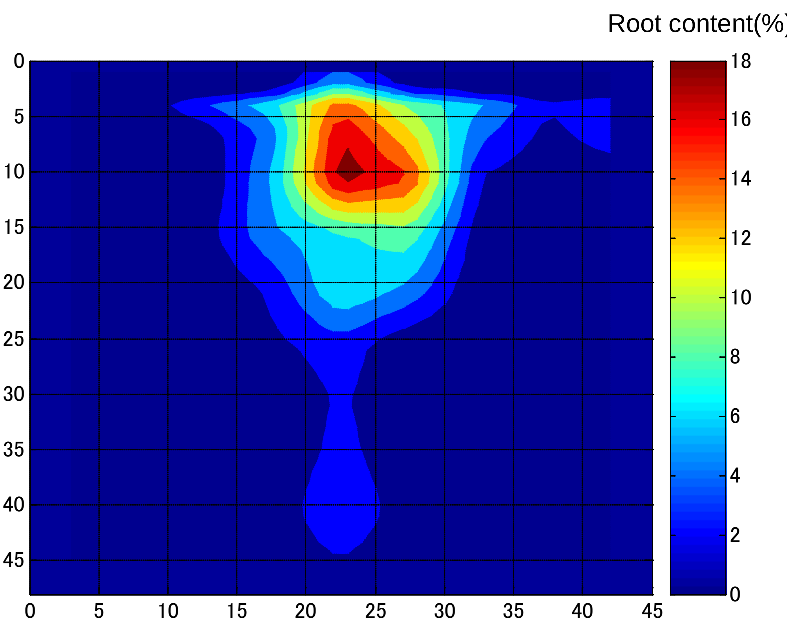


Figure 7. Distribution of the root content.

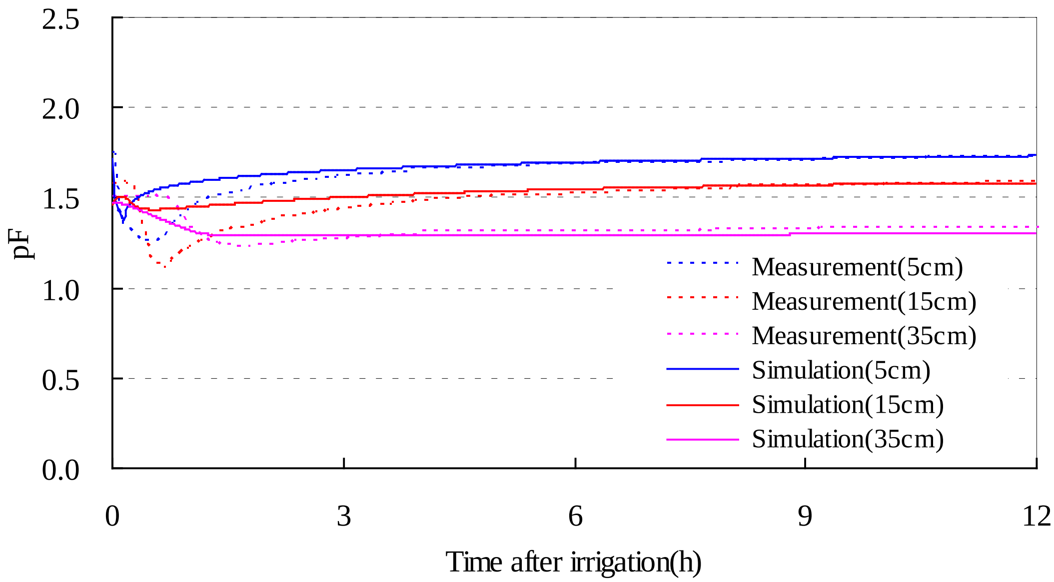
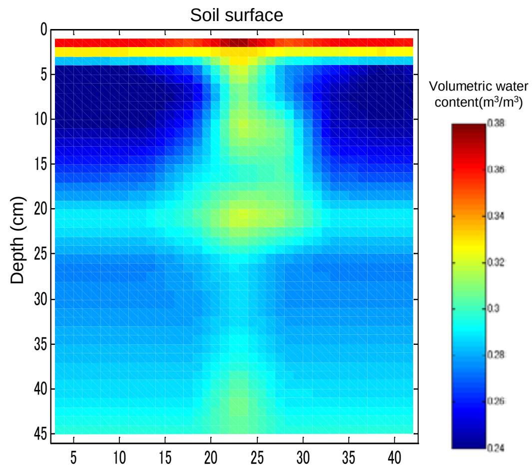
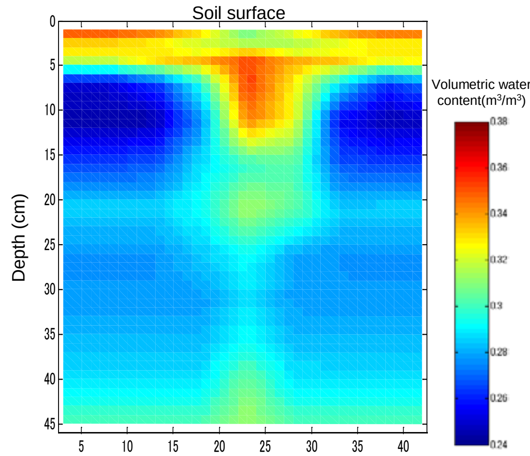


Figure 7. Distribution of the root content.

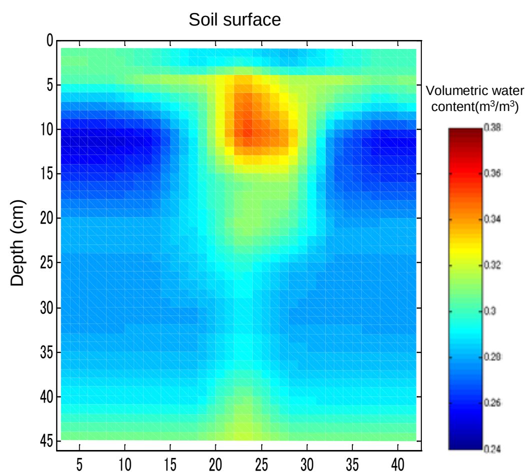
TEMPORAL AND SPARTIAL CHANGES OF VOLUMETRIC WATER CONTENT Using the simulation model, the temporal and spatial changes of the volumetric water content in the soil is estimated. After irrigation, the water movement from the soil surface can be described. After 10 minute from the irrigation start, as the irrigation is finished, the soil surface starts dry. After irrigation, the volumetric water content is high in the layer where the root content is high. This result indicates that the soil water retentivity is higher because of the root effect shown in Figure 4. The irrigation water supplied to the soil remains around the high root content layer after 12 hour after irrigation.



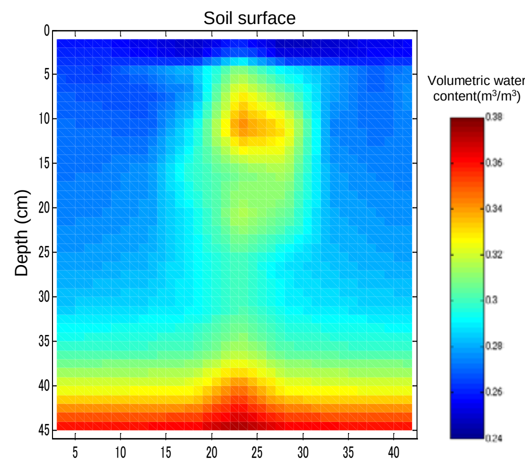
(a) 1 minute after irrigation



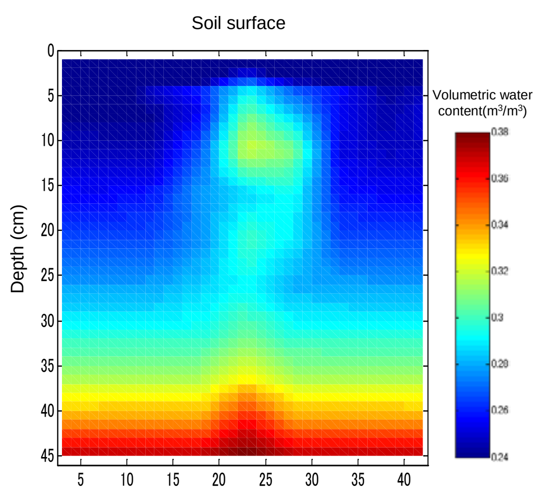
(b) 5 minute after irrigation



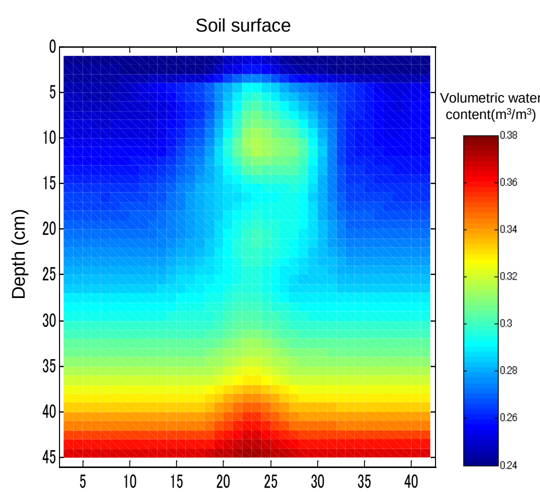
(c) 10 minute after irrigation



(d)1 hour after irrigation



(e)6 hour after irrigation



(e)12 hour after irrigation

Figure 8. Temporal and spatial changes of the volumetric water content

CONCLUSIONS To clarify the effects of the crop root on the soil physic properties and soil water transport environment, a simulation model considering the root effect on the soil water retentivity and the hydraulic conductivity is introduced, and a field experiment is conducted to evaluate the root effects on the soil water retentivity and the hydraulic conductivity. Soybean is planted in the acrylic slit pot and the soil containing the root is sampled to measure the soil water retentivity and the hydraulic conductivity. The soil water retentivity varies with the root content of the soil sample. The soil water retention of the sample containing the root is high in the high volumetric water content zone. The differences of the soil water retentivity become smaller when the matric potential is over 10 cm. The difference of the hydraulic conductivity is relatively small comparing the soil water retentivity. To verify the accuracy of the simulation model, matric potential is measured at 5cm, 15cm, and 35cm depth in the slit, and the root content is estimated using the photograph. The simulated result has good agreement with the measurement. Using the simulation model, the temporal and spatial changes of the volumetric water content in the soil is estimated. This result indicated that the irrigation water supplied to the soil remains around the high root content layer for long period after irrigation. The method introduced here is effective to evaluate the soil water transport and water consumption considering the root effect on the soil water retentivity and hydraulic conductivity.

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