塩水灌漑条件下における水価格を考慮した灌水量の決定
Determination of Irrigation Depth considering the Cost for Water under a Saline Condition

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Introduction

We have presented a new scheme, "optimized irrigation", in which irrigation depth is determined such that net income considering the price of water and weather forecasts during each interval is maximized using WASH_1D/2D which are numerical simulation models of water flow and solute transport in soils and crop growth. To evaluate whether the optimized irrigation is also able to restrict salinity stress and avoid salinization without any intentional leaching, we carried out an irrigation experiment.

Materials and methods

A variety (Sanuki) of Fababaen was grown in a greenhouse in Tropical Agriculture Research Front of Japan International Research Center for Agirucultural Sciences using a drip irrigation system whose emitter distance was 20 cm and lateral spacing was 70 cm. On November 19, seedling were transplanted below each emitter after exposing natural rain for six months. Three treatments were established: F: irrigated with fresh water using an automated irrigation system using two soil moisture sensors, ARP WD5-WET-SDI, installed below 10 cm, C: same as above but irrigation water contained NaCl at 1 g/L and leachings with 16 mm were carried out when the salinity of soil solution reached at 3 g/L, O: irrigation depth was determined with the scheme and 1 g/L NaCl solution was used for irrigation water. Each treatment had three replicates. To evaluate if WASH_2D can predict water flow and solute movement under such a condition, soil moisture and salinity sensors, ARP WD5-WET-SDI, were installed at the depth of 10 and 40 cm below emitter. The same amount of liquid fertilizer was applied to each treatment at a constant daily rate.

Results and Discussion

Time evolution of cumulative irrigation is shown in Fig.1. Treatment O received the largest amount owing to overestimation of basal crop coefficient. Treatment C received the smallest in the final stage possibly because of low transpiration owing to salinity stress. Figure 2 compares net income at a producer price of 1 $/kg, a fresh water price of 0.1 $/m^3, a saline water price of 0.05 $/m^3 and fixed miscellaneous costs at 300 $/ha. Treatment F gained the highest gross income owing to the highest yield (0.84 t/ha). Treatment C gained the lower yield but comparable net income as F owing to cheaper price of water. Treatment O had the lowest yield probably caused by nutrient loss owing to over irrigation.

Regarding the accuracy of simulation, fair agreement between observed and simulated water contents are shown in Fig.3 while the underestimation of water content was widened as time erapsed, implying that the transpiration

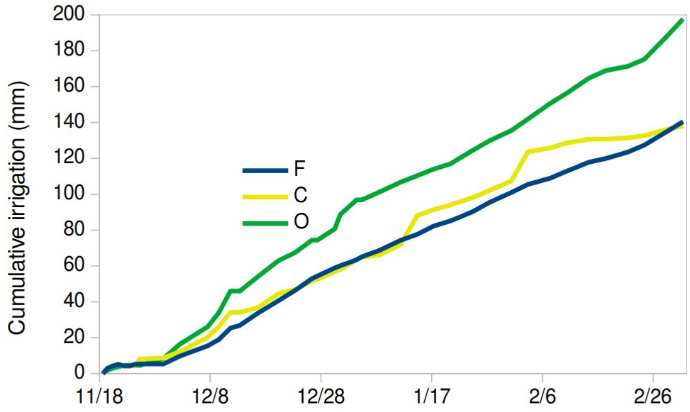

Fig.1 Comparison of cumulative irrigation

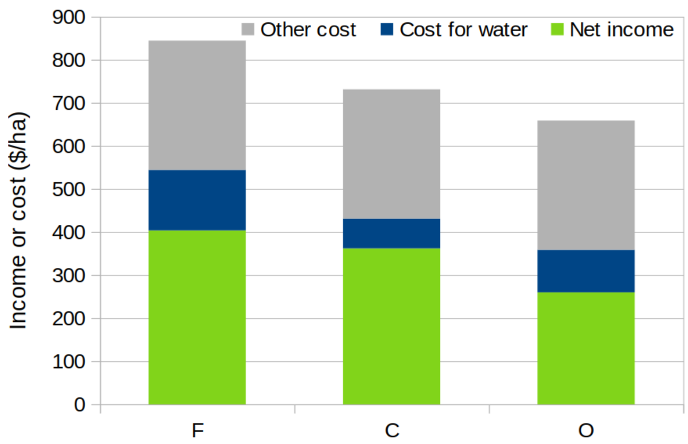

Fig.2 Comparison of net income

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was overestimated. On February 12, a 151 mm of rain occurred and groundwater rise may have occurred then. That effect was not incorporated in the simulation. As for the salinity of soil solution, fair agreement between observed and simulated values were obtained for the depth of 10 cm, but the numerical solution overestimated at the depth of 40 cm after January 26th when "salt front" reached to the depth in the simulation. This further indicates that the model overestimated root water uptake. We used a basal crop coefficient as a function of cumulative transpiration, but it should have been as a function of day after sowing at least after maturity stage. In addition, the "salt front" may have even been pushed back to upward owing to the groundwater rise.

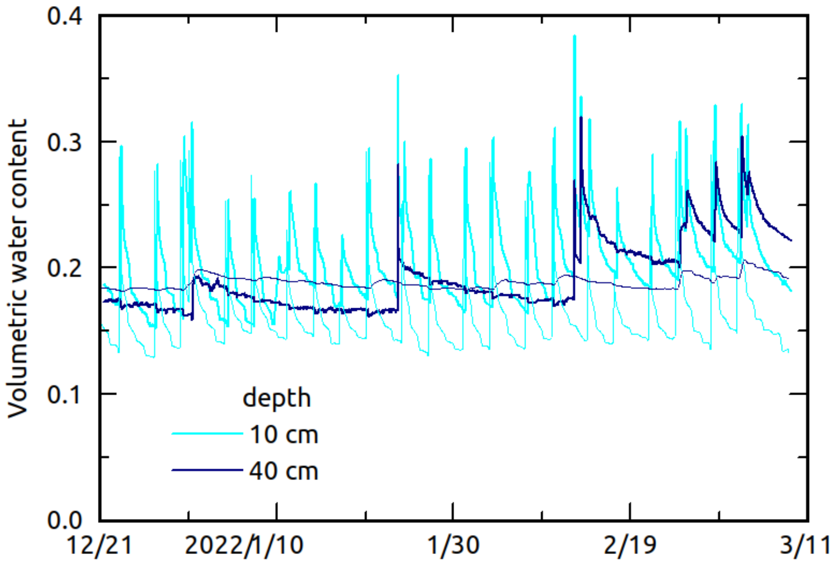

Fig. 3 Time variation of water content under the drip tube for treatment O.
Thick lines represent observed ones while thin ones are simulated.

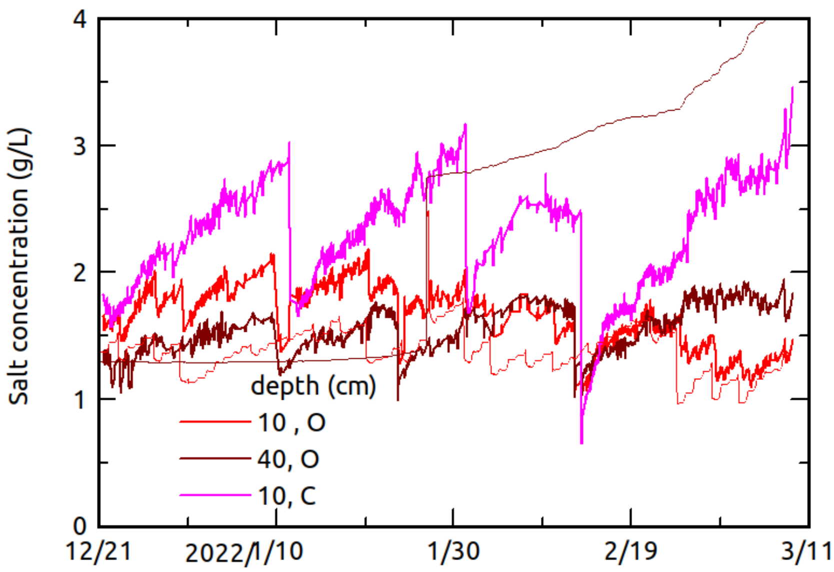

Fig.4 Time variation of the concentration of soil solution under the drip tube.
Thick lines represent observed ones.