塩水灌漑条件下における水価格を考慮した灌水量の最適化

Optimization 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

Potato (Nishiyutaka) was grown in a greenhouse in Arid Land Research Center, Tottori University, using a drip irrigation system whose emitter distance was 20 cm and lateral spacing was 60 cm. On September 18, seed potatoes were sown below each emitter after leaching with more than 200 mm. Three treatments, were established: 1) irrigated with fresh water using an automated irrigation system using two tensiometers installed below 10 cm (F), 2) same as above but irrigation water contained NaCl at 1 g/L (C), 3) irrigation depth was determined with the scheme. 1 g/L NaCl solution was used for irrigation water (O).

Each treatment had three replicates. After October 6, irrigation using the saline water started for treatments C and F. To evaluate if WASH_2D can predict water flow and solute movement under such a condition, soil moisture and salinity sensors, ARP WD3-WET-5Y, 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.

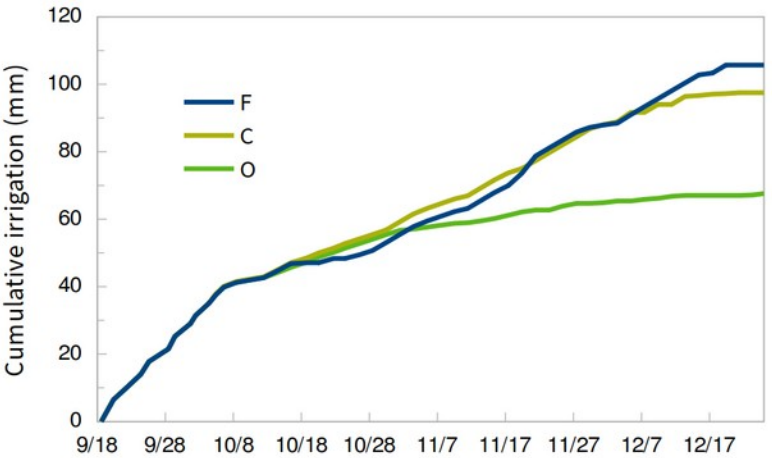

Fig. 1 Comparison of cumulative irrigation

Results and Discussion

Time evolution of cumulative irrigation is show in Fig.1. Treatment F received the largest amount owing to the largest transpiration rate without any stresses. Since we set a low suction (50 cm) for securing the occurrence of leaching for treatment C, it received amounts close to F even though plants were imposed to moderate salinity stress. Treatment O received the lowest amount because we set high water price at 0.25 $/m^3$ for the saline water. Figure 2 compares net income under producer price of 1 $/kg and fixed miscellaneous costs at 500 $/ha.

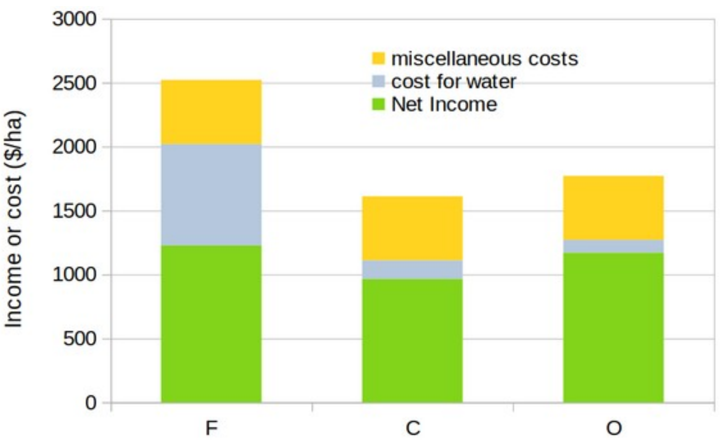

Fig.2 Comparison of net income

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Treatment F gained the highest gross income owing to the largest yield (2.5 tFW/ha). Treatment C gained the lowest income and yield in spite of larger total irrigation amount than treatment O. The leaching of nutrients caused by over irrigation and lower transpiration as treatment F might be attributed to his low yield. If we set a 5 times high water price for the fresh water, net income of treatment O was almost the same as that of treatment F.

Fair agreement between measured and simulated water contents are shown in Fig.3. Measured water contents at the depth of 10 cm in latter half season are not plotted because the growing tuber may have cause over-estimations of water content. Regarding the salinity of soil solution, fair agreement between measured and simulated values were obtained for the depth of 10 cm, but the numerical solution consistently underestimated at the depth of 40 cm. This indicates that more leaching to deeper layer and/or larger root water uptake at deeper layer might have occurred. Unused ions of liquid fertilizer may have partly caused this “underestimation”.

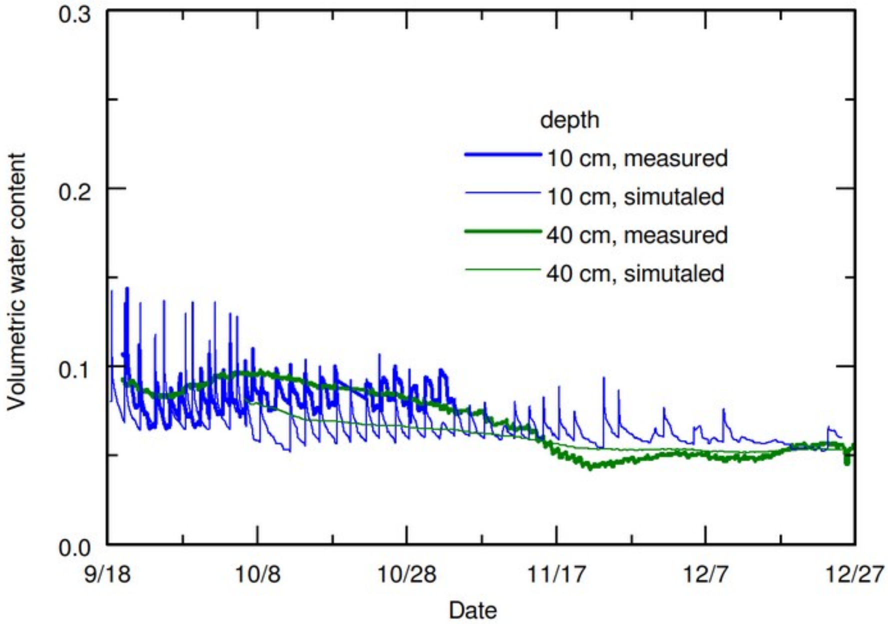

Fig.3 Time variation of measured and simulated water content below plant row

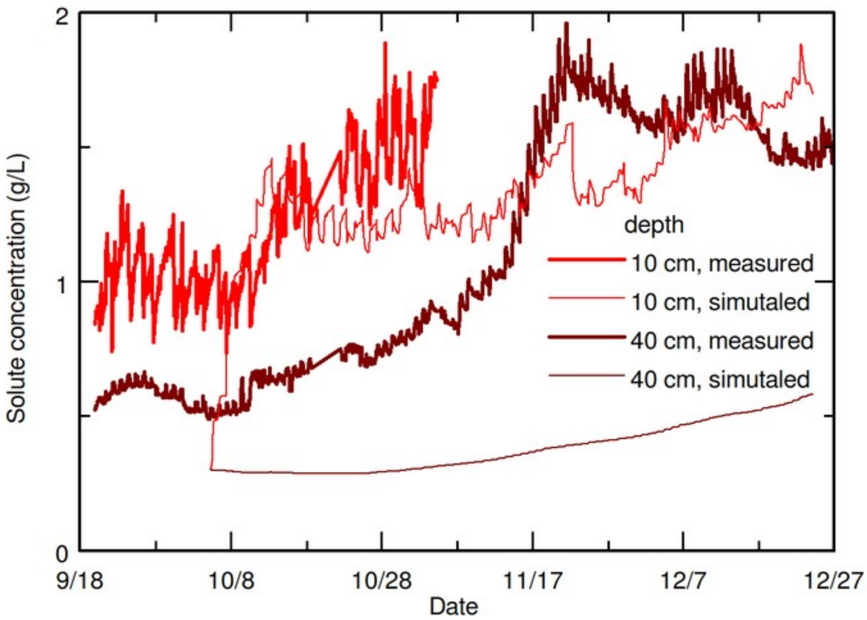

Fig.4 Time variation of measured and simulated concentration of pore water.