Numerical Analysis of the Effects of Capillary Barrier under Subsurface Drip Irrigation to Improve Water-use Efficiency

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In semi-arid and arid regions, efficient water-use in agriculture is crucial. The installation of the capillary barrier (CB) has been suggested as a promising approach for such a purpose. CB reduces deep drainage by suppressing the downward water movement. The downside of CB is that it may enhance surface evaporation by keeping irrigated water near the surface (Wongkaew *et al.*, 2018). One of the remedies to water loss by evaporation is to use subsurface drip irrigation (SDI) techniques. However, there are few studies on its feasibility in a system with CB. This study aims to evaluate the feasibility of CB under SDI numerically. The effects of the installation depths of the emitter and CB on water use efficiency were also investigated. In this study, the ring-shaped emitter was used because of its high performance and affordability (Saefuddin *et al.* 2019). HYDRUS (2D/3D) (Simunek *et al.*, 2016) was used to simulate water flow and root water uptake (RWU).

The emitter was installed at 10 different depths within the root zone. CB was installed at 5 different depths below the root. Strawberry and spinach were selected as model plants for the long-root and short-root plants because of their distinct root distributions. The installation depths for the emitter and the CB layer were defined relative to the root depth. The objective function (*OF*) was introduced to evaluate water-use efficiency. Uniform soil water pressure of -80 cm was applied to the Tottori Dune sand profile as the initial condition. The potential evaporation rate was set as 7.0 mm d^{-1}. The bottom boundary condition was set as gravity flow. Durner (1994) model was used to account for capillary flow and non-capillary type flow. RWU was simulated by the compensated model (Šimůnek and Hopmans, 2009).

For the long-root plant (strawberry), the peak of the *OF* value was obtained when the emitter was slightly above half the root depth and CB was inserted immediately below the root, which were found to be the optimal depths. This appears to be the result of the trade-off between active RWU near the surface and intense evaporation from the wetted ground surface. Smaller *OF* values were obtained for shallow-root plants when the emitter is near the surface. The water applied at a shallow depth might increase actual evaporation by wetting the upper layer. The best CB depth was found to be far below the root in this study. Installing CB shallowly may lead to an increase in evaporation and the breakage of CB due to the water accumulating upon CB.

References

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