Geophysical Research Abstracts
Vol. 16, EGU2014-6756, 2014
EGU General Assembly 2014
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Improving irrigation efficiency of sandy soils by subsurface water retaining membranes

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Sustainable crop production in sandy soils is challenging due to low soil water holding capacity and high water permeability. The subsurface water retention technology (SWRT) is a relatively new long-term approach that offers precision control of water and nutrients in the root zone. However, multiple design of SWRT membrane configurations and spatial distributions require more modeling for best application in arid regions with relevant irrigation methods. The objective of this study was to define optimal geometric parameters of the SWRT membranes and the most accurate irrigation rates for corn production in sandy soils. HYDRUS-2D model, that describes two-dimensional water flow in unsaturated soil, was calibrated and validated on data in a large sand-filled lysimeter with SWRT membranes installed at different depths with different aspect ratios. The model adequately reproduced soil water content dynamics measured at 12 locations inside the sand profile. Then HYDRUS-2D simulations were repeated with different SWRT installation depths and aspect ratios. The installation depths in these simulations were 20 cm, 40 cm, and 60 cm, while the aspect ratios were 2:1, 3:1, 5:1 and 10:1. The results of simulations confirmed water holding capacity of the soil can be differentially controlled by aspect ratios of SWRT membranes. SWRT membranes with an aspect ratio of 2:1 substantially increased soil water content at 20-cm soil layer above the membrane, and this effect diminished with increasing aspect ratio of the membrane. Installation depth within the soil profile had no significant effect on water loss. The HYDRUS-2D simulations were repeated with SWRT installed at depth of 20 cm for sprinkle, surface drip and subsurface drip irrigation. Corn irrigation was triggered at pressure head of -30cm at a depth of 15 cm for all irrigation techniques. Simulated water losses by deep infiltration in sands without SWRT membranes approached 60% with approximately 15% losses when SWRT membranes were installed at depths below the root zone. Irrigation technique did not affect water losses in the simulations, because most of the irrigated water accumulated inside of the SWRT membranes regardless of location of the water supply. Overall, SWRT appeared to be a promising technology for precision water control in the plant root zone and for minimizing water and nutrient losses during deep infiltration.