Improving Soil Water Retention by Subsurface Water Retaining Membranes (SWRT)

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Outline

- Experimental study of water movement in a sand box with installed SWRT.
- Understanding effects of SWRT on soil water redistribution.
- Calibration and validation of HYDRUS-2D model on experimental data.
- Evaluating the effect of the installation depth and aspect ratios (width to depth) of the SWRT membranes on vertical water fluxes and distribution of soil moisture.

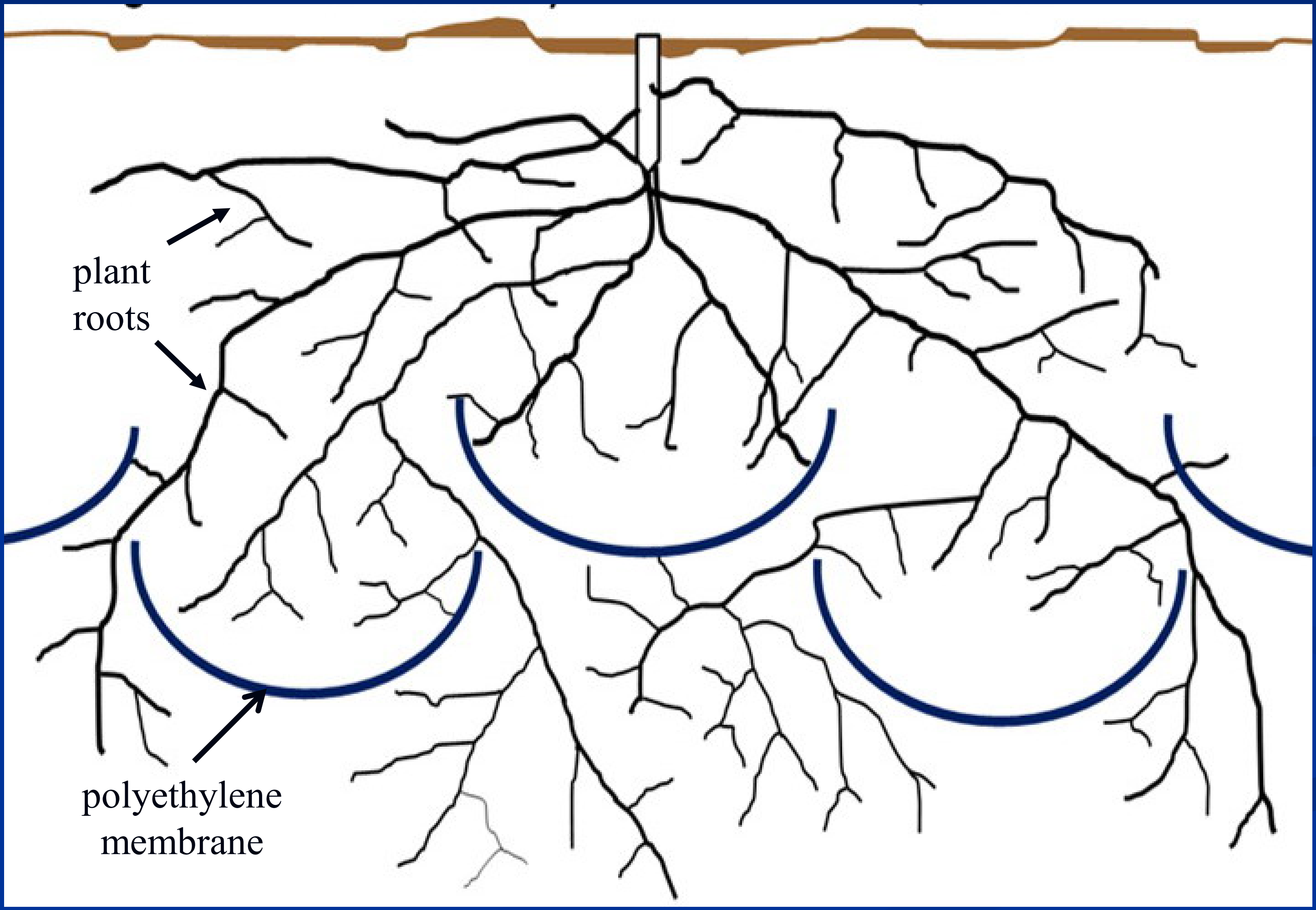
Why SWRT

1. Constantly increasing demands in water consumption by agriculture associated with growing world population:
    - agriculture accounts for roughly 70% of water use
    - by 2030 we will need 30% more water

2. Overall reduction of water sources suitable for irrigation.

3. Subsurface Water Retention Technology (SWRT) is a new technology for ameliorating plant drought that increases irrigation efficiency by keeping water in the root zone.

How does it work?



SWRT: a dream or reality?

Installing SWRT water saving membranes in the sand in the semi-arid regions of West Texas High Plains

Promoted growth and yield of irrigated maize growing on SWRT water and nutrient saving membranes

June 29, 2012 in East Lansing, Michigan

Non- drought stressed corn Plot

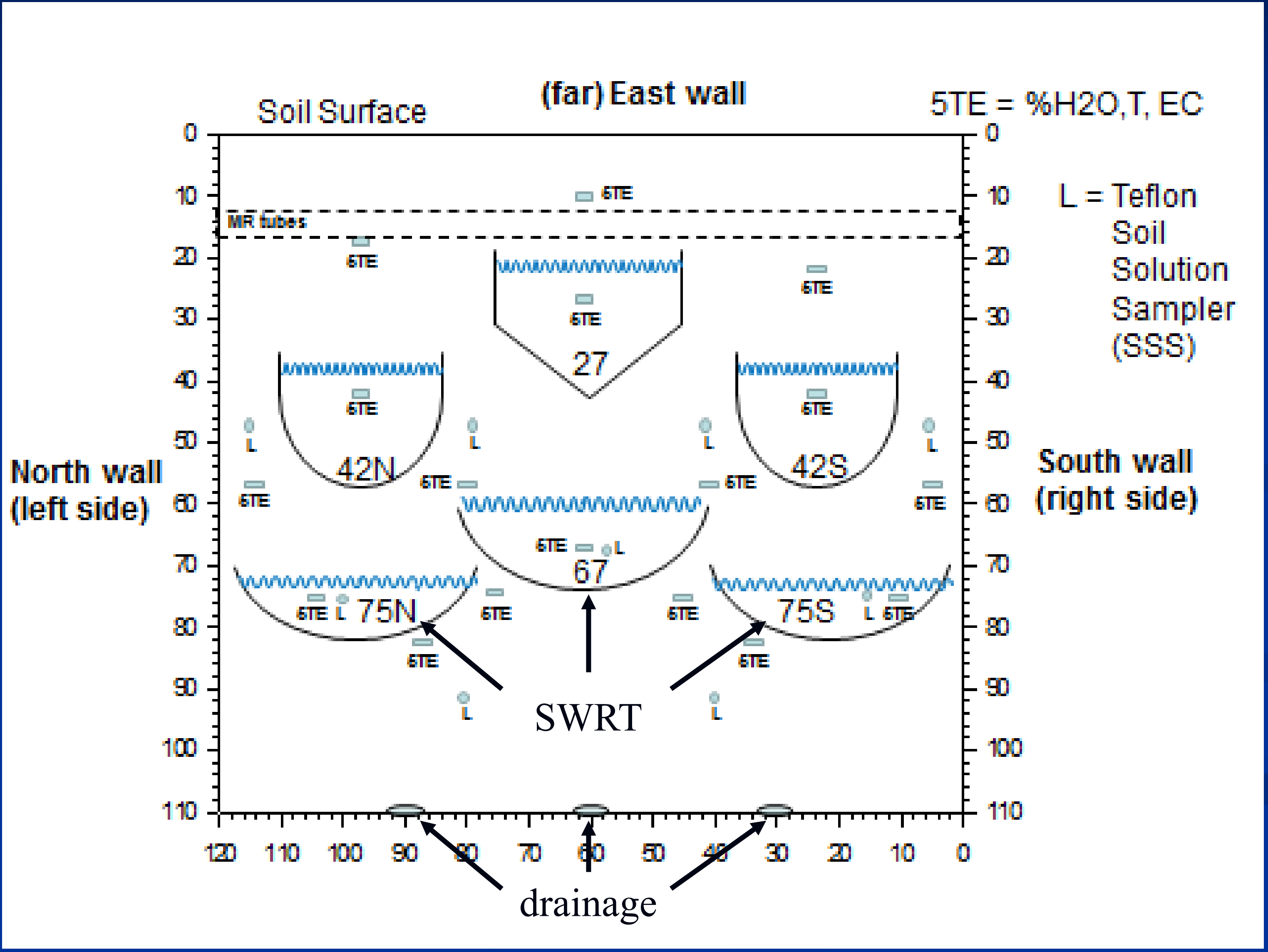
Drought stressed corn Plot

17,109 Kg/ha
SWRT corn grain

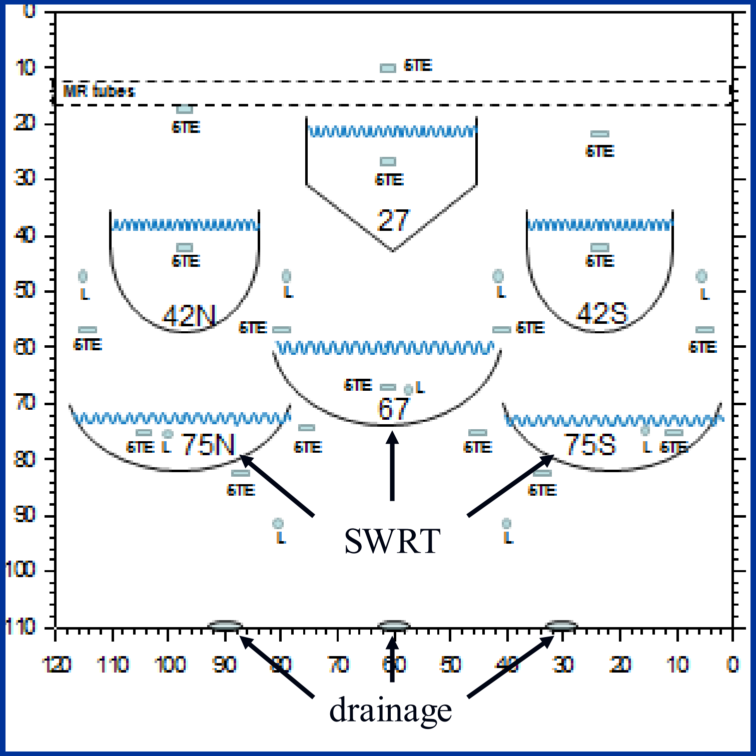
9,831 Kg/ha
Control corn grain

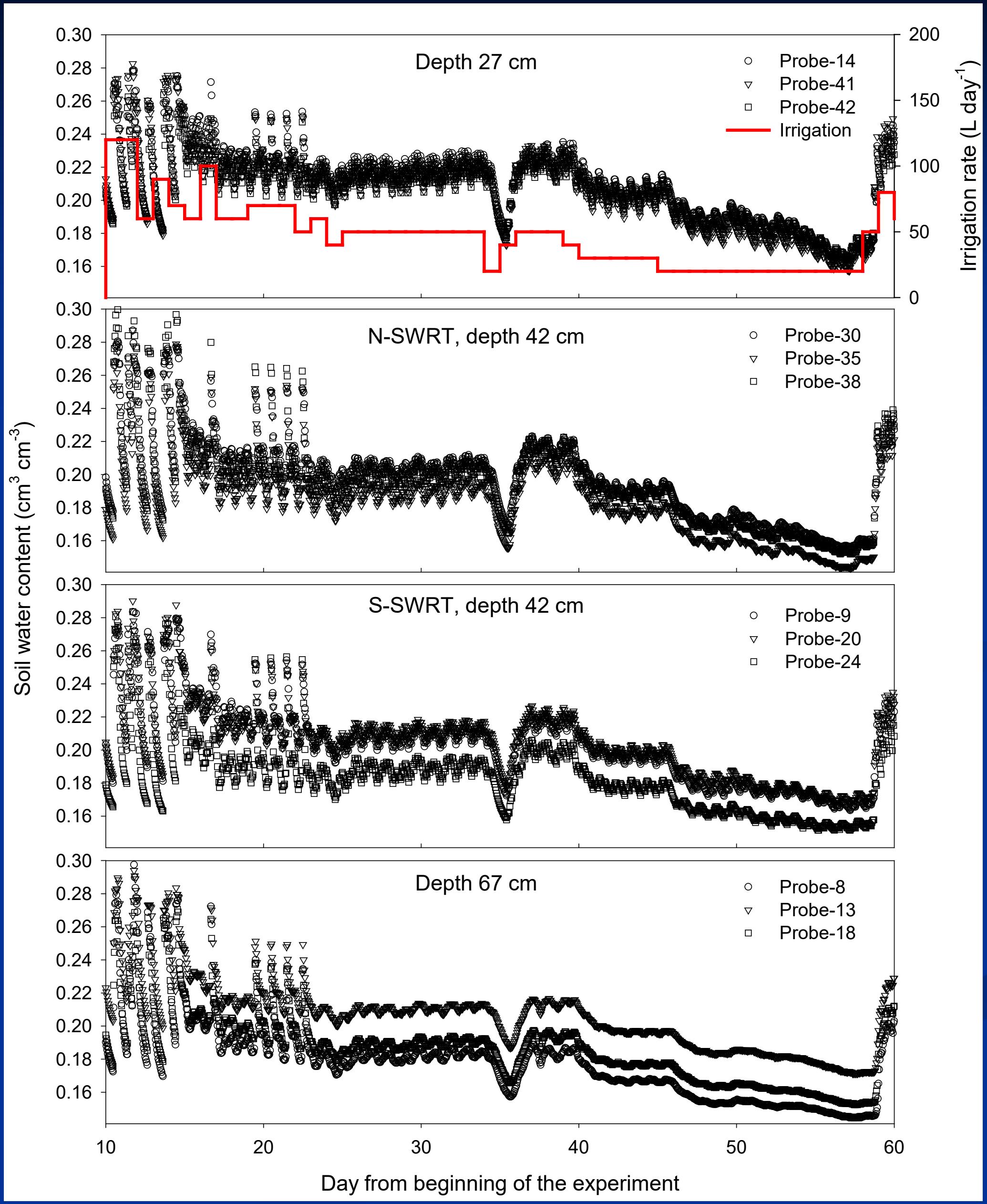
Maize growing on SWRT membrane-improved sandy soils produced 174% higher grain yields and 193% greater total biomass

Design of the sand-box experiment



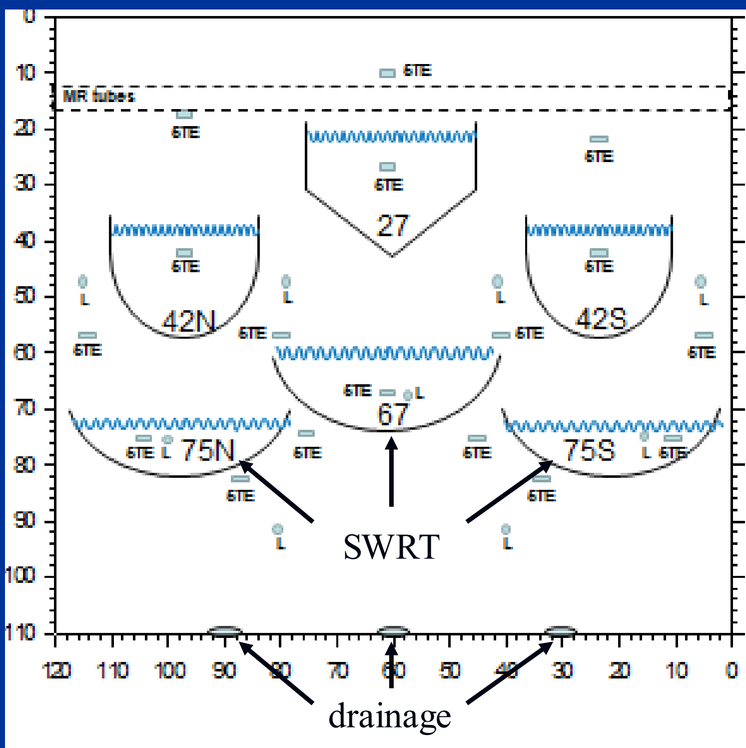
Water content dynamics measured in the sand-box experiment

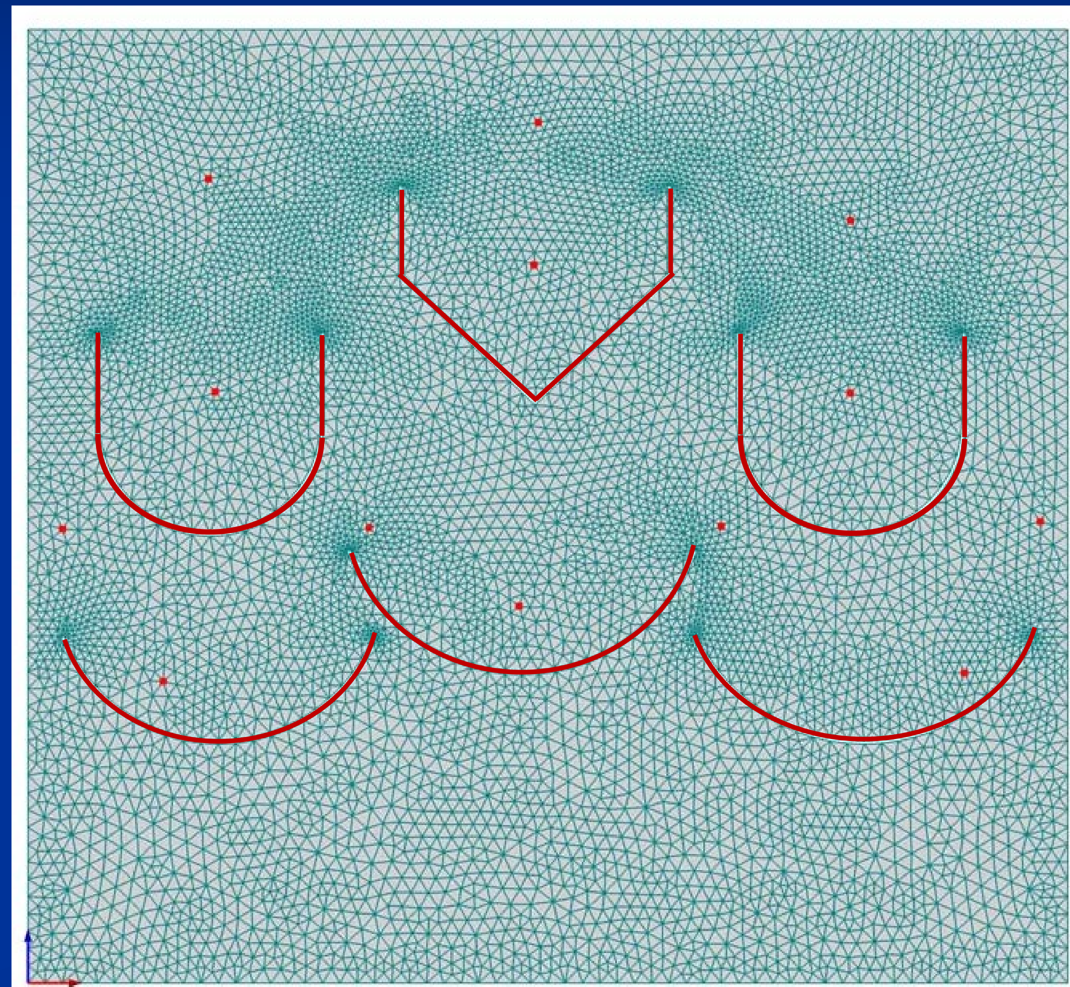




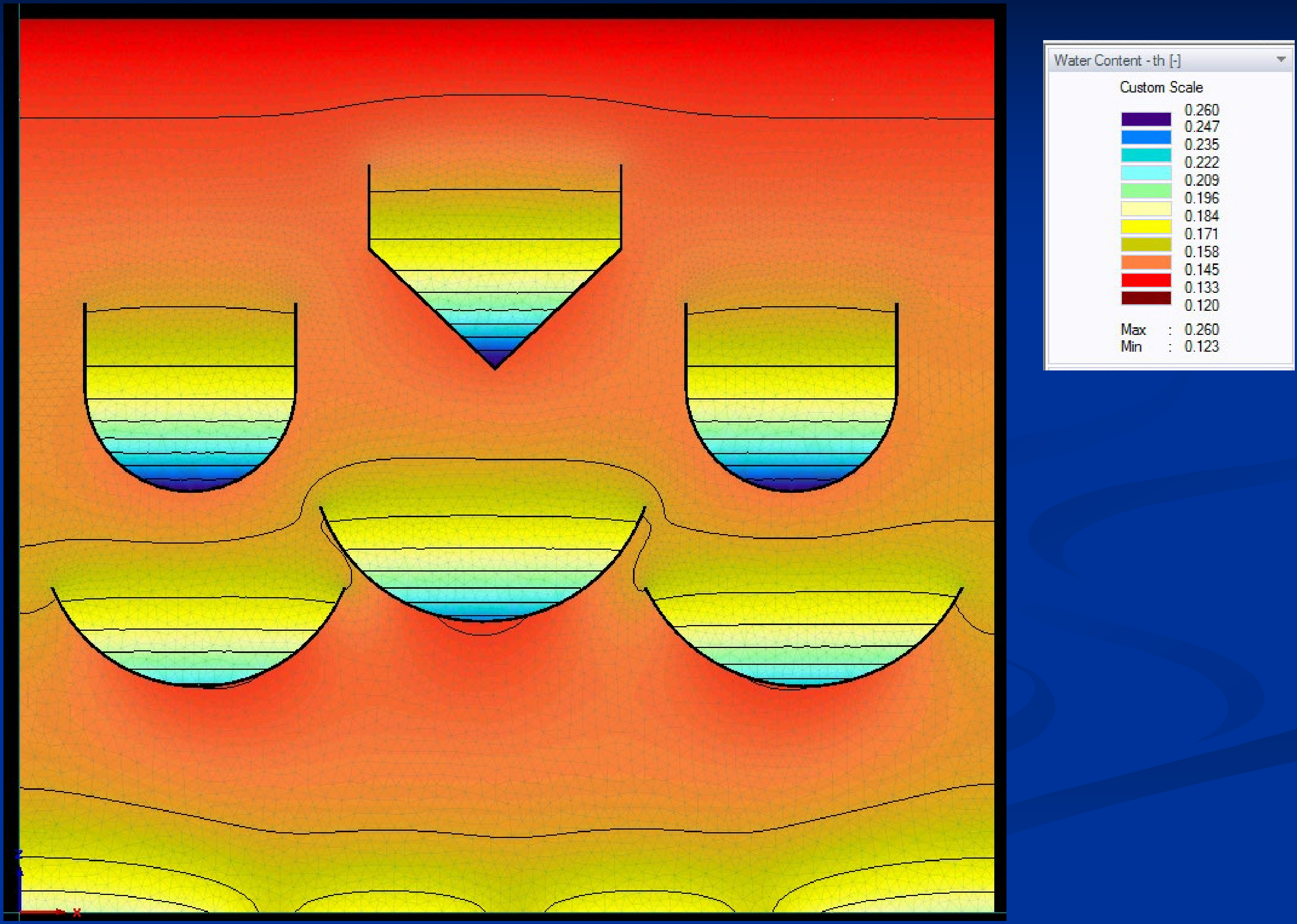
Mesh generated by HYDRUS-2D

6 openings
8345 simulation nodes
16106 2-D elements
13 observation nodes

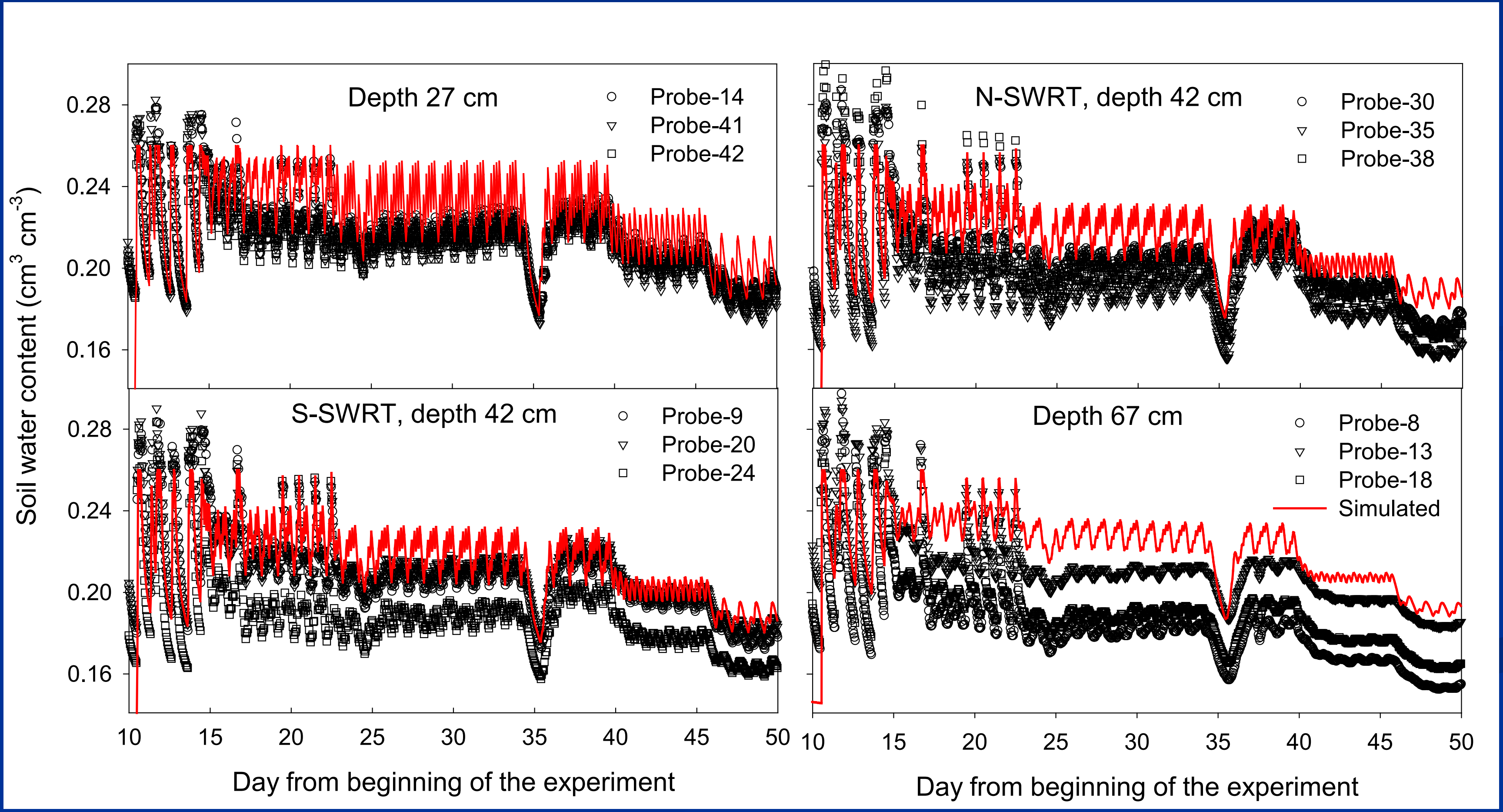




Example of HYDRUS-2D simulation



Calibration and validation of HYDRUS-2D model on the results of the sand-box experiment



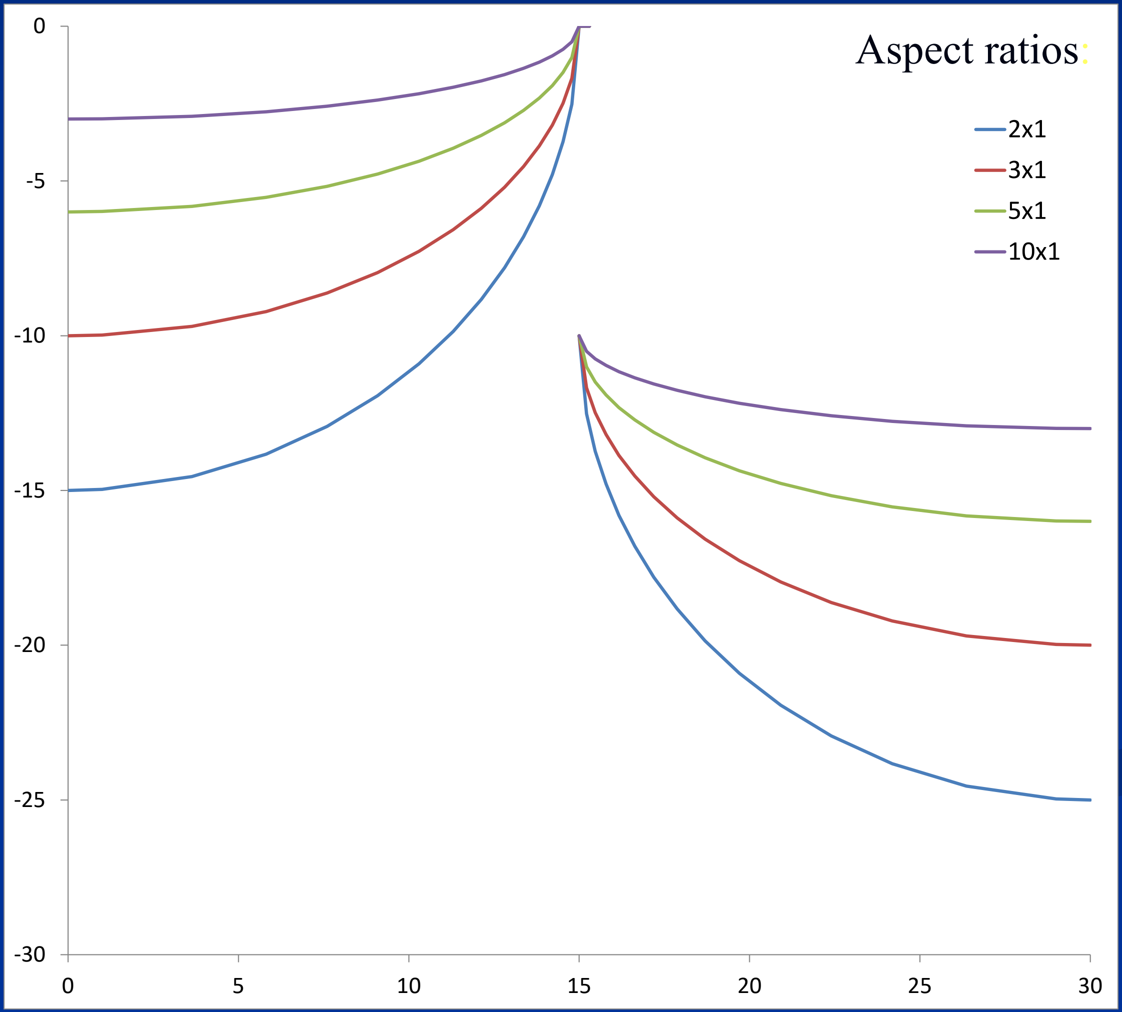
Effect of SWRT geometry and location in soil profile on water loses from sand profile

Width of SWRT: 30 cm

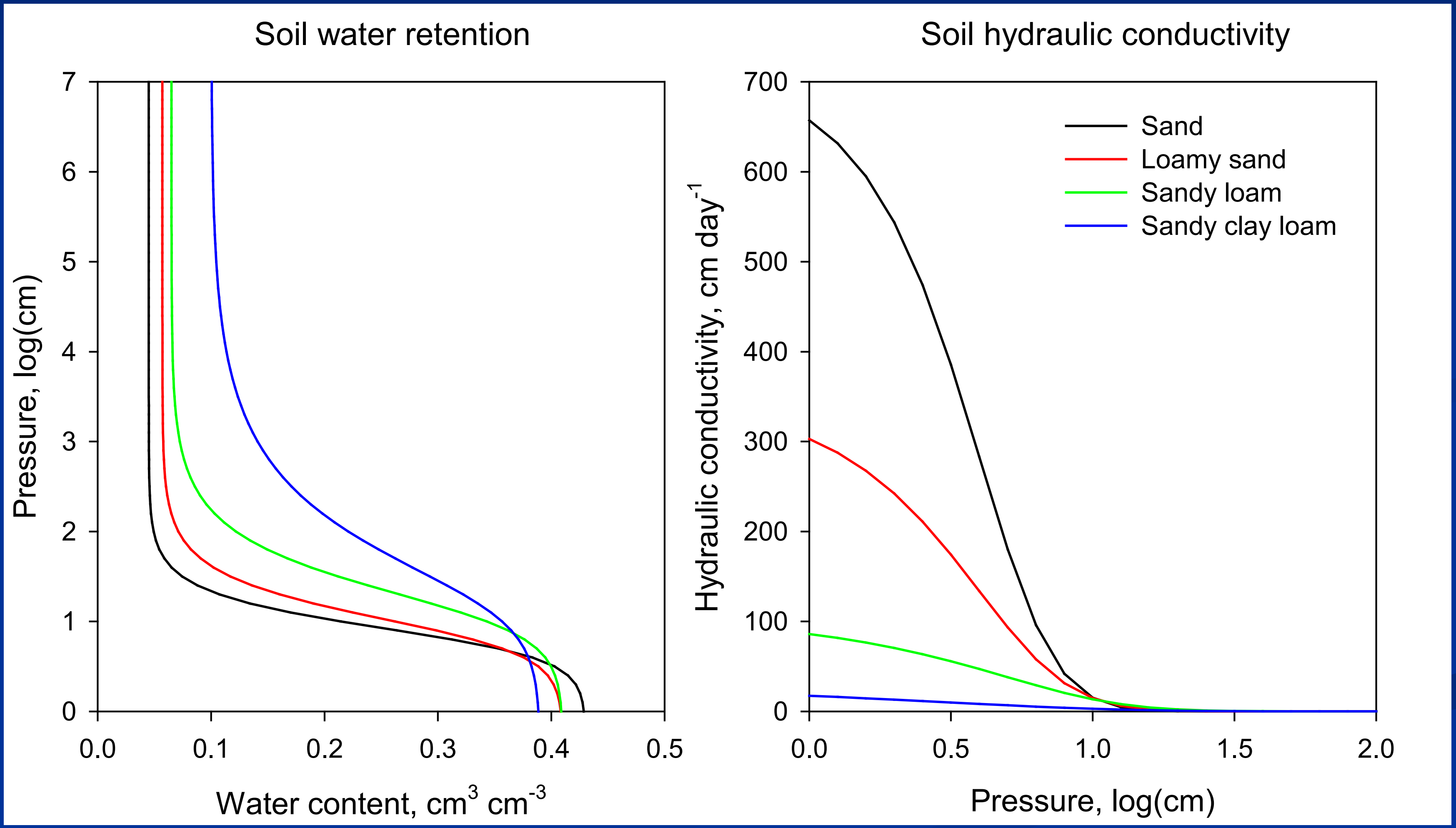
Installation depths: 20 cm, 40 cm, 60 cm

Aspect ratios: 2x1, 3x1, 5x1, 10x1

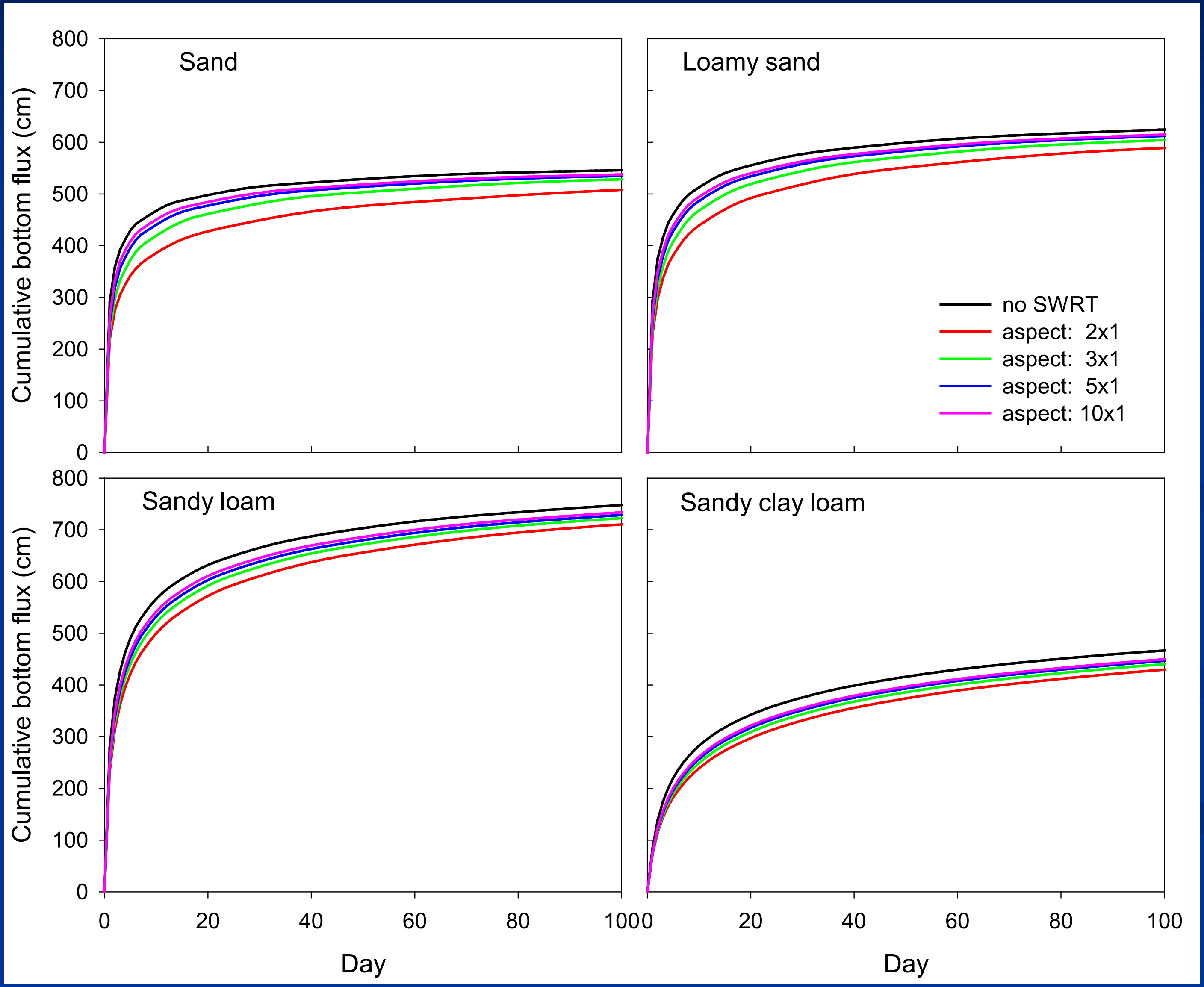
Soil texture	K_{sat} (m/day)
Sand	7.1
Loamy sand	3.5
Sandy loam	1.1
Sandy clay loam	0.3



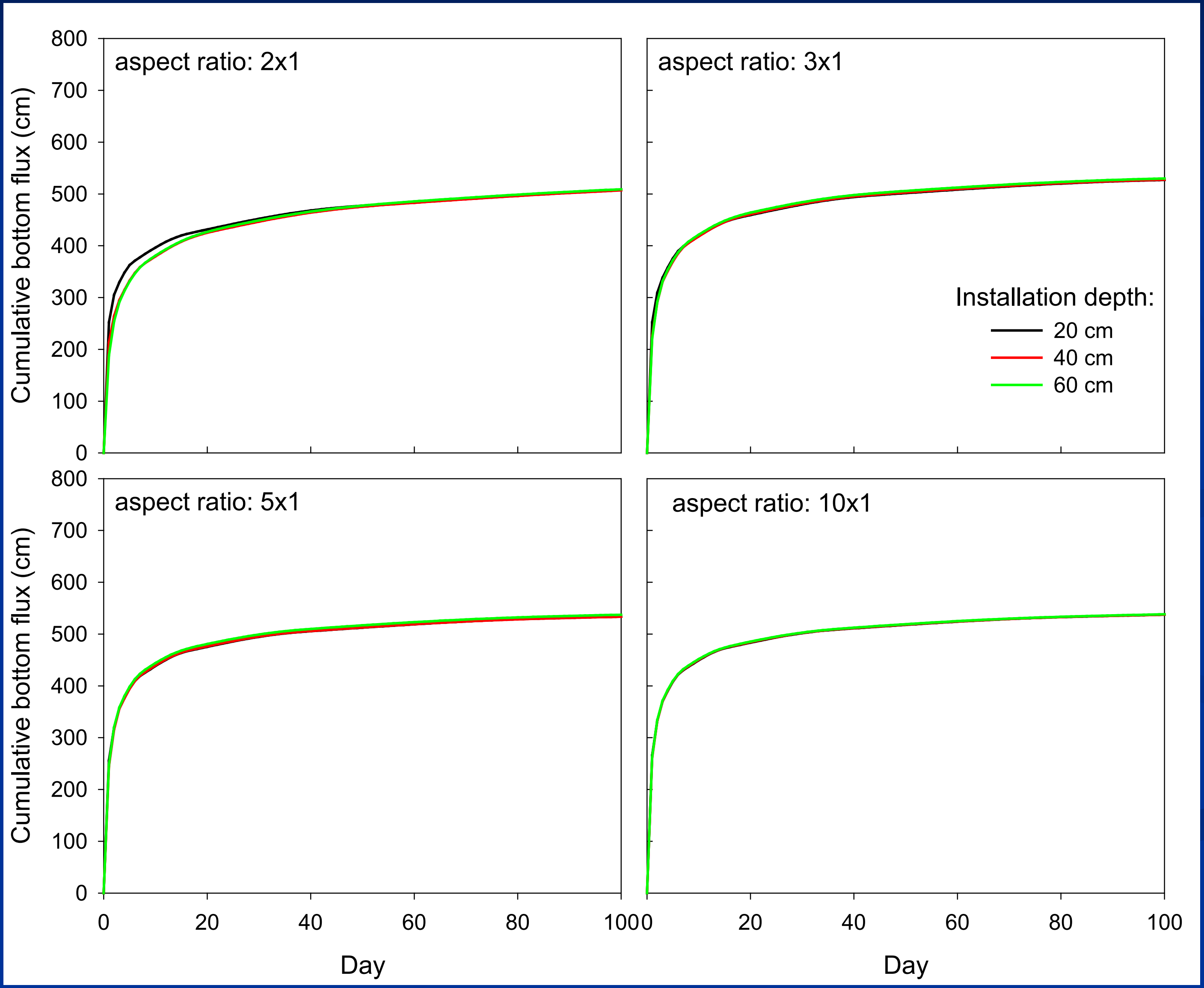
Soil hydraulic properties used in SWRT simulations



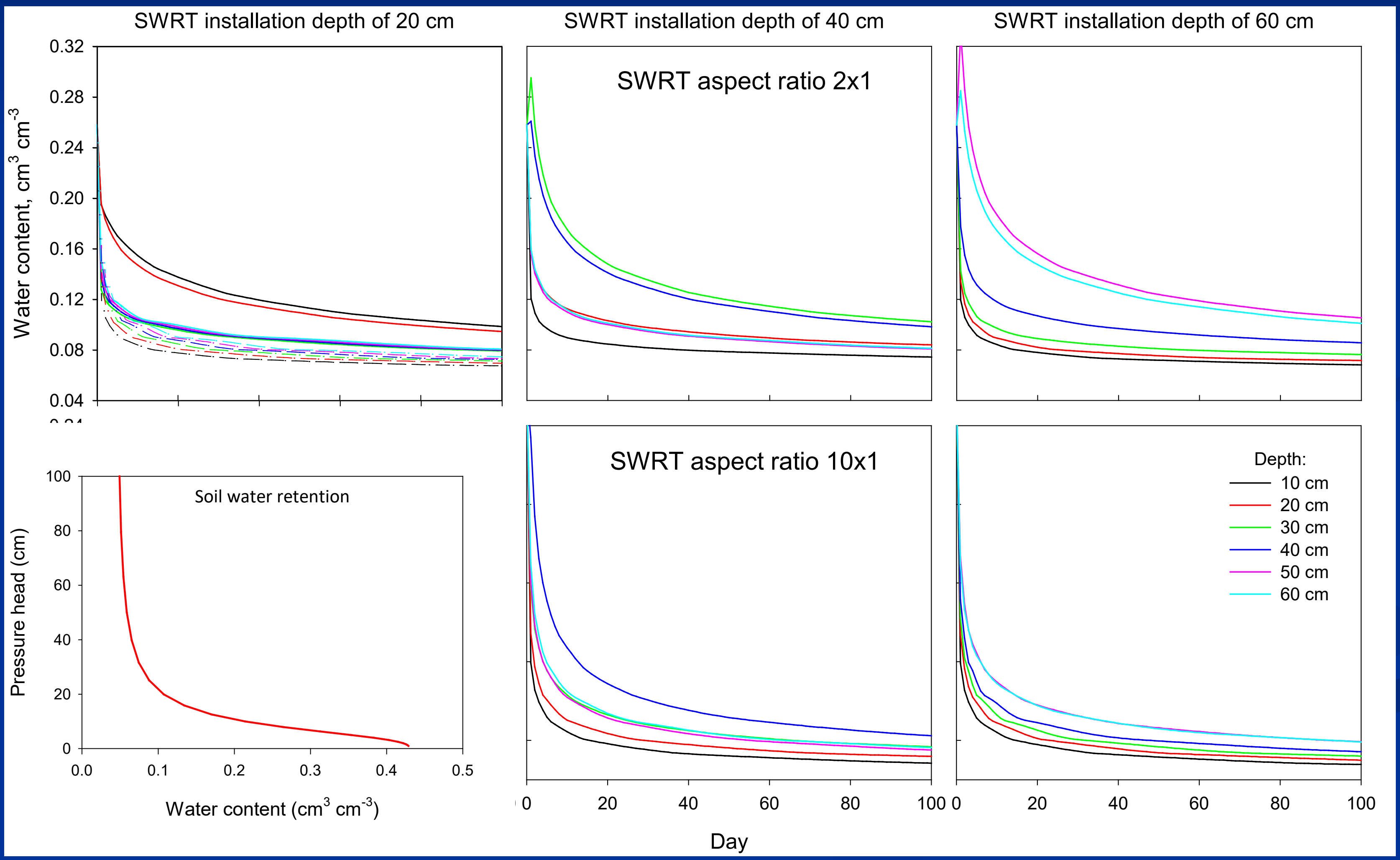
Effect of SWRT aspect ratio on cumulative water fluxes simulated from the bottom of four soil profiles



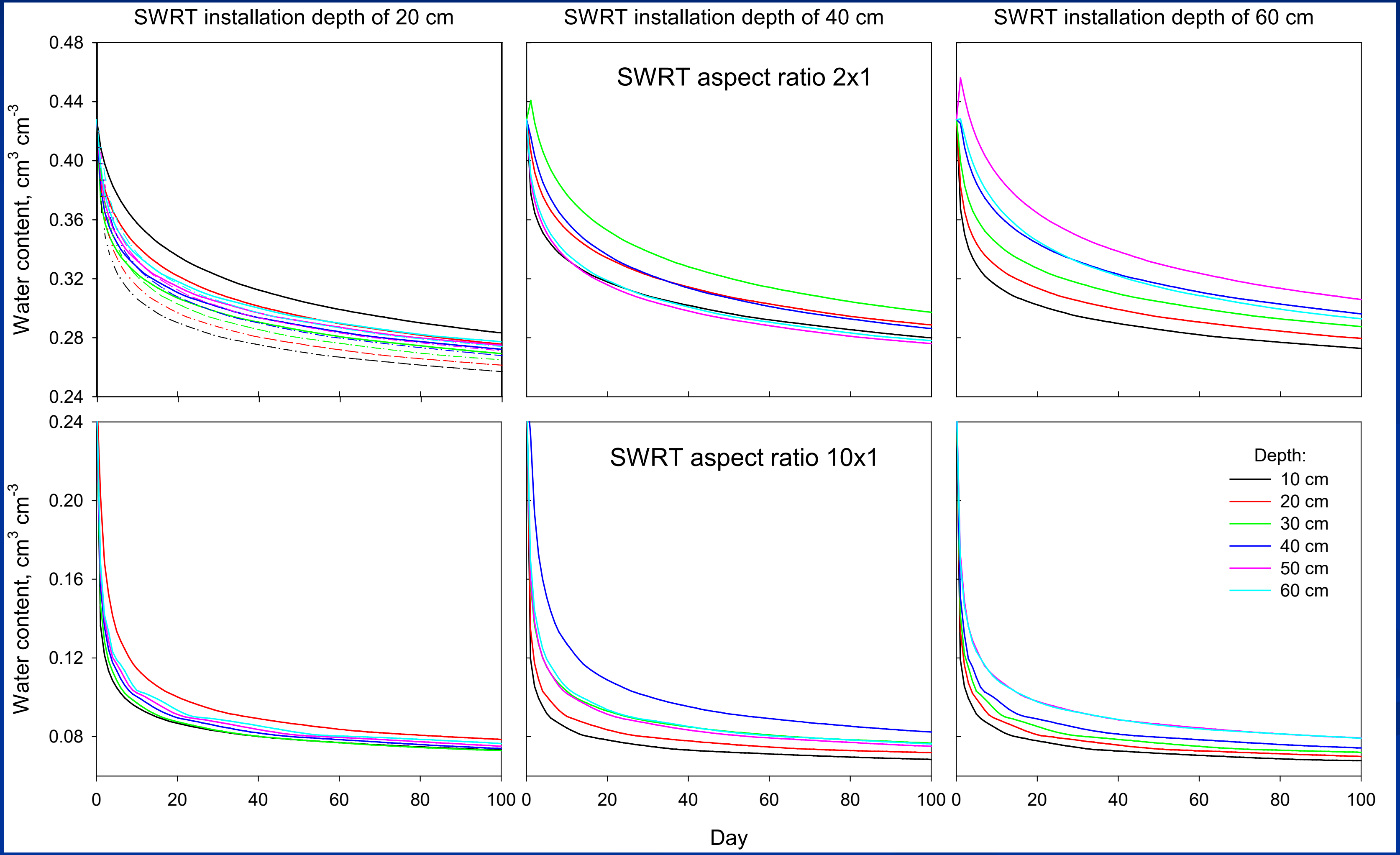
Effect of the SWRT installation depth on cumulative water fluxes simulated from the bottom of four soil profiles



Effect of the SWRT installation depth on water content dynamics for two aspect ratios in sandy soil



Effect of the SWRT installation depth on water content dynamics for two aspect ratios in sandy clay loam soil



CONCLUSIONS

- Experiment conducted in a sandy box showed that SWRT can control soil water content distribution in the root zone.
- HYDRUS-2D model was capable to reproduce measured dynamics of soil water content in the sand box with installed SWRT membranes.
- The performance of SWTR membrane was different for different soils. Water losses were smaller in sandy soil and loamy sand, compared to those in sandy loam and sandy clay loam soils.
- Installation depth of the SWRT membranes did not changed significantly cumulative water losses from soil profile, but altered vertical distributions of soil moisture. Water content was higher in 10-20 cm layer above the membrane, compared to other depths.
- The performance of SWTR membrane depended on the aspect ratio. Increase in the aspect ratio from 2x1 to 10x1 reduced water accumulation inside and above the membranes and resulted in larger water losses from the root zone.
- Overall, SWRT appeared to be a promising technology for reducing water and nutrient losses from root zone in highly water permeable soils.