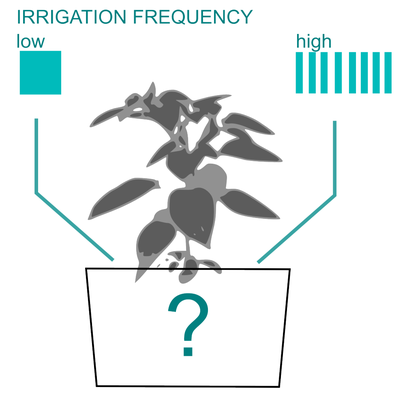
More crop per drop?

Exploring root uptake under high frequency irrigation using electrical resistivity tomography

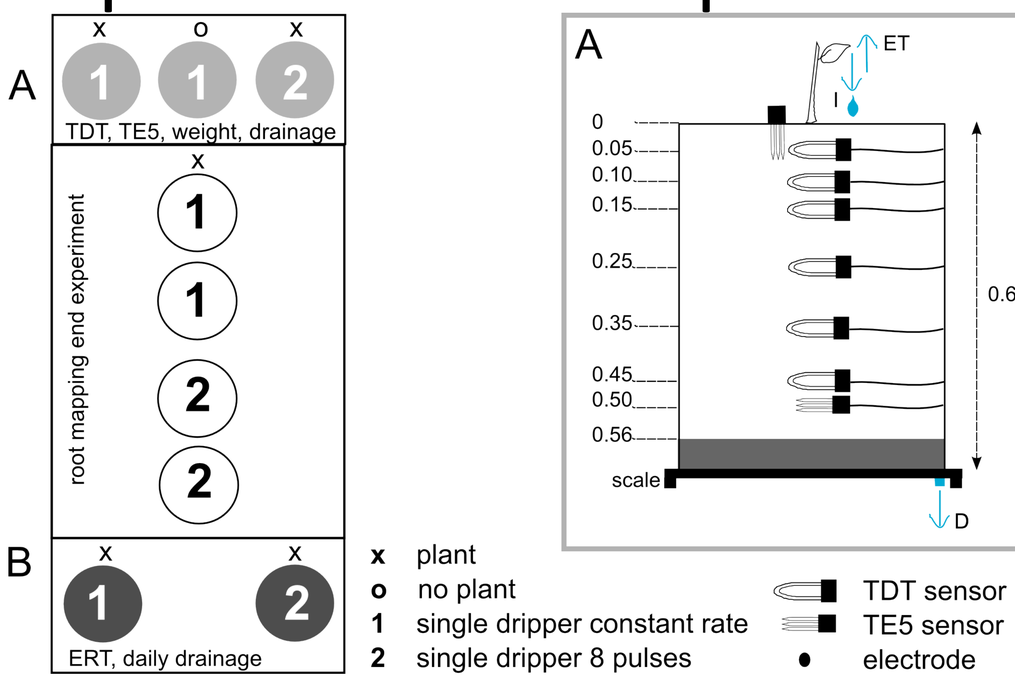
Sarah GARRE[1] (sarah.garre@ulg.ac.be), Shmuel ASSOULINE[2], Thomas GÜNTHER[3], Alex FURMAN[4] (afurman@technion.ac.il)

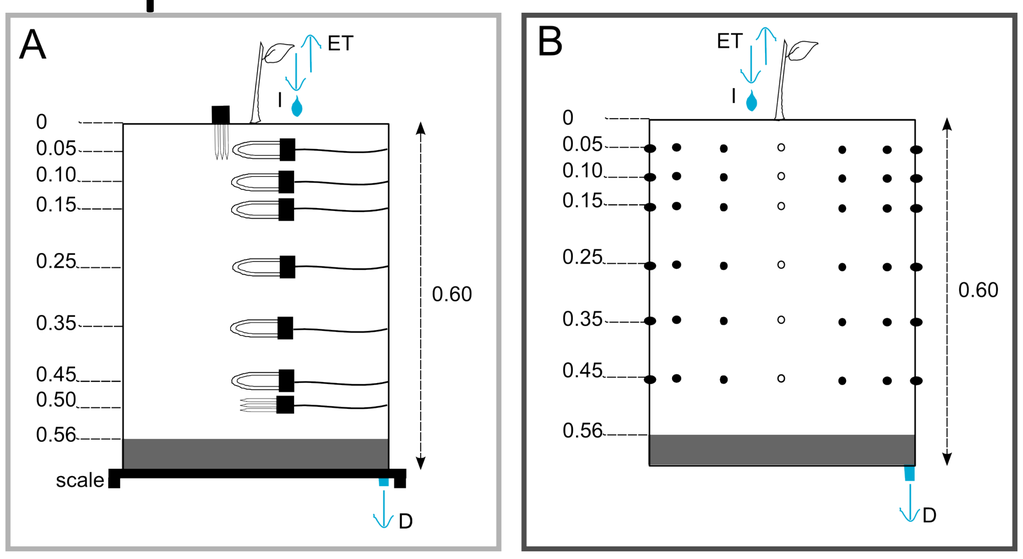
1. Université de Liège, Gembloux Agro-Bio Tech, AgricultureIsLife.be, Gembloux, Belgium 2. Agricultural Research Organization – Volcani Center, Soil Water and Environmental Sciences,, Bet Dagan, Israel, 3. Leibniz Institute for Applied Geophysics, Hannover, Germany 4. Technion IIT, Civil & Env. Engineering, Haifa, Israel

In water-scarce countries, irrigation of agricultural crops is imperative. In many countries, precision irrigation has been adopted, since it provides water exactly in the root zone of the plant. However, the frequency of irrigation is not always well adapted to the dynamic water needs of the plant over the day and over the growing season. This is because it is difficult to assess the soil moisture status with both high spatial and temporal resolution. In this study, we investigated how high frequency irrigation of bell peppers (*Capsicum annuum L.*) changes the soil moisture dynamics and more specifically, the root water uptake dynamics in space and time. We did this by combining a non-invasive imaging technique with classical sensors and plant parameters. The results of this study can give direct guidelines for precision farming, but can also be used to gain a better understanding in the mechanisms of root water uptake under high evapotranspiration demand and irrigation.



Experimental set-up





x plant
o no plant
1 single dripper constant rate
2 single dripper 8 pulses

TDT sensor
TE5 sensor
electrode

Fig. 1: Experimental set-up in Bet Dagan, Israel. The image on the left shows the placement of the 9 barrels with different treatments and equipment. Group A are barrels equipped with TDT and TE5 sensors, placed on a balance and with drainage measurements every 15 min. Group B are barrels equipped with electrodes for timelapse electrical resisitivity imaging (ERT) with daily drainage measurements. Four other barrels where reserved for root system observations at the end of the experiment. The photograph at the left shows a bell pepper plant in an ERT barrel.

Questions and (partial) answers

Does irrigation frequency affect water depletion in time?

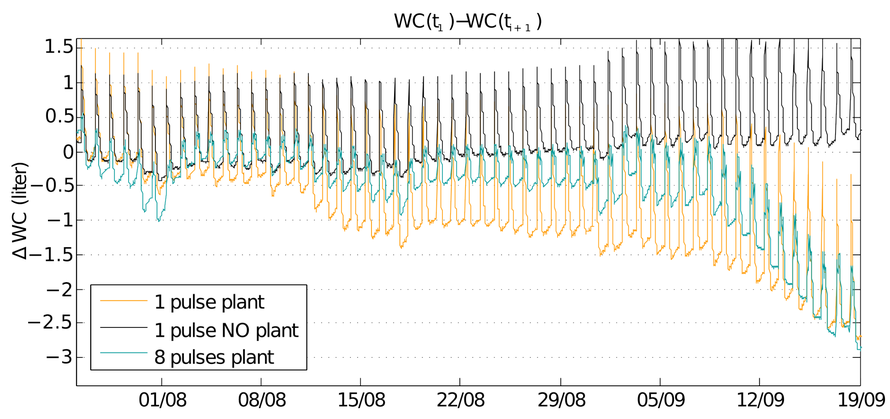


Fig. 2: Evolution of soil moisture for all treatments as comparted to WC(t1) with t1 = 22/07. The barrel without plant clearly shows irrigation pulses and consequent water loss by evaporation and drainage. The overall water content remains constant. The barrels with plant however show an overall in the middle of August and the beginning of September. The barrel with high frequency irrigation has a steeper decrease than the one with only 1 pulse in September, even though the irrigation rate was the same. The irrigation rate was adapted to expected evapotranspiration on 26/07 and 01/09.

How does irrigation frequency alter the soil moisture profile?

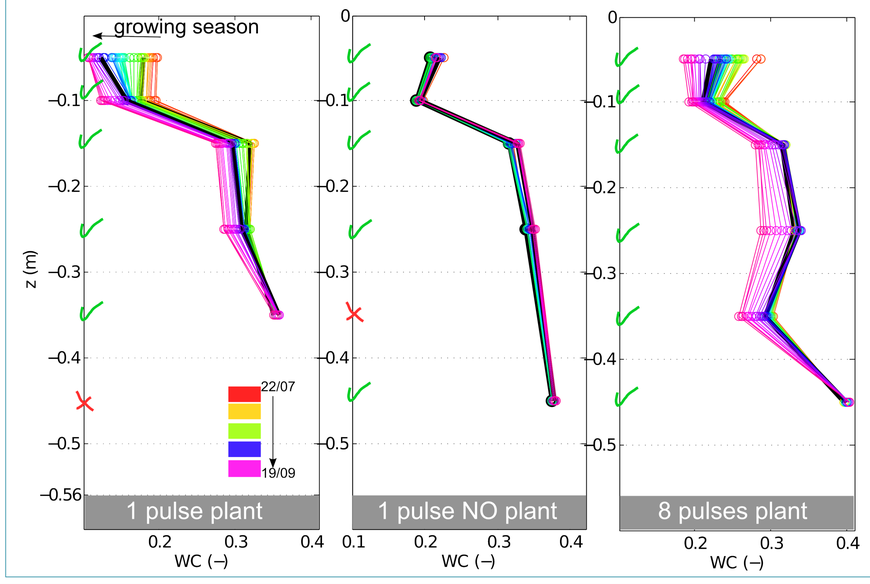


Fig. 3: Soil moisture profiles at 7:30 AM (just before irrigation starts) over the growing season for all treatments from TDT sensors. Both barrels with plant show a continuous drying of the soil especially in the upper 10 cm. Deeper drying (-35 cm) mainly occurs in september (purple lines) for the high frequency treatment. For the 1 pulse treatment drying at -15 cm occurs earlier in the season, but root uptake seems to be less important below -30 cm. Both 01/08 and 01/09 are indicated with a black line.

Which complementary information does ERT provide as compared to classical sensors?

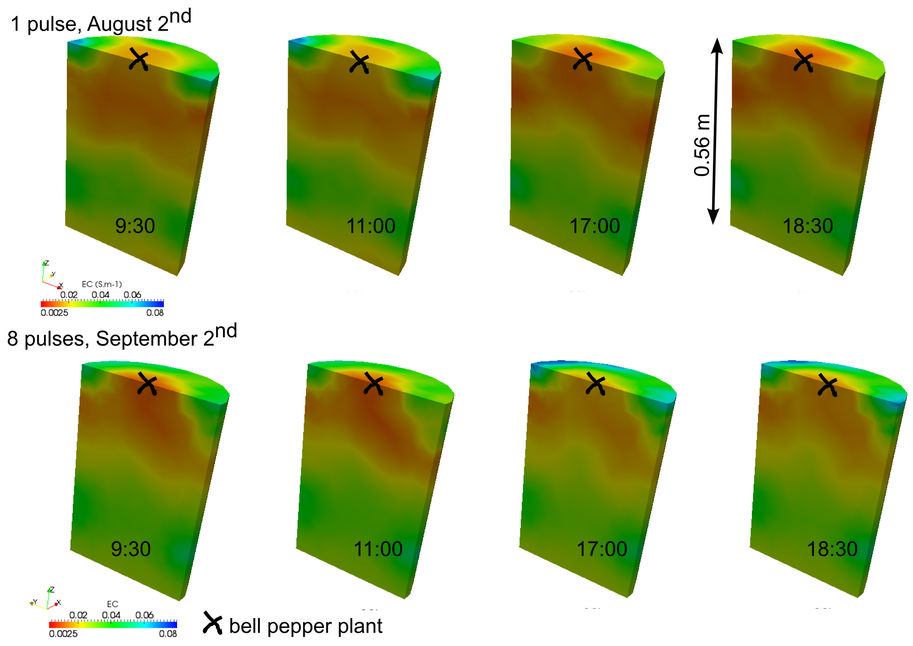


Fig. 4: 3-D distribution of electrical conductivity after inversion with an error level of 4% using BERT (Günter et al.). The barrel with only one irrigation pulse (8:00) is shown for August 2nd at four different timesteps. The barrel which received 8 small pulses (8:00-15:00) is shown for September 2nd. In both cases a clear drying bulb is visible in the middle of the barrel which gradually becomes broader with depth.

Conclusions

The results presented here are ongoing research. However, they show already that (i) there are important differences in soil moisture depletion between the low- and high-frequency irrigation and (ii) 3-D ERT gives interesting, additional information on the spatial distribution of water infiltration and root water uptake. Further data analysis will allow us to check the water balance, compare the results of the different methods and show in more detail how different irrigation practices affect water use efficiency.

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