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Resizing irrigation management for TWW quality with a physically-based model to preserve soil quality: A case study in Beit Dajan-Palestine

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Irrigation with Treated Wastewater (TWW) is a well-known and long-established agricultural practice in Palestine. Being a source of water and nutrients, long term use of TWW can lead to imbalances that affect plant development, soil, and groundwater quality. Consequently, irrigation frequency and interval should be properly scheduled, especially when Salts and Fertilizers (FS-TWW) cannot be separated from water.

Physically based models may be relevant tools to support an adequate irrigation management with TWW for a simultaneous supply of water and fertilizers assessed pursuant to the effects of TWW on soil properties and water fluxes into and out of the root zone.

The present research was conducted in the framework of Non Conventional WAter Re-use in Agriculture in MEditerranean countries (MENAWARA) ENI CBC Med project, with the aim to propose an alternative TWW irrigation management based on both water requirements and allowable thresholds of soil solution electrical conductivity (ECe), to prevent soil salinity using physically-based Hydrus-1D model.

To this purpose, a case study in Beit Dajan cultivated with citrus and irrigated with TWW was selected to determine the long term effects of TWW on the soil and on root uptake, considering a two-year (2018-2019) simulations and generating two FS-TWW irrigation scenarios: 1) non-optimized salt supply (NONOPT-FS-TWW) where irrigation volumes fully satisfied crop evapotranspiration demand: 2) optimized salt supply (OPT-FS-TWW) accounting for crop evapotranspiration and respecting allowable thresholds of soil solution electrical conductivity (ECe) by assuming an average soil salinity tolerance in the root zone.

Soil water movement, ECe, nitrate and ammonium concentrations were simulated, inputting averaged ten-yearly climate data and soil and water quality data measured at the end of each of the two considered years. The results in terms of soil salinity and root uptake impact are considered to define a proper TWW irrigation management for citrus.

The outputs of the scenario OPT-FS-TWW clearly demonstrate the reduction of soil salinity in the root zone, and of water and nutrient fluxes below 60cm, and thus an improvement of water and nutrient uptake, as compared to NON-OPT-FS-TWW scenario.

The results suggest that aligning the classical irrigation practices to TWW reuse by considering ECe as an additional variable is appropriate, allows to curb soil salinity, and ensures root water uptake of citrus, although TWW has high salinity levels that may jeopardize plant response after a sequence of irrigation events.

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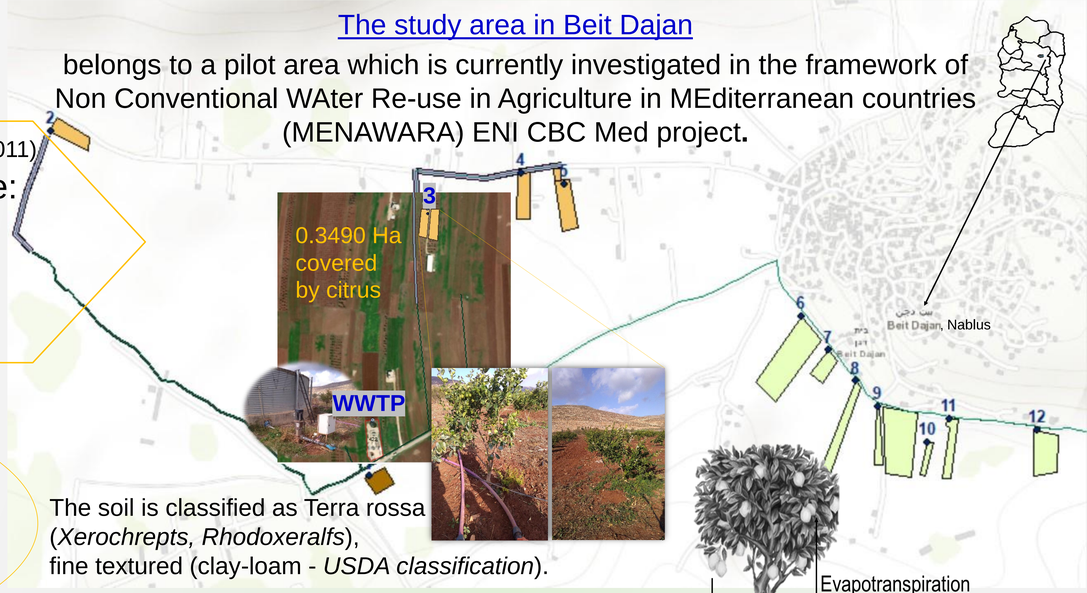
WW/year produced in Palestine is 106MCM odd. (PCBS, 2011)
WW reuse in irrigated agriculture is expected to increase:
31.7 MCM/yr by 2022, 58.5 MCM/yr in 2027,
and 93.0 MCM/yr in 2032 according to
National Water and Wastewater Strategy for Palestine.
(Trottier and Perrier, 2018)

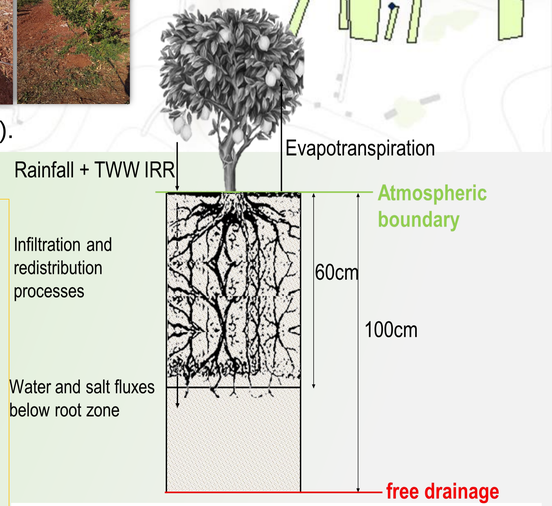
Focus point: The lack of an appropriate TWW irrigation management induces its misuse leading to reduce soil quality and impact the environment. Being TWW a source both water and salts (FS-TWW), long term use of TWW may engender their loss and imbalance from plant and soil.

The study area in Beit Dajan

belongs to a pilot area which is currently investigated in the framework of Non Conventional WAter Re-use in Agriculture in MEditerranean countries (MENAWARA) ENI CBC Med project.



The soil is classified as Terra rossa (*Xerochrepts, Rhodoxeralfs*), fine textured (clay-loam - *USDA classification*).



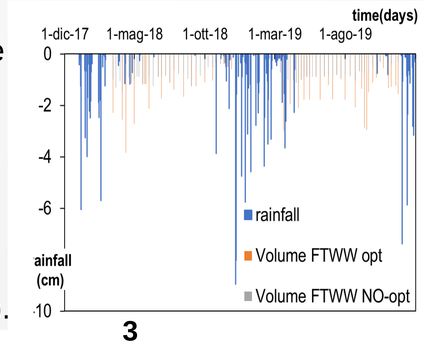
soil domain geometry set up

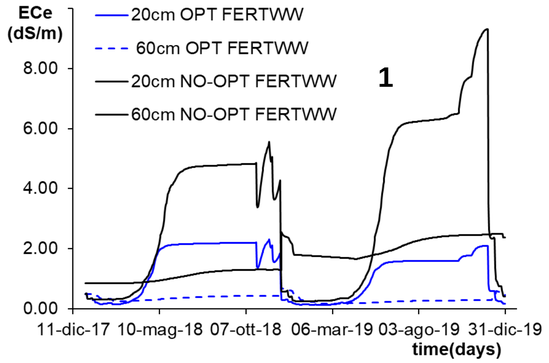
Results

I) NONOPT-FS-TWW

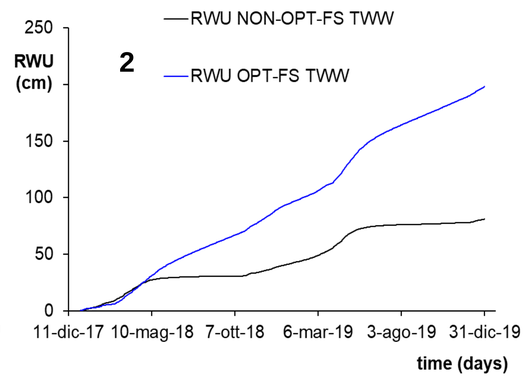
II) OPT-FS-TWW strategies influence soil water and salts distribution:

1. ECe trend is lower (blue line) for managing irrigation which also included water quality.
2. Low saltinity reduced the clogging of some soil pores and increased infiltration rate with a root uptake enhancement (blue line).
3. slight downward water fluxes under optimized TWW irrigation events (blue and orange lines). Downward and upward water fluxes (black line) are occurred under frequent TWW irrigation events (green line) induced both salt accumulation per capillary rise, and potential drainage fluxes below root zone (black and blue lines).

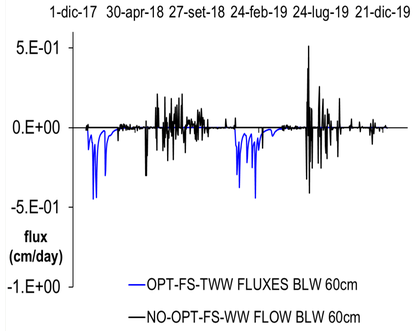




Time evolution of soil solution electrical conductivity (ECe)



Time evolution of Root Water Uptake (RWU)



Time evolution of water fluxes compared with the inflows (rainfall, irrigation events)

Theory:

1D form of Richards' and advective-dispersive equations was solved with HYDRUS-1D software package (Šimůnek et al., 2008a) assuming two TWW irrigation management scenarios:

I. non-salts optimization (NONOPT-FS-TWW)
I. salts optimization (OPT-FS-TWW)

Ho: Having to supply simultaneous water and salts, TWW irrigation events was managed accounting both water requirements and respecting allowable thresholds of soil solution electrical conductivity (ECe) assuming an average soil salinity tolerance in the root zone, as criteria for the evaluation.

Conclusions:

A simultaneous control of water and salt supplies reduced the effects of stress on citrus.
A combined approach based on both a physics-based modeling and monitoring may support Real-Time TWW irrigation management,and prevent soil and groundwater quality and loss in plant production.

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