Soil-Water Measurements as a Measure for Crop-Water Availability and Stress

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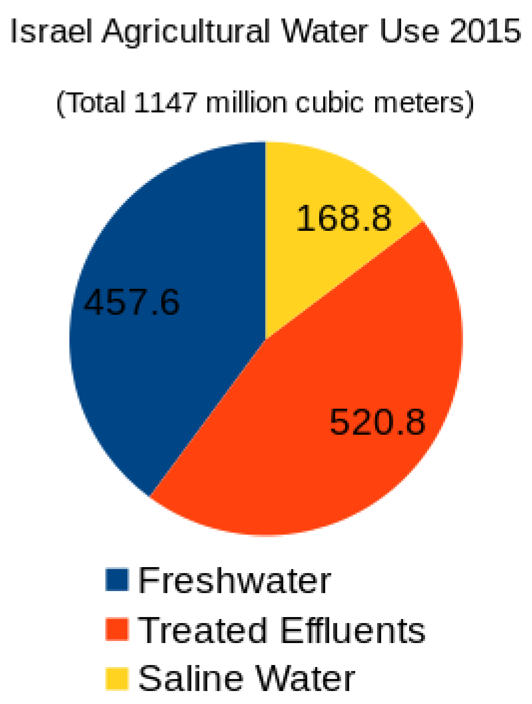
Growing under stress conditions (is the future)

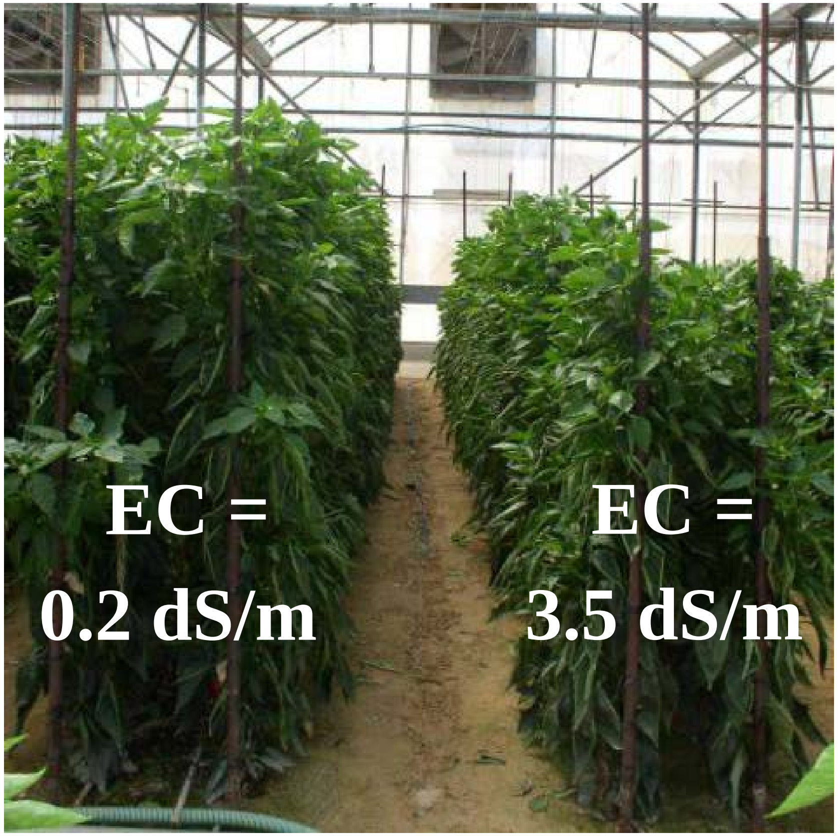
- High-quality freshwater is becoming more scarce and expensive
- Low quality (marginal) water is more available for agriculture
  - Saline groundwater that can not be used as drinking water
  - Treated effluent wastewater
- Salinity build-up in soils and groundwater



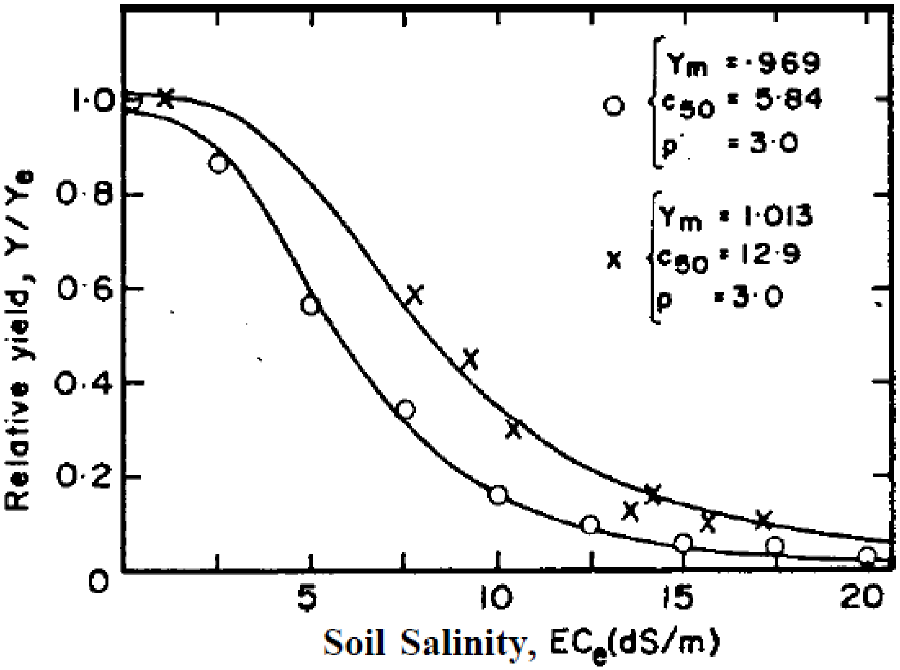
Source: Israel Water Authority

Higher Salinity – Lower Yield

Osmotic potential and specific ion toxicity



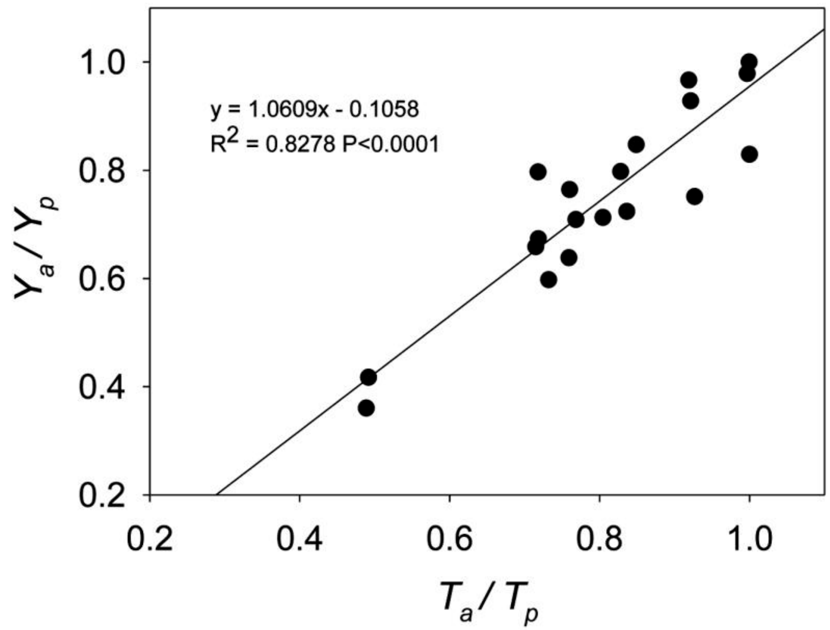
Ben-Gal, personal communication

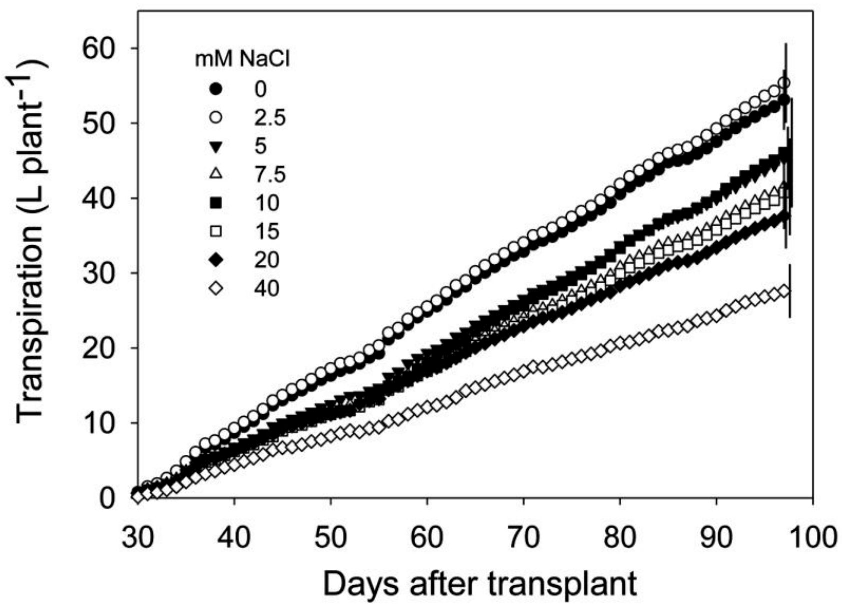


van Genuchten & Gupta 1993

Growing under stress conditions (is the future)

- Some plants cope well with salinity stress (example of bell peppers in lysimeters)





Groenveld et al. 2013

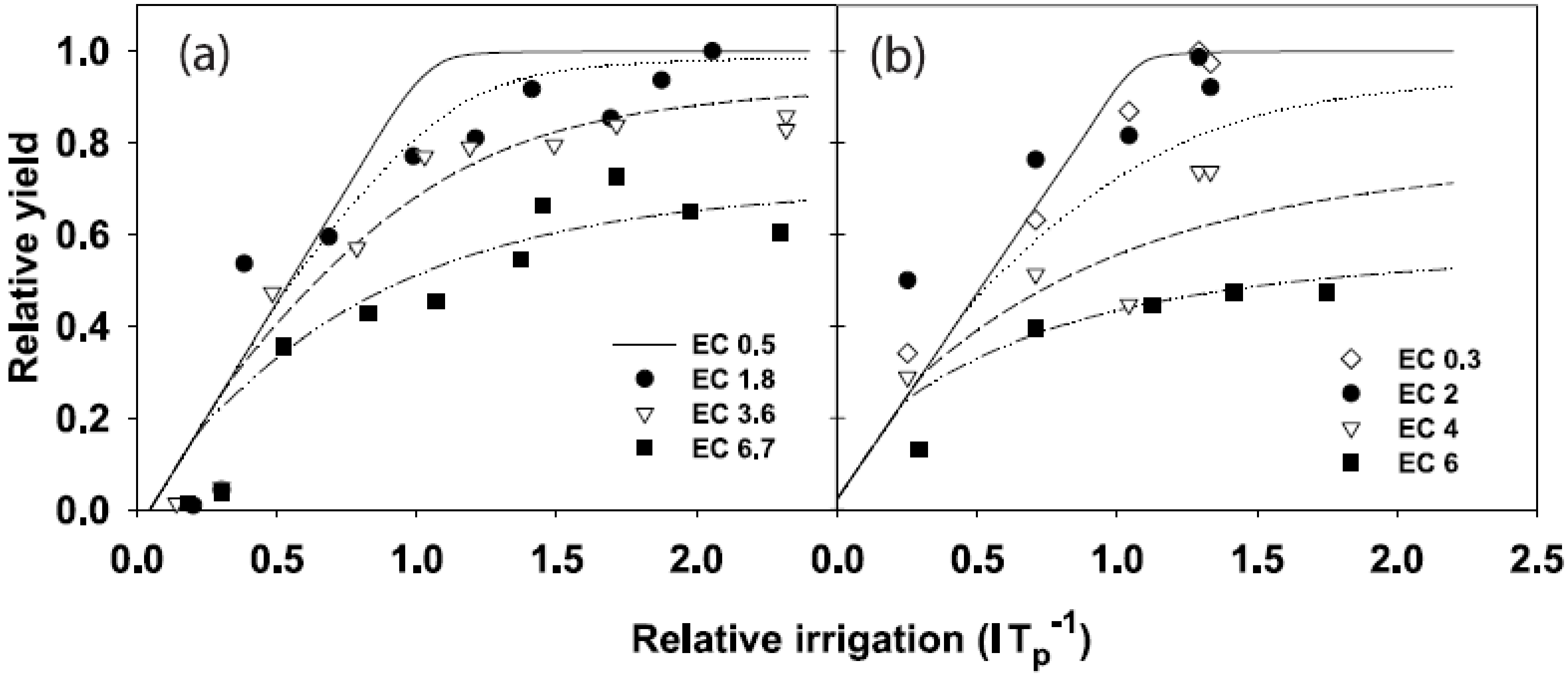
Measures for Irrigation Management

- Atmospheric demand
  - Atmospheric conditions and forecast
  - Crop coefficients
- Soil water availability
  - Matric potential (tensiometers)
  - Soil water content
- Plant conditions
  - Stem- and leaf-water potential (pressure-bomb, dendrometer)
  - Sap flow (heat pulse)

How are these relevant for low-quality water?

Water Availability, Salinity Stress and Leaching Fraction

The stress posed by saline conditions will likely not show if we measure water availability by water potential



Shani et al. 2007: Relative yield of corn as a function of irrigation level and irrigation water salinity. Symbols are experimental results from (a) Russo and Bakker (1987) with Arava sandy loam and (b) Hanks et al. (1978) with Millville loam.

Water in the soil-plant system

- Soil-matric and stem-water potential
  - Good indicators for water stress; thus, good measures for growing under **water-stressed** conditions!
  - Are showing the state of the system, but that limits our prediction capabilities.

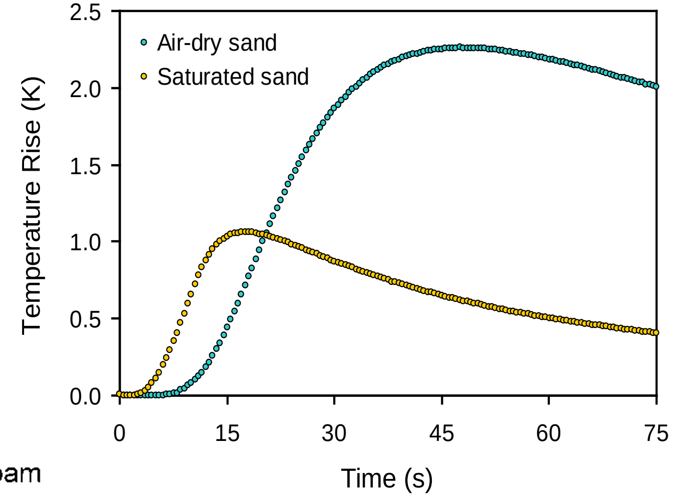
We want to know: how much water will be available and in what quality

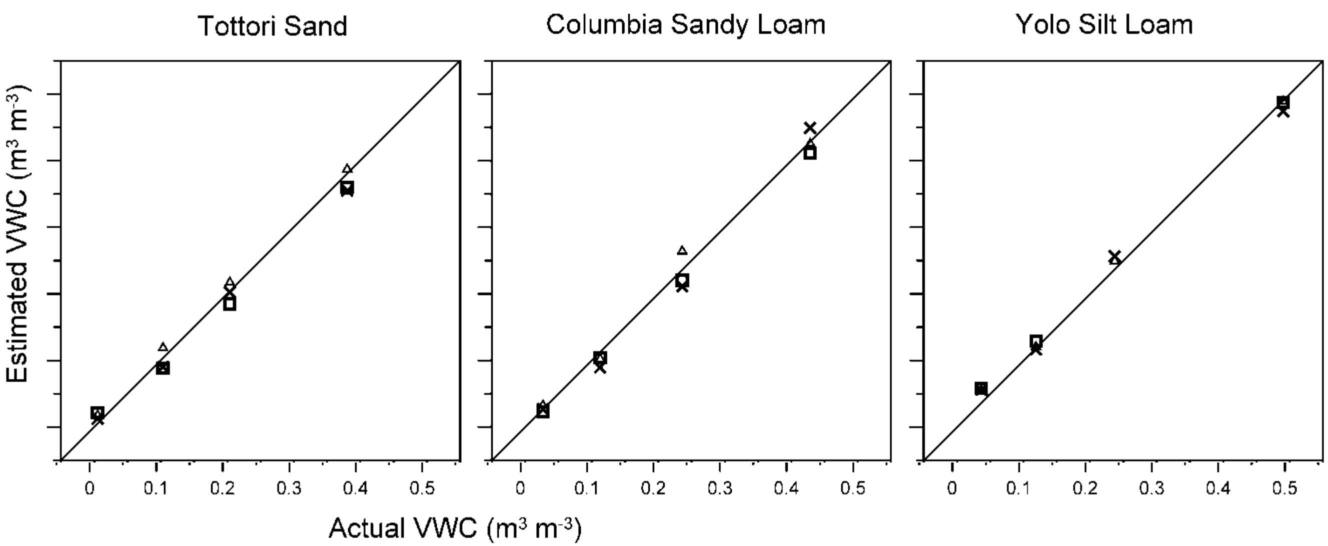
- Water in the system, real time (in-situ)
  - Soil water
    - Water content
    - Water flux density
    - Salinity: EC Bulk, Solution EC
  - Plant
    - Stem water flow

Sap Flow measurements in citrus (grapefruit) Cohen et al. personal communication

Water quantity and quality measurements with heat-pulse based methods

- Soil Water Content
  - Physically based measurement
  - Unaffected by soil texture and salinity





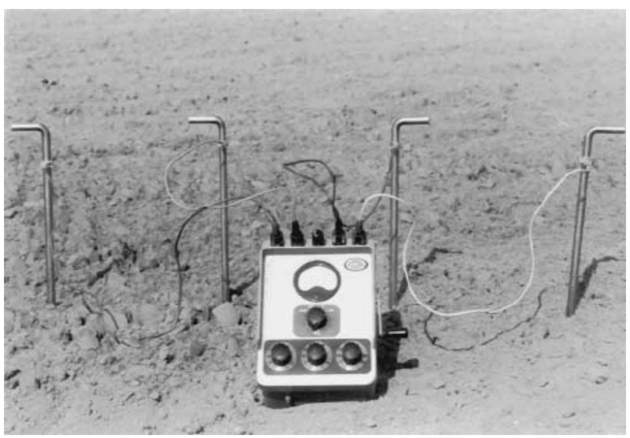
Kamai et al. 2015

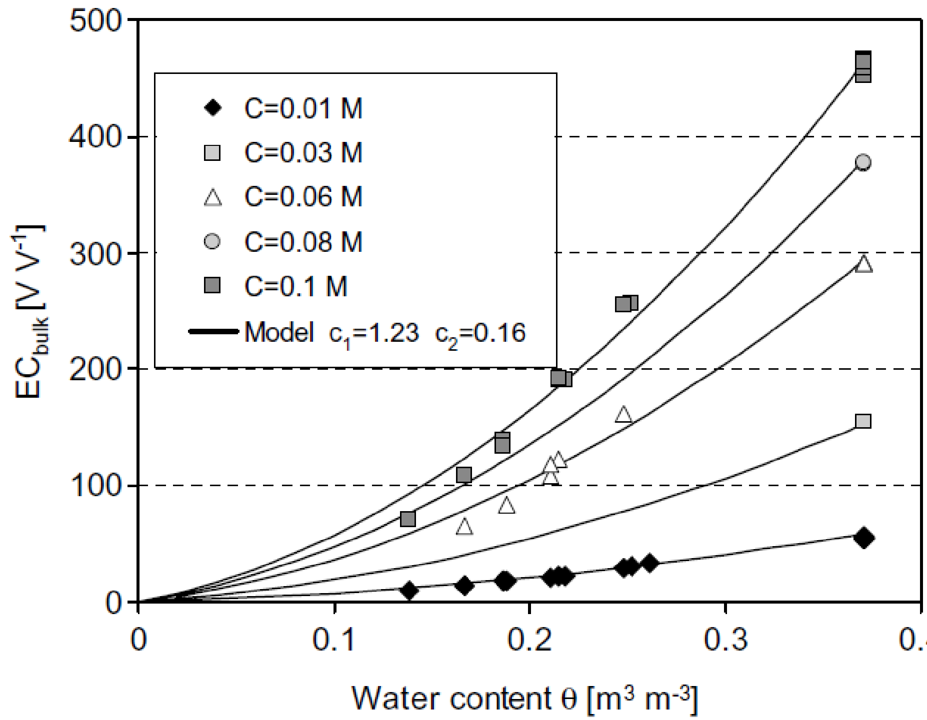
Water quantity and quality measurements with heat-pulse based methods

- Bulk EC and Solution EC
- Affected by soil texture
- Related through water content

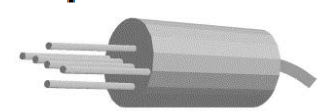
Rhoades et. al. (1976):

$$\mathrm{EC_{bulk}} = c_1 \mathrm{EC_w} \theta^2 + c_2 \mathrm{EC_w} \theta$$





Mortensen et al. 2006



Measurements for Irrigation Management – part of the story

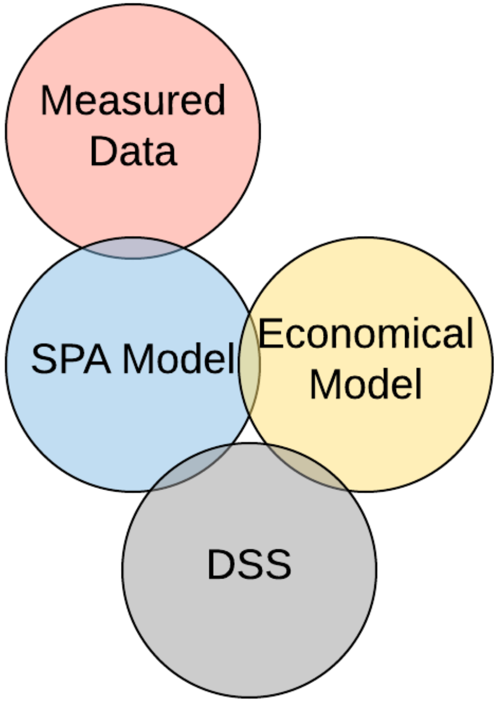
- In-situ real-time data

  heat pulse based sensors
- Soil-plant-atmosphere (SPA) model

  to assess the current water-state and plant growth of the system and use that to predict the future state
- Crop and water economical database (or model)

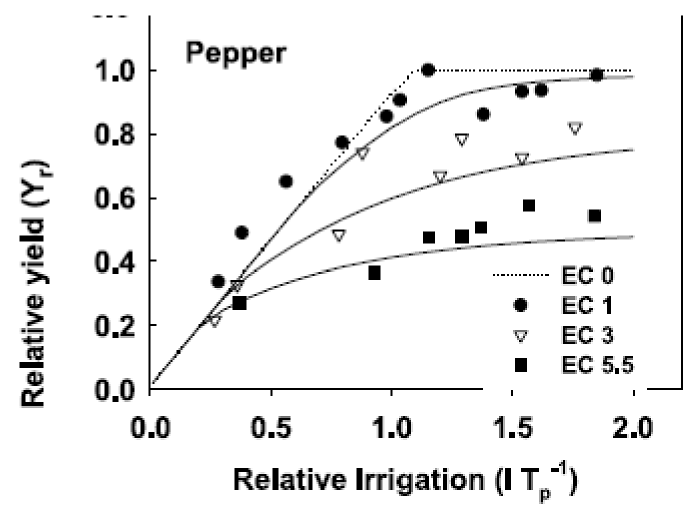
  Provide cost and revenue based on water use and crop produce
- Decision support system (DSS)

  that can correlate between these and provide water-use suggestions



Summary

- Because stress is a combination of water quantity and quality (and soil properties and atmospheric forcing), we want to
  - Focus on the water in the soil-plant system
  - Specifically on soil water, as the source for uptake
- Provide the soil and plant water measurement data supplementary measurements (e.g. potential), and not vise versa
- The information from multiple measurement types and locations needs to be centralized and analyzed in real-time, and integrated into a decision support system.



Peppers grown in Israel with saline water (EC 2-4 dS/m)

Thank you for your attention