

Integrating Electrical Resistivity Tomography and Sap Flow Measurements within Agro-Ecosystem Models to Improve Irrigation Efficiency of Date Palm (PALM-IRRI)

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WATER BALANCE AND RELEVANT PROCESSES



SOIL-PLANT ATMOSPHERE MODEL (COUPMODEL)



- A fully coupled model that simulates water flow, solute transport and carbon balance in the soil- plant system
- Given the initial conditions, boundary conditions and system properties, the model calculates transpiration, photosynthesis, and carbon allocation
- Calibrated and validated model is efficient for planning irrigation scheduling (amount and timing)

SAP FLOW SENSORS





- Calculation of water use from point-scale sap flow measurements is challenging due to unknown flow area
- Budget approach to stem water storage estimation thus also uncertain



Sap flow estimation using the heat dissipation method (Granier, 1985)

 $k = (\Delta T_{\max} - \Delta T) / \Delta T$

 $Fd = 189k^{1.231}$

Sperling, O., Shapira, O., Cohen, S., Schwartz, A. and Lazarovitch, N. (2012) Estimating sap flux densities in date palm trees using the heat dissipation method and weighing lysimeters. Tree Physiology. 32:1171-1178.

ELECTRICAL RESISTIVITY/IMPEDANCE TOMOGRAPHY



- Electrical resistivity tomography (ERT) provides the distribution of the magnitude of the electrical resistivity (water content, salinity)
- In induced polarization measurements, the phase shift between applied current and resulting voltage is also used to obtain the distribution of the imaginary part of the electrical conductivity (surface area, permeability)

AIMS OF PROJECT

- Evaluate the ability of electrical resistivity tomography (ERT) to improve transpiration estimates from sap flow measurements and the assessment of stem water dynamics
- Combine sap flow and ERT measurements to obtain improved estimates of transpiration and stem water content of date palm, and to use this novel sensor combination to calibrate a soil-plantatmosphere model used for irrigation scheduling

LABORATORY EXPERIMENT: STEM SEGMENT



SET-UP FOR ERT MONITORING OF STEM SEGMENT





- Flow experiment with three different applied suctions and no-flow periods
- ERT monitoring with high temporal resolution using two electrode rings

ERT DATA ACQUISITION STRATEGY



- EIT40 measurement system: 40 combined current/voltage channels with flexible configuration assignment
- 20 equidistantly distributed brass electrodes per layer
- Current injection and potential measurements based on skip-8 configuration
- Total of 340 measurements are obtained per frequency and layer

OVERVIEW OF FLOW EXPERIMENT



 Amount of applied suction affects flow behaviour in stem segment as well as the salinity of the drained water

ERT IMAGING RESULTS FOR STEM SEGMENT



- Heterogeneous spatial distribution of *Re(σ)* at both planes
- Consistent variation of $Re(\sigma)$ throughout the three flow periods
- Observed breakthrough depends on the variation in applied vacuum pressure
- ERT clearly able to show radial variability of flow in the stem segment

ERT EXPERIMENTS ON LYSIMETER





- Baseline monitoring of irrigation, transpiration, sap flow, and ERT measurements
- No-irrigation period to see response to water stress

OVERVIEW OF RESULTS FROM LYSIMETER EXPERIMENT



ERT EXPERIMENTS ON LYSIMETER



- Diurnal variation in baseline period suggest variation in stem water content storage
- Clear response to water stress

EXPERIMENTS ON MATURE DATE PALM



- Two electrode layers of 20 electrodes each at 1.0 m from areal roots (layer A), and 4.7 m from ground level (layer B).
- Three dual probe sap flow sensers installed at three different depths into the stem
- Three TDR sensors 1.0 m away from the stem at 20, 40, and 60 cm depth

OVERVIEW OF RESULTS FOR MATURE DATE PALM



Sap Flux Density at different depths



- High variability in sap flux density consistent with observed high variability in electrical conductivity
- Applied stress apparent in soil water content, but transpiration and electrical conductivity do not show a strong response

ERT EXPERIMENTS ON MATURE DATE PALM



Temporal resolution is 30 minutes

Video optimised to 4 frames per second

CONCLUSIONS

- Continuous information from sensors will be an aid in the decision-making system and will improve the management of inputs (water and manpower) and thus the profitability of the plantation
- Ability of ERT to determine radial variability in water flow confirmed using laboratory experiments on stem segments
- Field ERT measurements showed variation in stem water storage and water stress as well as strong radial variability useful to guide sap flow sensor installation

WHAT IS STILL GOING ON?



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 Acquisition of sap flow estimates using different sensors including rest 	nev	V

- Acquisition of sap flow estimates using different sensors including new commercial design that provide real-time data and is suitable for use in date palm plantations (Treetoscope)
- Measurements with TreeTronic ERT system





A device for continuous measurement of frond elongation: Central and Northern Arava R&D

Zhen, J., Tripler, E., Peng, X., and Lazarovitch, N. (2017). A wireless device for continuous frond elongation measurement. Computers and Electronics in Agriculture, 140:1-7.



Daily frond elongation in two yield loads (0 and 100 %): Central and Northern Arava R&D

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