MODELING WATER MOVEMENT THROUGH A FLORIDA SPODOSOL AND ENTISOL USING HYDRUS-2D

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Introduction

- Citrus production in Florida accounts for ~63% of national production.
- Understanding citrus water movement in the soil is important for sound irrigation management and water conservation.
- Irrigation management in Florida is key to improved citrus yields due to the sandy soil characteristic that makes irrigation scheduling extremely difficult.

Objective

To measure and predict water movement patterns within a 0.5-m radius by 0.6-m deep simulation domain using drip- and microsprinkler irrigation.

Governing Equations

The predictive equation for the unsaturated hydraulic function in terms of soil water retention parameters is given by van Genuchten (1980) as:

$$\theta(h) = \begin{cases} \theta_r + \dfrac{\theta_s-\theta_r}{[1+|\alpha h|^n]^m} & h<0 \\ \theta_s & h \geq 0 \end{cases}$$

$$K(h) = K_s S_e^l \left[1-\left(1-S_e^{1/m}\right)^m\right]^2$$

Where

$$m = 1-\frac{1}{n}, \quad n>1$$

$$S_e = \frac{(\theta-\theta r)}{(\theta_s-\theta_r)}$$

Where θ_r, θ_s, K_s and l are residual water content (L^3L^{-3}), saturated water content (L^3L^{-3}), saturated hydraulic conductivity (LT^{-1}), and pore connectivity.

α (L^{-1}) and n are empirical coefficients affecting the shape of the hydraulic functions.

The governing flow equations for water flow and nutrient transport are given by the Richards (1931)

$$\frac{\partial\theta}{\partial t} = \frac{\partial}{\partial x_i}\left[K\left(K_{ij}^A \frac{\partial h}{\partial x_j} + K_{iz}^A\right)\right] - s(h)$$

Where θ is the volumetric water content [L^3L^{-3}], h is the pressure head [L], , x_i (i=1, 2) are the spatial coordinates [L] for two-dimensional flow, t is time [T], K_{ij}^A are components of a dimensionless anisotropy tensor K^A (which reduces to the unit matrix when the medium is isotropic), K is the unsaturated hydraulic conductivity function (LT^{-1}), and s is a sink/source term [$L^3L^{-3}T^{-1}$], accounting for root water uptake (transpiration). The sink/source represents the volume of water removed per unit time from a unit volume of soil due to compensated citrus water uptake.

Materials and Methods

Study sites

The studies were conducted at
1) the University of Florida, Southwest Florida Research and Education Center, Immokalee, Fla. (26 25' N, 81 25' W) in the Florida Flatwoods and
2) near the Citrus Research and Education Center, Lake Alfred, Fla. (28°5' N, 81°45' W) on the Florida Ridge.

Irrigation treatments

Treatments were as follows:
(1) Conventional microsprinkler practice (CMP) – irrigated weekly;
(2) Drip open hydroponics system (DOHS) – irrigated daily in small pulses;
(3) Microsprinkler open hydroponics system (MOHS) – irrigated daily.

Estimation of soil moisture

•Determination of soil water release curves (SWRC) at 0 through 100 kPa.

•Gravimetric and sensor-based measurement of soil moisture content.

•Use of Br tracer for monitoring water movement.

•Calibration of HYDRUS-2D using site-specific data.

•Simulation of water movement through a 0.5-m radius by 0.6-m deep simulation domain.

Discussion and Conclusions

•Results indicate reasonably good agreements between measured and predicted values water content (R^2 > 0.87).

•Br movement was also well predicted (R^2 > 0.87 and RMSE 0.04 -0.46 mg/kg)

•The results suggest that a carefully calibrated HYDRUS-2D model could be used for irrigation decision support on Florida's Spodosols and Entisols.

Results

Table 1. Statistical comparison between observed and simulated water contents in spring and summer 2011

Soil	¶Comparison	R^2
Candler	OBS vs. MS –spring at 10 cm	0.99
Candler	OBS vs. MS –spring at 40 cm	0.87
Candler	OBS vs. DRIP-spring at 10 cm	0.99
Candler	OBS vs. DRIP-spring at 40 cm	0.93
Candler	DRIP vs. MS at 10 cm	1.00
Candler	DRIP vs. MS at 40 cm	1.00
Immokalee	OBS vs. MS-spring at 10 cm	0.99
Immokalee	OBS vs. DRIP-spring at 10 cm	1.00
Immokalee	OBS vs. MS-spring at 40cm	1.00
Immokalee	OBS vs. DRIP-spring at 40 cm	0.95
Immokalee	DRIP vs. MS-spring at 10 cm	1.00
Immokalee	Drip vs. MS-spring at 40 cm	0.99
Immokalee	OBS vs. MS-summer at 10 cm	0.99
Immokalee	OBS vs. DRIP-summer at 10 cm	0.96
Immokalee	OBS vs. MS-summer at 40cm	0.99
Immokalee	OBS vs. DRIP-summer at 40 cm	1.00

¶OBS-Observed or measured in the field, MS-Microsprinkler irrigation, DRIP-Drip irrigation, R^2-Coefficient of determination

Table 2: Statistical comparison between observed and simulated Br contents in spring and summer 2011.

Soil	¶Comparison	R^2	RMSE (mg kg^{-1})
Candler	OBS vs. MS –spring at 10 cm	0.89	0.18
Candler	OBS vs. MS –spring at 40 cm	0.76	0.25
Candler	OBS vs. DRIP-spring at 10 cm	0.96	0.35
Candler	OBS vs. DRIP-spring at 40 cm	0.75	0.46
Immokalee	OBS vs. MS-spring at 10 cm	0.79	0.57
Immokalee	OBS vs. DRIP-spring at 10 cm	0.90	0.44
Immokalee	OBS vs. MS-spring at 40cm	0.74	0.06
Immokalee	OBS vs. DRIP-spring at 40 cm	0.63	0.04

¶OBS-Observed or measured in the field, MS-Microsprinkler irrigation, DRIP-Drip irrigation, R^2-Coefficient of determination , RMSE-Root mean square error

References

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