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RESEARCH ARTICLE

Effect of split drip irrigation with limited water supply on soil water-salt dynamics and crop growth in a saline soil

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SUPPLEMENTARY MATERIALS

S1 Material and methods captions

S1.1 Model description

Hydrus-2D model was developed by Šimůnek et al.[1] to simulated the 2-dimensinal flow of soil water, heat, solute and viruses in variably saturated-unsaturated media (www.HYDRUS.com). In this study, Hydrus-2D was applied to calculate the water flow and nitrogen transport and transformation. Below we give an overview of the main Hydrus-2D processes that were involved in this study.

S1.1.1 Water flow

Consider two-dimensional isothermal Darcian flow of water in a variably saturated rigid porous medium and assume that the air phase plays an insignificant role in the liquid flow process. The governing flow equation for these conditions is given by the following modified form of the Richards' equation:

$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial x}\left[K(h)\frac{\partial \mathrm{h}}{\partial x}\right] + \frac{\partial}{\partial z}\left[K(h)\frac{\partial h}{\partial z}\right] + \frac{\partial K(h)}{\partial x} - \mathrm{S} \qquad (1)$$

where θ is the volumetric water content of the soil ($cm^3 \cdot cm^{-3}$), t is the time (d), x is the horizontal axis (cm), $K(h)$ is the hydraulic conductivity ($cm \cdot d^{-1}$), h is the pressure head (cm), z is the vertical coordinate taken positive upwards (cm), and S is the sink term accounting for water uptake by plant roots ($cm^3 \cdot cm^{-3} \cdot d^{-1}$), here is 0. The unsaturated soil hydraulic properties are described using the van Genuchten–Mualem functional relationships[2].

S1.1.2 Solute transport

The general form of equation for soil salt migration in unsaturated soils is as follows:

$$\frac{\partial(\theta C)}{\partial t} = \frac{\partial}{\partial x}\left[\theta D \frac{\partial C}{\partial x}\right] + \frac{\partial}{\partial z}\left[\theta D \frac{\partial C}{\partial z}\right] + \frac{\partial}{\partial z}(q_w C) \qquad (2)$$

where C is the solute concentration in soil ($g \cdot cm^{-3}$), D is the dispersion coefficient ($cm^2 \cdot d^{-1}$), q_w is the water flux ($cm \cdot d^{-1}$). Solute transport parameters were estimated with methods given by Mallants et al.[3] and Toride et al.[4].

S1.1.3 Initial and boundary conditions

The two-dimensional transport domain was defined as a rectangle with a width of 45 cm and a depth of 50 cm (Fig. 1). Measured values of soil water content and salt contents were used as the initial condition in the model. There were four boundary conditions defined in Hydrus-2D, including the upper boundary, the bottom boundary, and two lateral boundaries (the left and right boundary). The time-variable flux boundary condition was specified at the emitter to represent drip irrigation. The emitter fluxes were represented in Hydrus-2D with a 5-cm long time-variable boundary conditions and is calculated as follows:

$$q = \frac{Q}{L} \qquad (3)$$

where q is the boundary flux ($cm \cdot d^{-1}$), Q is the actual emitter flux ($cm^2 \cdot d^{-1}$), and L is the width of the variable flux boundary condition (cm).

Table S1 Comparison between the simulated and measured values at different points

Item		P1	P2	P3	P5	P6	P7
Soil water content ($cm^3 \cdot cm^{-3}$)							
One-time drip irrigation	RMSE	0.018	0.020	0.026	0.013	0.012	0.012
	NSE	0.895	0.767	–1.174	0.732	0.495	0.425
Split drip irrigation	RMSE	0.025	0.027	0.017	0.022	0.020	0.011
	NSE	0.421	0.190	0.495	–0.180	–1.129	0.541
Soil salt content ($g \cdot kg^{-1}$)							
One-time drip irrigation	RMSE	0.150	0.211	0.103	0.127	0.173	0.145
	NSE	–2.932	–0.302	0.829	0.645	–0.100	–0.189
Split drip irrigation	RMSE	0.158	0.253	0.160	0.085	0.071	0.117
	NSE	0.900	0.780	0.448	0.753	0.867	–0.134

Table S2 Soil salt reduction within the 0–5 cm layer around the drip emitter under drip irrigation

Soil salt content	One-time drip irrigation		Split drip irrigation 0–5 cm		Split drip irrigation 0–15 cm	
	0–5 cm	0–15 cm	First time	Second time	First time	Second time
Initial ($g \cdot kg^{-1}$)	3	3	3	1.28 ± 0.10	3	2.12 ± 0.97
After irrigation ($g \cdot kg^{-1}$)	0.54 ± 0.05	1.75 ± 1.40	1.64 ± 0.23	0.46 ± 0.10	2.32 ± 0.80	1.70 ± 1.40
Desalination ratio	82.00%	41.67%	45.33%	64.06%	22.67%	19.81%
Final ($g \cdot kg^{-1}$)	0.46 ± 0.21	1.41 ± 1.11	–	0.41 ± 0.17	–	1.47 ± 1.23
Final desalination ratio	84.67%	53.00%	–	86.33%	–	51.00%

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