IRRIGATION PRACTICES THAT IMPROVE DRIP FUMIGATION

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Fumigants are being applied through drip irrigation systems. Drip fumigation has become an increasingly popular alternative in California where about 8000 acres of strawberries, melons, and peppers were drip fumigated with 1,3-D or chloropicrin in 2003. When fumigants are applied in irrigation water, the primary means of distribution of the fumigant through the soil appears to be with the water with little movement beyond the wetted area. Thus, it becomes critical to distribute the water throughout the root zone in order to fully control pests and pathogens.

A limitation to drip fumigation is how far horizontally the water and fumigant can be spread from a drip tape emitter. This will determine how closely the emitters and tapes must be spaced to get complete treatment of a planting bed, and thus, how many tapes must be used and how much the application system costs. While one or two drip tapes in a strawberry bed may be sufficient to irrigate the crop, this may not be sufficient to fully fumigate the bed.

Management techniques have been proposed to increase the horizontal spread of water from drip tape, including pre-irrigation to wet the beds, high application rates, and pulsing the water. The objective of this study is to test these techniques to determine application practices that can maximize the relative horizontal-to-vertical water movement from a drip tape.

Methods

We approached this complex problem from two directions. Well-tested computer simulation models of water movement in soils are available and enable efficient testing of a wide range of practices on a wide range of soil. However, because soil is extremely complex and difficult to fully describe (parameterize), it is critical to verify that the simulations are accurate. Thus we concurrently measured and simulated water distribution from drip tape. We use HYDRUS-2D, a finite element Richard's equation-based porous media flow model (Šimůnek et al. 1999), to simulate water distributions.

We measured water distributions in the field from 4 m long sections of drip tape placed just below the surface in flat, freshly-tilled, dry, Hanford sandy loam soil. Water distributions were measured by applying water, excavating a pit and exposing a face perpendicular to the drip tape, observing and recording the visible wetting pattern, and measuring the water distribution on a sampling grid gravimetrically or with time domain reflectometry (TDR).

In the first phase of this project (Skaggs et al. 2004), the accuracy of the model was validated for constant flows from a drip tape in Hanford sandy loam soil. In the current phase of the project, we are measuring and simulating the effects of varying flow rates (2, 4, and 6 L/m/h) and flow sequences (three or four consecutive on/off periods). We have also simulated the impact of pre-irrigation (precedent soil water content) and the relative movement of water and solutes in the water. Measurements and simulations were evaluated immediately following the irrigation, and 24 hrs later.

Results

Simulations tested the effect of application rate (2, 4, and 8 L/m/h), application sequence (4 equal consecutive flow and non-flow periods, and 3 equal flow periods interrupted by 2 non-flow periods three times as long as the flow periods), and precedent soil water content (1/3 bar (field capacity = 16%) and 50% available (about 75% of field capacity = 11%)). The simulations are summarized in Table 1 which shows the ratio of the horizontal to vertical water movement (wetting front) from the drip tape at the end of the irrigation. In general, lower application rates and lower precedent soil water content resulted in slightly greater horizontal movement of the water and solutes. However the differences were relatively small – typically less than 10%. Application sequences had small and inconsistent effect. In dry soil, the solutes moved with the water, but in pre-wetted soils, solutes tended to lag slightly behind the water in the horizontal direction. After 24 hrs, the relative horizontal to vertical spread was similar to that immediately following the irrigation.

Measured water distributions in dry soil (average of 2 or 3 replications) exhibited no trends and more random variability than the simulations (as expected, due to the non-homogeneous nature of field soils).

That lack of clear trends, other than the effect of high precedent soil water content, is not unexpected. Soil texture and water content are the primary determinant factors in soil capillary forces that determine horizontal water movement. The downward gravity force remains constant. It is not possible to “push” water through soils with surface drip tape – and in fact, high application rates tends to favor gravity forces as indicated by the simulations.

Future plans are to study additional soil textures (esp. sandy soils) with both simulation and field measurements, and to conduct field measurements with high precedent soil water contents.

References

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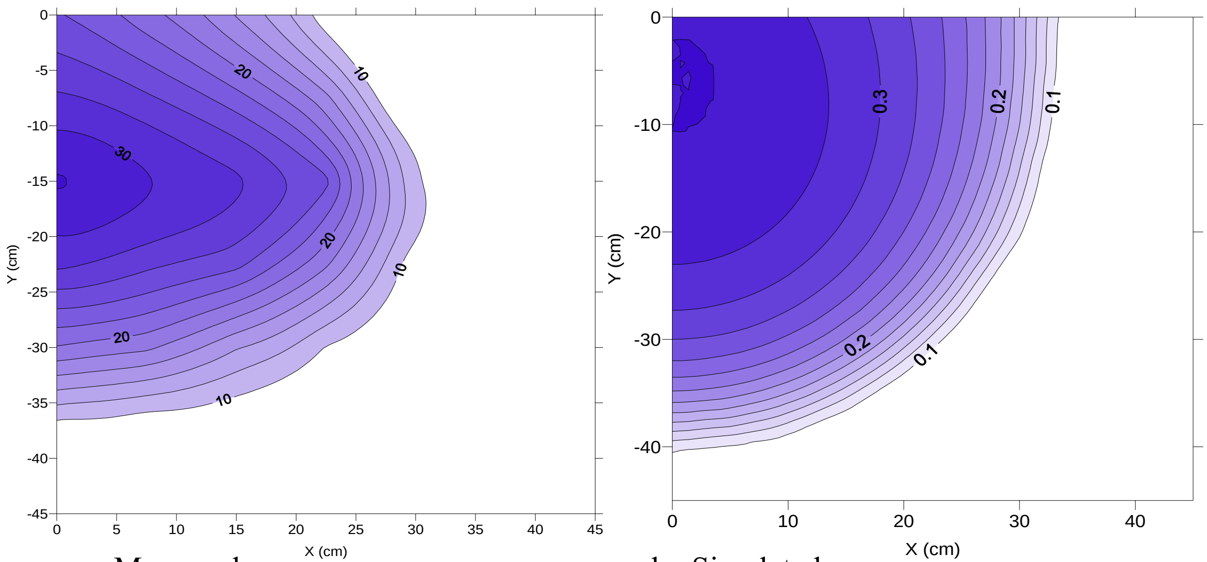

a. Measured

b. Simulated

Figure 1. Water distributions from a drip tape: 2 L/m/h flow rate, 40 L/m continuous application, precedent SWC = 6% (dry).

Table 1. Measured and Simulated wetted area from a drip tape immediately following a 40 L/m irrigation. Sequence is Continuous, 4 equal fractional applications with equal intermediate off times, or 3 equal fractional applications with 3x extended off times. SWC = Soil Water Content before irrigation (%).

			Simulated			Measured		
Flow Rate	Sequence	SWC	Hor	Vert	Ratio H/V	Hor	Vert	Ratio H/V
L/m/h		%	cm	cm		cm	cm	
2	Continuous	6	37	42	.88	31	36	.86
4	Continuous	6	33	40	.83	27	35	.77
6	Continuous	6	31	39	.79	31	35	.89
8	Continuous	6	30	38	.80			
4	4 intervals	6	36	42	.86	31	47	.66
4	3 intervals	6	39	45	.86	30	36	.83
2	Continuous	11	39	44	.89			
4	Continuous	11	35	43	.82			
8	Continuous	11	32	40	.80			
2	Continuous	16	42	51	.83			
4	Continuous	16	38	48	.79			
8	Continuous	16	35	45	.78			