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Soil wetting patterns under surface drip irrigation for different soil conditions

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During the design process of a drip irrigation system the flow rate and the distance between emitters must be selected to achieve an adequate soil wetting pattern for crop root extension, taking into account crop irrigation needs. As wetting patterns strongly depend on soil hydraulic characteristics, it is convenient to carry out field tests under the same field conditions where the irrigation system is planned. These field tests consist of applying a volume of water similar to the irrigation water needs, using different emitter flow rates, and then measuring the maximum radius and depth of the wetting pattern. Irrigation manuals usually propose the excavation of a soil pit to visually identify the maximum radius and depth of the soil wetting pattern, which imposes practical limitations, one of the most important being that, depending on the soil type and the initial water content, the extension of the wetted bulb cannot be visually distinguished. To overcome the inconveniences of the soil pit method, an alternative procedure using a portable time domain reflectometer (TDR) with access tubes is proposed. The field tests consisted of measuring soil water content around an isolated emitter before irrigation, immediately after it and 24 hours later. These soil water content readings were made in two perpendicular directions from the emitter and the mean value was considered. The maximum radial extension and depth of the sampling grid were 75 cm and 150 cm, respectively, and the soil water readings were spaced 15 cm in horizontal and vertical directions. The soil tests were conducted in three representative agricultural soils in Girona (Spain): Oxyaquic Xerofluvents, Typic Calcixerepts and Typic Haploxeralfs. In each soil the different soil horizons were described and the particle size and bulk density were characterized.

Four different emitter flow rates (2, 4, 8.5 and 24 L/h) were tested for the different soil types. The average maximum radius and depth of the wetting pattern were determined by comparing the measured water contents before and after irrigation.

The consistency of the experimental soil water readings was tested by comparing these values with those simulated with a model based on the numerical solution of Richards' equation. A mass balance was also calculated from the experimental soil water readings.

The proposed method for field test using TDR was robust and obtained the maximum radius and depth of the wetting patterns for all the tests. In all cases the maximum radius and depth of the wetting patterns were achieved after redistribution. Experimental and simulated results showed little effect of the drip flow rate and soil type on the maximum radius and depth of the wetting patterns, for a constant irrigation volume of 25 L. The dimensions and shape of the wetting pattern, as well as the soil water contents predicted with the numerical model were in reasonably good agreement with those obtained in the field tests. The root mean square error comparing measured and simulated soil water contents ranged from 1.5% to 4.0% and the determination coefficient from 0.27 to 0.83. The mean maximum radius of the wetted bulb predicted with the numerical model was 5.9 cm wider than that determined using the field method and the depth was 6.4 cm shorter. However, there were important mass balance errors in the field tests, due to the very heterogeneous soil water contents. The limited extension explored by TDR would require a narrower sampling mesh to reduce mass balance errors.