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Estimation of infiltration in a soil column using heated fiber optics

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Infiltration is a key process in water resources management. Its measurement in irrigation events is complex and seldom calculated however, it is estimated as a percentage of the irrigation water. A better understanding of its physical principles would help to improve irrigation management by increasing irrigation efficiency and saving water, fertilizer and energy resources. On the other hand, it would be helpful to assess the suitability of a given irrigation method to certain soils.

This paper presents the study of infiltration in a constant bulk density (1.5 g/cm3) sandy-loam soil that was packed in a hexagonal transparent soil column of 1 m diagonal and 0.6 m height. The fiber optic cable was coiled forming three concentric helices of 20 cm, 40 cm and 60 cm diameter around the column. Heating pulses of 10 W/m were applied continuously during infiltration to a cable of 31 m length. The resulting temperature increase was measured by the Distributed Fiber Optic Temperature (DFOT) method (Silixa Ultima) with [U+F0B1] 0.1ºC accuracy and 12.5 cm spatial resolution. A water height between 1.5 and 2 cm was steadily maintained on soil surface during 120 min. The soil temperature around the fiber optic cable was monitored and logged every 2 s before, during and after infiltration. The value of the temperature integral from two minute heating pulses, applied before and after infiltration, were used to determine soil water content. Instant infiltration was determined by expression developed by Perzlmaeir et al (2004) and by the Nusselt and Prandtl non dimensional numbers. Disregarding the errors inherent to the expressions for calculating infiltration, results highlight the potential of active heat fiber optic to study spatial and temporal infiltration variability in soils.