Inverse Estimation of Soil Water Retention Curve from Infiltration Data

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Many applications involving water flow and solute transport in the vadose zone require unsaturated soil hydraulic properties. Direct methods for measuring hydraulic properties are often costly and time consuming. Inverse modeling approach uses information from easily measured data to estimate soil properties which are usually difficult to obtain. This approach has become an alternative to direct measurements. In this study, soil water retention curve was determined by inverse method using infiltration data and then compared with those obtained by conventional laboratory experiments. The field experiments were carried out at the research farm of the College of Agriculture and Natural Resources, University of Tehran, located in the Alborz Province, Karaj, Iran. Soil sample collection was carried out together with the field infiltration experiment. All measured values of water content were specified using pressure plates at pressure heads (h) of -300, -1000, -3000, -5000 and -10700 cm. Soil samples were taken to determine Mualem–van Genuchten hydraulic parameters (θ_r, residual water content, θ_s, saturated water content, α and *n*, shape parameters, and K_s, lab saturated hydraulic conductivity). A double ring infiltrometer was utilized to conduct the field infiltration experiments. The infiltration experiments were conducted for 240 minutes. The diameter of inner and outer rings was 0.2 and 0.5 m, respectively. Infiltration measurements were taken in the inner ring with three replications. Soil texture of the experimental field was mainly loam based on the USDA soil classification, characterized by a soil bulk density of 1.3 g/cm^3. Electrical Conductivity (EC) and Sodium Adsorption Ratio (SAR) of soil were 1.6 dS/m and 1.5, respectively. Soil water retention curve were inversely estimated using HYDRUS-1D model and infiltration data. HYDRUS-1D simulates water flow in the soil by the Richards equation. Variable flux, free drainage and soil water content were considered as the upper boundary, lower boundary and initial conditions, respectively. The soil hydraulic parameters were inversely estimated by minimizing the difference between observed and simulated values of cumulative infiltration data using Marquardt optimization algorithm. The coefficient of determination (R^2), root mean square errors (*RMSE*), the mean absolute error (*MAE*) and Nash–Sutcliffe efficiency (C_e) were used as evaluation criteria. The infiltration data simulated by the inverse modeling procedure (HYDRUS-1D) matched well with the observed ones (Fig. 1). The final cumulative infiltration depth (after 240 min) was 22.9 cm. There was no significant difference between the measured and simulated values of infiltration depth according to the Paired-Samples T Test procedure ($p>0.05$). Values of R^2, *RMSE*, *MAE* and C_e between the measured and simulated infiltration depths were 0.999, 0.012 cm, 0.010 cm and 0.999, respectively. Soil water retention curves were obtained regarding the optimized Mualem–van Genuchten soil hydraulic parameters (θ_r, θ_s, α, *n* and K_s). The estimated water retention curve is also presented in Fig. 1. The values of R^2, *RMSE*, *MAE* and C_e between measured and simulated soil-water content at different pressure heads were 0.877, 0.041 cm^3/cm^3, 0.031 cm^3/cm^3 and 0.83, respectively. As a consequence, the soil hydraulic parameters were adequately estimated. The estimated retention curve by the inverse solution was in good agreement with that fitted to laboratory data. The soil hydraulic parameters could be inversely estimated using the measured double-ring infiltration data. Using the inverse procedure provided a relatively simple, rapid, and reliable alternative method for determining soil water retention curve. The costs of determining soil hydraulic properties (double rings vs. pressure plate apparatus) would

be also reduced.

Keywords: Soil hydraulic properties, HYDRUS, Inverse solution, Infiltration

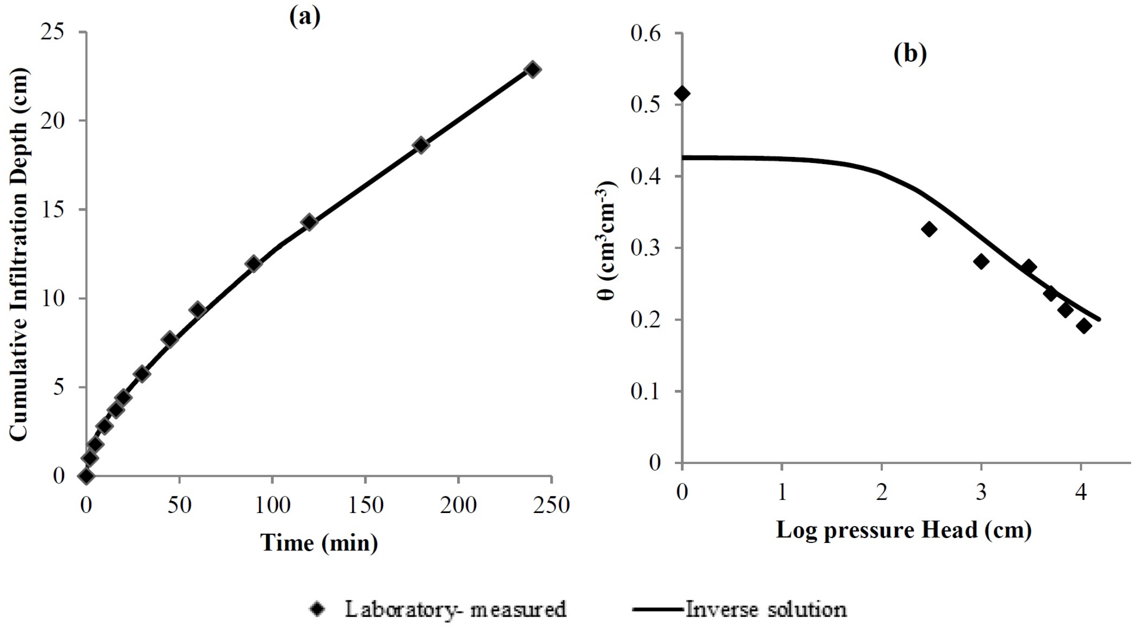

Fig. 1. Measured and estimated cumulative infiltration depths, (a); and soil water content versus pressure head, $\theta(h)$, (b)