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Improvement of HYDRUS-1D for Considering Dynamic Root Growth and Enhanced Salt Tolerance Under Different Soil Salinity and Nitrogen Applications

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Soil salinity (S) is one of the most important abiotic stresses limiting crop production in arid and semi-arid regions. To find out the effects of different S and nitrogen applications (N) on the dynamic of fine root growth and its salt tolerance enhancement, a two-year field experiment was conducted for sunflower in Hetao Irrigation District, China. The experiment consisted of a 3×2 factorial design with three salinity levels (S0: ECe=1.9 dS m-1; S1: ECe=7.4 dS m-1; S2: ECe=12.7 dS m-1) and two N rates (N1: 45 kg N ha-1; N2: 135 kg N ha-1). The dynamic development of sunflower roots was in-situ monitored with minirhizotron imaging system during the growth period, which revealed various and flexible root growth patterns among different treatments. Salt stress obviously decreased root penetration rate in the seedling stage, while it accelerated root elongation after bud initiation, especially for the roots within 35-80 cm depth. Faster root vertical development and earlier decline of root: shoot ratio were found in S0N2 and S1N2 treatments, which indicated that N2 rate enhanced sunflower salt tolerance at S0 and S1 levels. A logistic growth function was used to describe the time-varying root depth growth, and the fine root length density (FRLD) distribution was described by a modified Vrugt's function with three fitted parameters (a, pz, z*). The above two functions were also applied to improve the root growth module in HYDRUS with time-varying solute reduction parameters such as salt tolerance threshold (ECth) and slope (s), which made it available for HYDRUS to consider the change of salt tolerance in different growth stages. Soil water contents (SWC) observed in 2015 and 2016 were used for the calibration and validation of previous and modified HYDRUS and the results proved that the modified model could greatly improve the simulation accuracy on SWC under saline conditions.