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A new compensated root water and nutrient uptake model implemented in HYDRUS programs

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Plant root water and nutrient uptake is one of the most important processes in subsurface unsaturated flow and transport modeling, as root uptake controls actual plant evapotranspiration, water recharge and nutrient leaching to the groundwater. Root water uptake in unsaturated flow models is usually uncompensated and nutrient uptake is simulated assuming that all uptake is passive. We present a new compensated root water and nutrient uptake model, implemented in HYDRUS programs. The so-called root adaptability factor (Jarvis, 1989) is used to represent a threshold value above which reduced root water or nutrient uptake in water- or nutrient-stressed parts of the root zone is fully compensated for by increased uptake in other soil regions that are less stressed. Using a critical value of the water stress index, water uptake compensation is proportional to the water stress response function.

Total root nutrient uptake is determined from the total of active and passive nutrient uptake. The partitioning between passive and active uptake is controlled by the a priori defined concentration value c_max. Passive nutrient uptake is simulated by multiplying root water uptake with the dissolved nutrient concentration, for soil solution concentration values below c_max. Passive nutrient uptake is thus zero when c_max is equal to zero. As the active nutrient uptake is obtained from the difference between plant nutrient demand and passive nutrient uptake (using Michaelis-Menten kinetics), the presented model thus implies that reduced passive nutrient uptake is compensated for by active nutrient uptake. In addition, the proposed root uptake model includes compensation for active nutrient uptake, in a similar way as used for root water uptake.

The proposed root water and nutrient uptake model is demonstrated by several hypothetical and real examples, for plants supplied by water due to capillary rise from groundwater and surface drip irrigation.