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Cumulative Nutrient Uptake by Roots of Crops as Simulated by Fixed and Moving Boundary Models. Corrections and Improvements

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ABSTRACT

This work examines the relevance of physical models used to study the flux and nutrient uptake by roots of crops. The physical models studied are the one-dimensional fixed boundary model of Cushman-Barber [1] and an improved version of our one-dimensional moving boundary model [2].
The moving boundary model is solved by immobilizing the domain in dimensionless variables and computed by the finite elements method. To estimate the cumulative nutrient uptake a generalized and verified formula is used for both models. For simulations of nutrient uptake five datum sets extracted from literature were used. First, we compute the cumulative uptake of nutrient of low mobility as K and P by pine seedling in high soil concentrations. Second, we compute the cumulative uptake of high mobility as N by rice, wheat and rape in high soil concentrations. Third, we compute the P uptake for peanut for low, intermediate and high soil concentrations. Four, we compute the K uptake by maize, wheat and sugar beet for low K soil and soil with K addition and finally we compute the P uptake by wheat to low concentrations. The results obtained show that both models produce similar results for ions without limitations of availability, low variation of root density and low Peclet numbers. For low concentrations, large variations of root density and low numbers of Peclet the moving boundary produces better predictions particularly for K. For P the moving boundary produces better predictions only at low concentrations being these predictions comparable to the obtained by 3D-dimensional architectural models [3]. Obtained improvements are mainly due to three factors: the use of a generalized formula for the cumulative nutrient uptake, the use of same dynamics to obtain influxes and the cumulative uptake in the moving boundary model, and the use the finite elements method. Finally, in the light of these findings, conclusions drawn by previous papers [4] could be reinterpreted.

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