XVIII International Conference on Water Resources
CMWR 2010
J. Carrera (Ed)
CIMNE, Barcelona 2010

MODELING HETEROGENEITIES IN ROOT WATER EXTRACTION

Quirijn de Jong van Lier*, Klaas Metselaar†, Angelica Durigon*

* Department of Biosystems Engineering, University of São Paulo
C.P. 9, 13418-900 Piracicaba (SP), Brazil
e-mail: qdjvlier@esalq.usp.br; adurigon@esalq.usp.br, web page: http://www.esalq.usp.br

† Wageningen University, The Netherlands
e-mail: klaas.metselaar@wur.nl, web page: http://www.wur.nl

Summary. Physically based root water extraction models usually apply an analytical or numerical solution of the Richards equation for a set of boundary conditions. These models can be employed for the prediction of soil water extraction and transpiration rates as a function of soil hydraulic conditions, rooting characteristics and atmospheric demand. Recently we developed such a model at the single root scale and upscaled it to the root system scale, dealing with the macroscopic heterogeneity, i.e., differences between soil hydraulic status and rooting density between soil layers. Comparisons to experimental data showed that it was possible to make predictions about root water extraction partition over several layers with distinct hydraulic and/or rooting characteristics. To do so, however, it was necessary to include a root system efficiency factor, coping for mesoscale heterogeneity, i.e., the effects of uneven root distribution within layers.

We propose a new modeling approach to deal physically with this mesoscale heterogeneity. We suppose each soil layer to be composed of two or more sub-volumes which have homogeneous rooting density characteristics at the mesoscale level. Extraction partition is then estimated analogously to the existing macroscopic partitioning model. Water flow between sub-volumes is calculated as a function of pressure heads in the sub-volumes and their contact area. Results are compared to observations in a greenhouse experiment with common bean plants.

Including the mesoscale heterogeneity in the model shows to result in an earlier modeled onset of limiting hydraulic conditions and lower relative transpirations in the early stage of the falling rate phase; the final stage of the falling rate phase shows slightly higher values of relative transpiration when including mesoscale heterogeneity. These effects become stronger with diminishing specific surface area of the sub-volumes. Compared to differences with observed values of relative transpiration, alterations in model estimates by the inclusion of mesoscale heterogeneities in root length density is small. The root water extraction model based on the matric flux potential concept is relatively insensitive to these mesoscale heterogeneities and their detailed description seems not to be a priority in applying or calibrating this model.