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Modelling competition for water between tree and crop roots in an agroforestry system

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In times of climate change, many regions of the world suffer from heat waves and drought periods, which can lead to failure of crops. To a certain extent, irrigation can help to overcome these extreme events. However, in a sustainable agricultural system the water and nutrient applications should be minimized in order to avoid the waste of valuable resources.

Another method to use water more efficiently is the introduction of agroforestry systems, e.g. planting tree strips within a field. On the one hand, these tree strips reduce the evapotranspiration of the crop-soil-system due to shading and reduction of wind speed. On the other hand, temperatures tend to be higher near the trees and the tree roots may deplete available water and nutrient resources for crops.

Recently, an agroforestry sub-model has been implemented into the modular model system Expert-N to simultaneously simulate tree and crop growth. In principle, trees and crops are simulated separately at different grid points next to each other. However, the agroforestry sub-model allows for the exchange of water and matter between the different grid points to simulate mutual influences of trees and crops. Up to now the following processes are considered: shading, distribution of dead tree biomass to the crop area, and changed water distribution as tree roots grow into the crop area.

Depending on the simulated tree root length density at the crop grid points, the tree roots can uptake a certain amount of water from neighbouring grid points. If the total water demand of trees and crops cannot be fulfilled, the water uptake at the respective grid point is reduced for both, trees and crops.

Expert-N is used to simulate the plant production and the water cycle within an agroforestry system. The results comprise plant biomasses, leaf area indices, evapotranspiration, and soil water contents. To show the impact of the agroforestry sub-model on the simulation results, the differences between two simulations, which only vary in the activation of the agroforestry sub-model, are presented and discussed.