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Soil hydrology of agroforestry systems: Competition for water or positive tree-crops interactions?

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In dry periods during the growing season crops may suffer from severe water stress. The question arises whether the alternation of crop and tree strips might enhance and sustain soil water resources available for crops during drought events. Trees reduce wind exposure, decreasing the potential evapotranspiration of crops and soils; additionally hydraulic lift from the deep roots of trees to the drier top soil might provide additional water for shallow-rooted crops. To understand the above and belowground water relations of agroforestry systems, we measured soil moisture and soil water potential in crop strips as a function of distance to the trees at varying depth as well as meteorological parameters.

At the agroforestry site Reiffenhausen, Lower Saxony, Germany, two different tree species are planted, each in one separated tree strip: willow breed Tordis (*(Salix viminalis x Salix Schwerinii) x Salix viminalis*) and poplar clone Max 1 (*Populus nigra x Populus maximowiczii*). In between the tree strips a crop strip of 24 m width was established with annual crop rotation, managed the same way as the reference site.

During a drought period in May 2016 with less than 2 mm rain in four weeks, an overall positive effect on hydrological conditions of the agroforestry system was observed. The results show that trees shaded the soil surface, lowering the air temperature and further increasing the soil moisture in the crop strips compared to the reference site, which was located far from the trees. At the reference site the crops took up water in the upper soil (<20 cm depth); after the soil reached water potentials below -100 kPa, root water uptake moved to deeper soil layers (<40 cm). Because of the higher wind and solar radiation exposure the reference soil profile was severely dried out. Also in the crop strips of the agroforestry system, crops took up water in the upper soil. However, the lower soil layers remained wet for an extended period of time. The tree strips reduced the wind speed, hence lowering evapotranspiration in the crop strip. The plot was not aligned directly to North and we observed steeper soil water potential gradients in the part of the crop strip more exposed to sunlight.

The two tree species behaved differently. The poplar strips showed more marked diurnal changes in soil water potential, with fast drying during daytime and rewetting during nighttime. We suppose that the rewetting during nighttime was caused by hydraulic lift, which supports passively the drier upper soil with water from the wetter, lower soil layers.

This experimental study shows the importance of above- and belowground tree-crop interactions and demonstrate the positive effect of tree strips in reducing drought stress in crops.