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# Comparing soil functions for a wide range of agriculture soils focusing on production for bioenergy using a combined isotope-based observation and modelling approach

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Increase crop production for bioenergy will result in changes in land use and the resulting soil functions and may generate new chances and risks. However, detailed data and information are still missing how soil function may be altered under changing crop productions for bioenergy, in particular for a wide range of agricultural soils since most data are currently derived from individual experimental sites studying different bioenergy crops at one location.

We developed a new, rapid measurement approach to investigate the influence of bioenergy plants on the water cycle and different soil functions (filter and buffer of water and N-cycling).
For this approach, we drilled 89 soil cores (1-3 m deep) in spring and fall at 11 sites with different soil properties and climatic conditions comparing different crops (grass, corn, willow, poplar, and other less common bioenergy crops) and analyzing 1150 soil samples for water content, nitrate concentration and stable water isotopes. We benchmarked a soil hydrological model (1-D numerical Richards equation, ADE, water isotope fractionation including liquid and vapor composition of isotopes) using longer-term climate variables and water isotopes in precipitation to derive crop specific parameterization and to specifically validate the differences in water transport and water partitioning into evaporation, transpiration and groundwater recharge among the sites and crops using the water isotopes in particular. The model simulation were in good agreement with the observed isotope profiles and allowed us to differentiate among the different crops.

We defined different indicators for the soil functions considered in this study. These indicators included the proportion of groundwater recharge, transit time of water (different percentiles) though the upper 2m and nutrient leaching potential (e.g. nitrate) during the dormant season from the rooting zone. The parameterized model was first used to calculate the indicators for the sampled locations and to derive the changes in soil functions by altering the land cover among the different bioenergy crops in comparison to the grassland as a reference. We could show that percolation is strongly influenced by the crops and climate, the transit time is influenced by a combination of soil type, climate and land use, but the effect of soil type is very strong and the nitrate leaching is strongly influenced by soil type. The high variability of transit times and nitrate leaching are due to high variability of the temporal distribution of precipitation.

Finally, the model was used to regionalized the indicators to a wide range of soils in the state of Baden-Württemberg and to assess if there are locations where bioenergy crops may improve the considered soil function. Our idea behind this was to propose location where specific bioenergy crops may be highly suitable to improve the current soil function to increase for example the protection of groundwater for drinking water, reduce erosion risk or increase water availability. The proposed method allows to assess the influence of different bioenergy crops on soil functions without costly multi-year measurement systems for assessing the soil functions using soil water content measurements or/and soil water suction devices.