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Nutrient leaching losses and nutrient retention efficiencies in temperate agroforestry systems versus conventional agricultural systems

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Intensively managed agriculture is often accompanied by detrimental environmental effects such as nutrient leaching losses to the groundwater and greenhouse gas emissions to the atmosphere. This results in a strong need for more environmentally friendly agricultural management systems. Alley-cropping agroforestry systems are an example for innovative management systems that have come to increasing attention in Europe. In these systems, fast growing tree species for bioenergy use are implemented in alternating strips with cropland or grassland, and thus agroforestry systems take advantage of beneficial ecological functions of both of their components, tree and crop/grass. In such systems, trees can act as a safety-net against nutrient leaching as they can take up nutrients that are beyond the reach of shallow grass/crop roots or at times when grass/crop demand is low. However, at present no comparisons of nutrient leaching losses and nutrient retention efficiency have yet been conducted between conventional and agroforestry systems.

Our study aimed to 1) quantify nutrient leaching losses in conventional and agroforestry systems of either grassland or cropland, 2) evaluate the nutrient retention efficiency in the soil under these management systems, and 3) assess whether differences in nutrient retention efficiencies between conventional and agroforestry systems are related to differences in nutrient-cycling processes in the soil and/or to differences in plant uptake of nutrients. We hypothesized that conventional systems will have higher nutrient leaching and lower nutrient retention efficiencies than agroforestry systems.

This study was conducted at six paired sites of conventional and agroforestry systems (with alley cropping of fast growing trees) of grasslands or croplands, located in central Germany. Measurements in the agroforestry systems were taken within tree strips and at various distances to the tree strips within the grass or crop strips. Soil water samples were collected monthly in 2016 and 2017 using suction cup lysimeters. The samples were analyzed for nitrogen, phosphorus and base cation concentrations. To calculate leaching losses, water drainage flux was estimated using a novel agroforestry module of the model system Expert-N. Nutrient retention efficiency (NRE) was calculated as: 1- (leaching losses/soil-available nutrient).

At a cropland site, first results showed that nitrate concentrations in soil water were lower within the tree strips of the agroforestry system compared to the conventional system. Nitrate and ammonium concentrations in soil water did not differ between agroforestry and conventional systems at one grassland site, but were higher in the conventional than in the agroforestry system at another grassland site.

This study will provide important information on whether temperate agroforestry systems can be a sustainable alternative to conventional agriculture by reducing nutrient leaching losses to the groundwater and by optimizing nutrient retention in the soil.