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Spatial variability of soil quality indices in an arable and a grassland alley cropping agroforestry system in Germany

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Modern agriculture has caused unintended, negative effects on environment and ecosystem services (e.g. deforestation, depletion of soil organic carbon (SOC), decrease in productivity) emphasizing the need for more sustainable approaches. Agroforestry systems (AFS) combine the cultivation of trees/shrubs and annual/perennial crops/grassland within one field and are recently regarded as a sustainable multifunctional land-use alternative providing a number of ecosystem services and environmental benefits (e.g. improvement of soil quality, above- and belowground C-sequestration). Additional inputs of organic material (e.g. leaf litter, fine roots, root exudates) are associated with shifts in quantity/quality of available substrates, thus influencing soil microbial community and activity. The functional meaning of a large and diverse community of soil microorganisms in this context is crucial, since they are known as predominant drivers of a variety of soil processes, like decomposition of organic matter resulting in nutrient recycling. In the temperate zone, alley cropping systems (ACS), combining tree rows/strips with agricultural used alleys, are receiving increased attention assuming that beneficial effects of trees additionally extend towards the intercropped areas over time. However, literature indicates that our understanding about tree effects on soil microbial community within ACS under different management practices is still limited. Hence, topsoils (0-5, 5-20 cm) were sampled in different distances from tree strips (0/1/4.5 m) in four replicate transects at two german ACS within one site: poplars intercropped with barley-rape-wheat rotation, willows intercropped with grassland seeded with a mixture of ryegrass/white clover. Various soil quality indices, such as SOC, total nitrogen (TN), microbial biomass C (MBC) and N (MBN) and ergosterol were analyzed to estimate whether temperate ACS support the widespread perceived provision of soil quality improvement. Additionally, abiotic factors (pH, clay content) were determined. Furthermore, effects of tree species and magnitude of impacts on soil quality indicators as a function of tree distance and topsoil depth are presented. To account for spatial dependence within the ACS, different candidate models (independent, transect-specific-effect, spatial-power-law-model) were tested using mixed effects mod-els for each soil depth. Model selection was conducted by AIC. Significant differences were estimated by Tukey-Kramer-Tests. Results show that implementation of poplars has increased SOC, TN, MBC-to-SOC, ergosterol-to-SOC- and ergosterol-to-MBC-ratios in 0-5 cm soil depth within the tree strips, indicating an improved C-use efficiency and higher proportion of saprotrophic fungi to microbial biomass. Patterns can be attributed to inputs of aboveground plant litter associated with shifts in litter quality and absence of tillage. It can't be resolved, if the observed shift in microbial composition to a higher fungal dominance and an increased C-sequestration potential have a cause-effect relationship. Furthermore, the effect of willows is smaller in comparison to poplars suggesting tree-specific dependent processes. In both intercropped alleys no effects with increasing distance can be identified lacking effects of trees on soil quality indices in the alleys. Conceivably, tree litter deposition on intercropped areas is smaller than supposed and maybe negative effects (shadow, water) shape the interaction zone between tree strips and alleys.