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Soils organic C sequestration under poplar and willow agroforestry systems

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Short rotation coppices (SRC) as monocultures or as agroforestry (AF) applications (e.g. alley cropping) are two techniques to implement forest into agricultural practices. Despite afforestation promotes soil carbon (C) accumulation, age and type of the tree stand can affect the C accumulation in different degrees. Here, we studied the impact of afforestation on C accumulation for: i) pure SCR of willow (*Salix viminalis x Salix schwerinii*) and poplar (*Populus nigra x Populus maximowiczii*) and ii) AF cropping system with willow. Forest systems have been established within the BEST agroforestry project in Germany. Adjacent agricultural field have been used as a control.

Soil samples were collected in 2014, three years after plantation establishment, from three soil depths: 0-3, 3-20, and 20-30 cm. Total organic C, labile C (incubation of 20 g soil during 100 days with measuring of CO_2) and aggregate structure were analysed. Additionally, density fractionation of the samples from 0-3 cm was applied to separate particulate organic matter (POM) and mineral fractions. Aggregates and density fractions were analyzed for C content.

High input of plant litter as well as root exudates have led to increases of organic C in AF and SRC plots compare to cropland, mainly in the top 0-3 cm. The highest C content was found for willow SRC (18.2 g kg^{-1} soil), followed by willow-AF (15.6 g kg^{-1} soil), and poplar SRC (13.7 g kg^{-1} soil). Carbon content of cropland was 12.5 g kg^{-1} soil. Absence of ploughing caused increase portion of macroaggregates (>2000 μm) under SRC and AF in all soil layers as well as the highest percentage of C in that aggregate size class (70-80%). In contrast, C in cropland soil was mainly accumulated in small macroaggregates (250-2000 μm). Intensive mineralisation of fresh litter and old POM, taking place during first years of trees development, resulted to similar portions of free POM for willow AF, willow SRC and cropland (8%), and even lower ones for poplar SCR (4.5%). C content in the mineral fraction increased for SRC and AF 1.3-1.5 times compare to cropland, showing that the early stage of trees development lead to C accumulation in stable fractions.

CO_2 efflux from the surface 0-3 cm was in 2-3 times higher than from 3-20 cm. CO_2 efflux did not follow soil C contents and was the highest for poplar SRC plot (1.8 mg C g^{-1} soil), followed by willow AF (1.6 mg C g^{-1} soil), willow SRC (1.4 mg C g^{-1} soil) and cropland (0.8 mg C g^{-1} soil). Estimated size of labile C pool for forest soils was two times higher and decomposition rates were 1.3 times faster than for the arable site.

We conclude that afforestation in the first years mainly affects C accumulation in the top soil. Due to changing in soil structure most of the C was associated with large macroaggregates. Afforestation measures promoted C accumulation in the mineral fractions, whereas C associated with free POM even decreased in case of poplar SRC, compare to cropland soil.