INITIAL SOIL CARBON SEQUESTRATION UNDER MONO CULTURES AND SHORT ROTATION ALLEY COPPICES WITH POPLAR AND WILLOW

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Introduction

Within renewable biomass feedstock production, short rotation coppice (SRC) is the most cost- and impact-effective land use system in terms of avoiding CO_2-emissions (*Don et al. 2012*). Applied in single rows and alternating with a common agriculture practices, SRC can be identified as agroforestry systems (AFS) and may be called "alley coppices".

Due to the constant litter input, a permanent root growth and a reduced soil disturbance by e.g. ploughing, SRC may offer also a high potential of carbon (C) sequestration in soils. In the present work, we focus on the initial soil carbon sequestration in various SRC applications.

Material and Methods

Location: South of Göttingen, Germany. **Plot Design** (see **Fig. 1**):

- 1 block willow variety Tordis (**Willow-SRC**)
- 1 block poplar variety Max 1 (**Poplar-SRC**)
- 1 block 4 rows of Tordis (7,5 x 75 m) + 9 m wide grassland alleys (**Willow-AF**)

The neighbouring cropland served as a reference plot. The soil texture of the site is varying from loamy sand in the NE part to silty clay in the SW corner. Inorganic carbon was rarely detected and if, <1.4 % and thus not further considered. **Plot Installation**: **2011**.

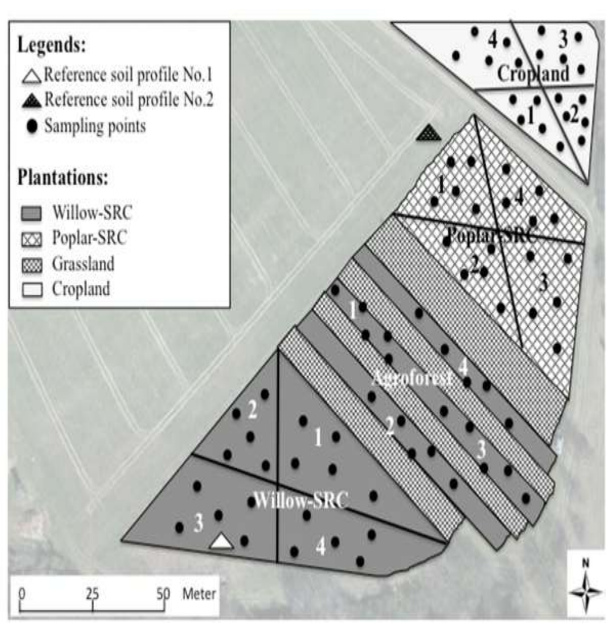

Fig.1: Soil sampling design site Reiffenhausen in 2014. Triangles indicate the location of the initial reference soil profiles applied before plot installation in 2011.

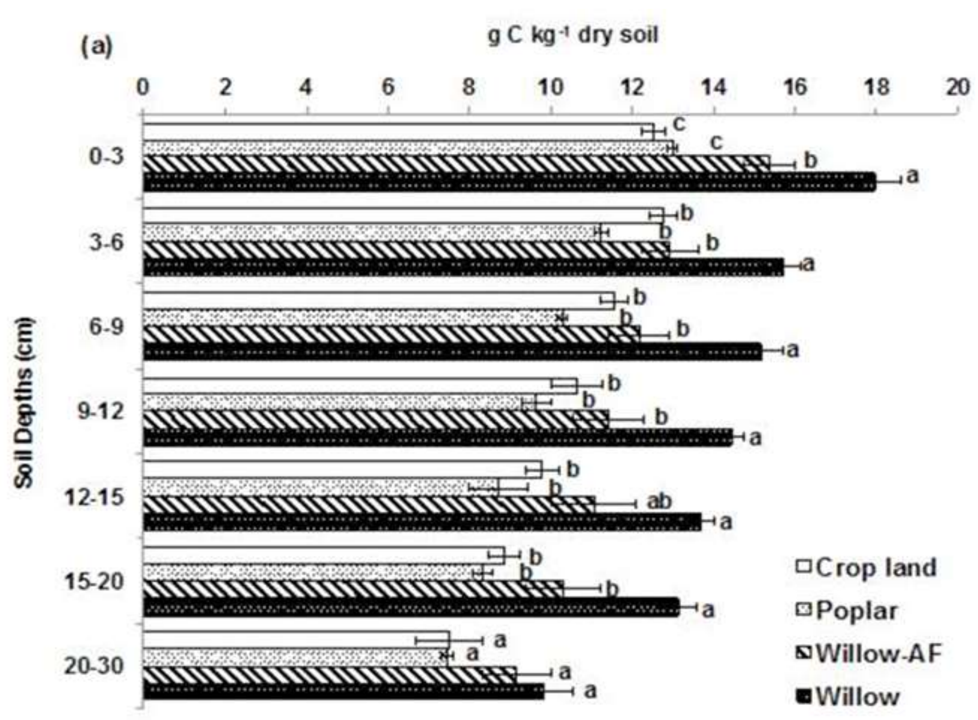

Fig. 2: Mean (± SE) total C [g kg^{-1} dry soil] distribution up to 30 cm soil depth. Different letters indicate significant difference ($p<0.05$) between plantation types at each soil depth.

Soil sampling and analyses:

A first sampling was applied to identify potential fine scale C accumulation patterns in March 2014: 7 single layers (0-3, 3-6, 6-9, 9-12, 12-15, 15-20, 20-30 cm; each five samples of single sampling spots were mixed to one composite sample per quadrat and horizon).

Results indicated a significant C accumulation under willow SRC down to a depth of 20 cm, but under willow AF only in the uppermost layer of 0-3 cm (**Fig. 2**)

A second sampling for advanced analytics with the same sampling design was applied only for the soil depths of 0-3, 3-20 and 20-30 cm in May 2014.

Aggregate size distribution (large macro-aggregates (**LMA**) >2000 µm, small macro-aggregates 250-2000 µm, micro-aggregates <250 µm) was determined by the dry sieving method.

Microbial biomass carbon (**MBC**) was measured after the fumigation-extraction procedure.

The density fractionation with sodium polytungstate solution was applied only for samples of the 0-3 cm soil layer free light fraction (**fLF**<1.6), occluded light fraction, (**oLF**<1.6), occluded dense fraction (**oDF**1.6-2.0), and mineral fraction (**MF**>2.0); [g cm^{-3}, respectively] were separated.

Results

LMA dominated at each soil depth and for all plots, with the highest portion under Willow-SRC (up to 90 %) and the lowest in the cropland (30-50 %). The LMA under Willow-SRC also accumulated the highest portion of C, whereas this aggregate size class contained significantly less carbon under cropland (data not shown).

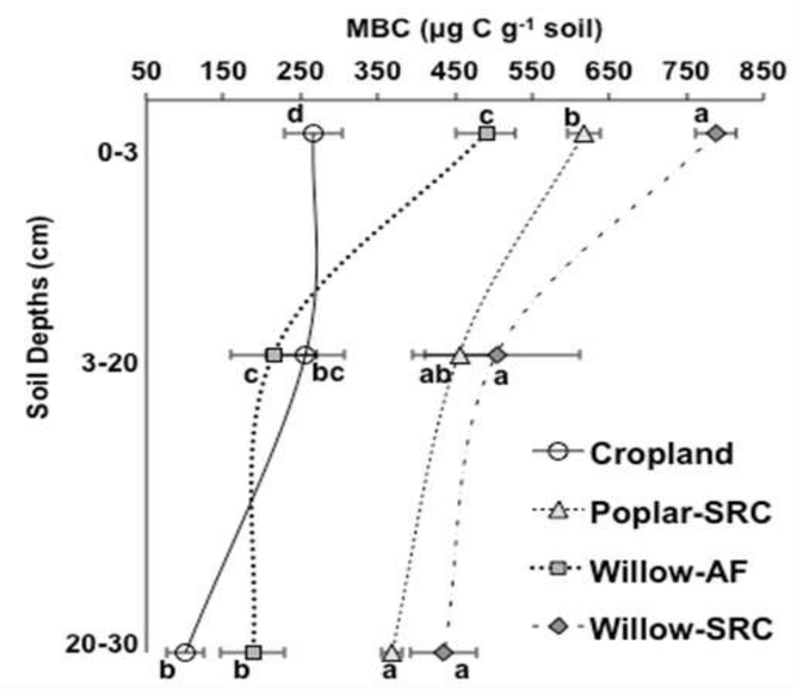

Fig. 3: Mean (± SE) microbial biomass carbon (MBC) [µg C g^{-1} dry soil] in 0-30 soil horizons. Different letters indicate significant differences ($p<0.05$) between plantation types at each soil depth.

MBC significantly increased in the order: crop land < Poplar-SRC, Willow-AF < Willow-SRC and varied in the 0-3 cm soil layer from 266 (cropland) to 789 µg C g^{-1} soil (Willow-SRC; **Fig. 3**). The MBC decreased significantly from top to bottom soil layers in all plots except the cropland, where it was uniformly distributed in the first 0-20 cm.

In all plots, the major part (ca. 80%) of total C of the top soil (0-3 cm) was associated with the MF>2.0 (**Fig. 4, right axis**), with the highest C content under Willow-SRC. The C content in the fLF<1.6 was similar in all plots (**Fig. 4, left axis**) and the lowest C content was found in the oLF<1.6 under cropland.

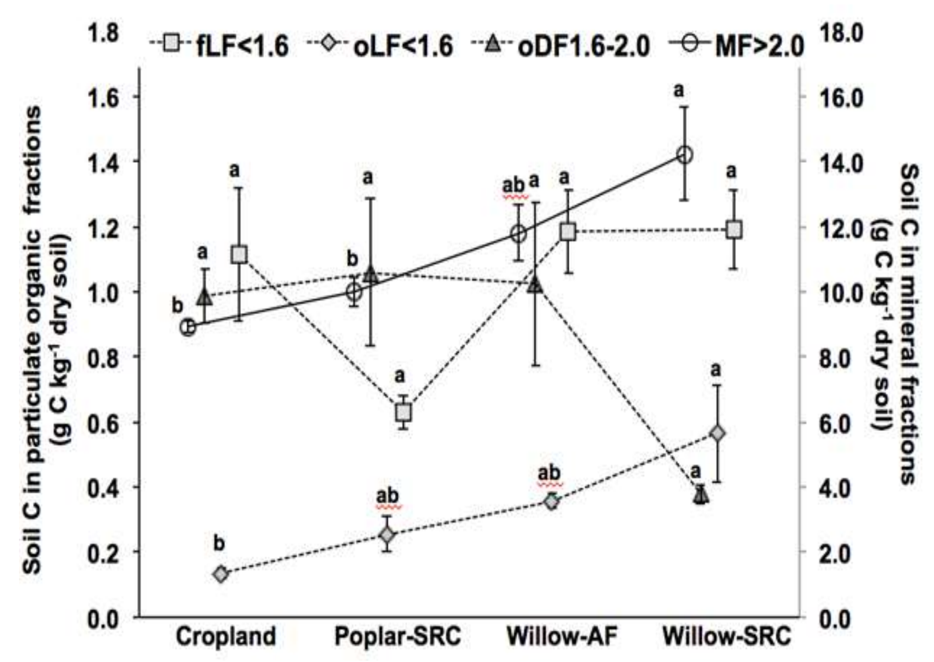

Fig. 4: Mean (± SE) C content [g C kg^{-1}] in soil fractions separated from the top soils (0-3 cm). For the fLF<1.6, oLF<1.6 and oDF 1.6-2.0, see left y-axis; for the MF>2.0, see right y-axis [g cm^{-3}, respectively]. Different letters indicate significant difference ($p<0.05$) between plantation types at each density fraction.

Discussion and conclusions

Soil texture analysis of the plots, applied prior to the SRC installation (n=3/plot, 0-30 cm soil depth; *Hartmann et al. 2014*) indicated a significantly higher clay content for the Willow-SRC plot and medium to lower values for the Willow-AF and the Poplar-SRC plot. Combined with the given C analysis, a linear increase of the C content with the clay content in the most upper 0-3 cm soil depth was found (R^2 = 0.47; see **Fig. 5**). Thus, plant community effects determine ca. 50% of the variation in C accumulation under Willow-SRC and Willow-AF.

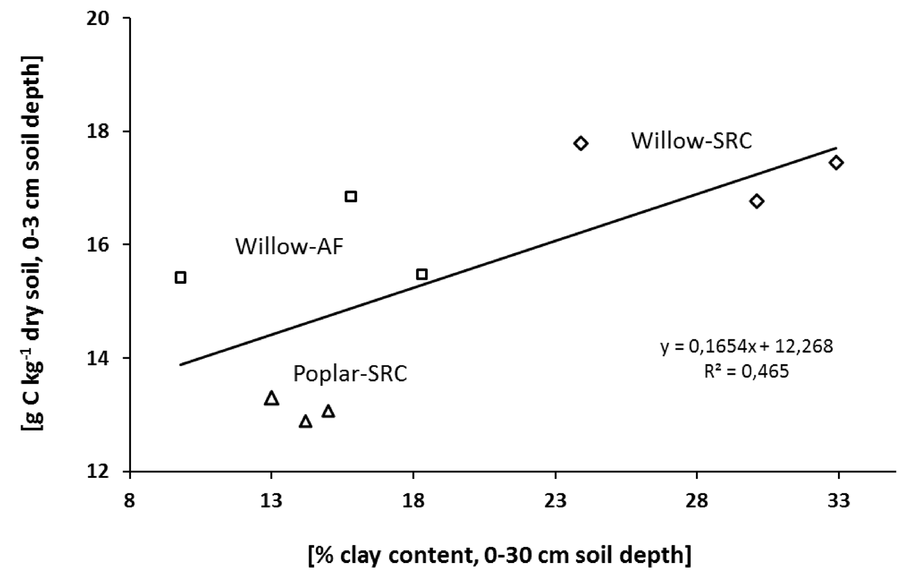

Fig. 5: Correlation between [%] clay content, before SRC installation) in 0-30 cm soil depth (n=3 per plot) and spatially related C contents [g C kg^{-1}], measured in this study in 0-3 cm soil depth (no separate clay content data were available for the cropland reference plot).

We conclude that already 3 years after the implementation of SRC a positive effect on C sequestration in the top soil layer, especially under willow, is visible. However, results have to be taken with caution, due to confounding factors (here, variations in clay content at the plot scale). Nonetheless, reduced soil disturbance is obvious under all SRC applications, which can be clearly seen from enhanced macro-aggregate formation and increased microbial biomass C accumulation.

Don A et al. (2012): GCB Bioenergy 4(4), 372-391; Hartmann L et al. (2014): Forstarchiv, 85, 134-150.

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