How do trees affect soil organic carbon (SOC) stocks in a 13-years old Swiss agroforestry system?

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1 Background

Agroforestry systems are increasingly recognised as a possible strategy to abate and mitigate climate change. Among those, alley cropping systems (ACS) offer both on the tree strips (TS) and arable strips (AS) a wide range of ecosystem services (such as carbon sequestration and improved nutrient cycling). In temperate climates, data about tree effects on key soil processes are still scarce (see Figure 3).

As a consequence, we have assessed SOC stocks and different physical, chemical, and biological soil properties in a 13-years old Swiss ACS system as a function of distance and depth to the tree.

2 Methods

Soil cores were collected using a transect-sampling design and were split into three depth segments (see Figure 1). Each soil sample was analysed for physical, chemical and biological soil properties (see Table 1). Soil organic carbon stocks were calculated on an equivalent soil mass (ESM) basis. Accumulation rates of SOC stocks for a given ESM_i (i = 2'000 Mg ha^{-1}, 6'500 Mg ha^{-1}, 11'000 Mg ha^{-1}, equivalent to ~ 0-0.2 m, 0-0.5 m, 0-0.8 m) were calculated based on following equation:

$$\text{SOC stock accumulation rate}_{ACS_i} = \frac{(p_{TS} * \text{SOC stock}_{TS_i} + p_{AS} * \text{SOC stock}_{AS_i}) - \text{SOC stock}_{control_i}}{\text{Age}}$$

where $p_{TS;AS}$ is the percentage of the aerial contribution of the TS (or AS respectively) within the ACS and $\text{SOC stock}_{TS;AS}$ is the mean SOC stock in the TS or AS. Linear mixed models were used to determine the effect of tree distance and sampling depth on soil properties.

3. Sampling Design

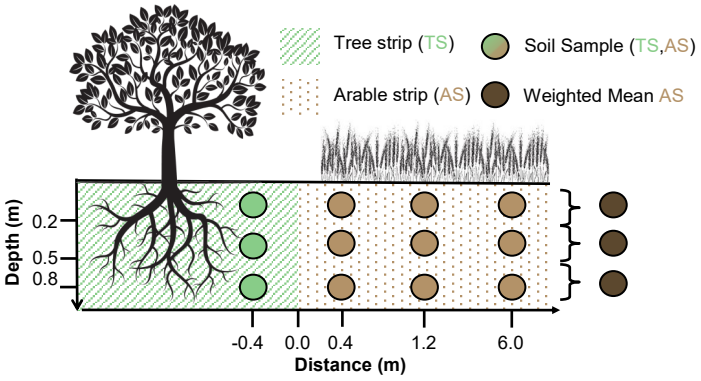

Figure 1 *Transect sampling design*

Table 1 Assessed properties

Physical	Soil bulk density, water content
Chemical	Soil organic carbon, lime content, pH, labile CNP
Biological	Soil respiration, microbial CNP, potential enzyme activities

References

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4. Results

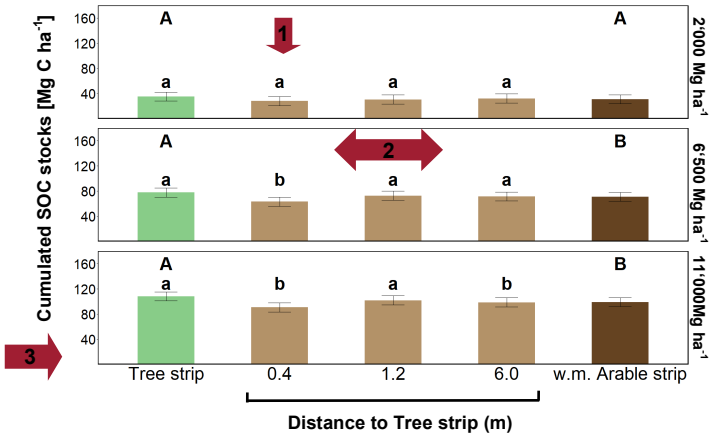

Figure 2 *Soil organic carbon (SOC) stocks at different locations within the alley-cropping system for three equivalent soil masses* [Mg C ha^{-1}]. *The w.m. Arable strip was estimated based on the areal contribution of the individual sampling locations. Different small case (or capital letters) indicate significant differences among the four sampling locations (resp. between tree strip and w.m. arable strip; Tukey-Kramer, p-value < 0.05).*

1. Lowest SOC stocks always on the arable trip closest to the tree strip, likely due to restricted fertilisation and a competition for resources between crops and trees („boarder effect")
2. Increased SOC stocks on the tree strip, compared to the arable strip, but only when subsoil is included
3. System comparison (after 13 years):
   $\text{SOC stock}_{agroforestry}$ - $\text{SOC stock}_{control}$ = 2.6 ± 1.0 Mg C ha^{-1}.

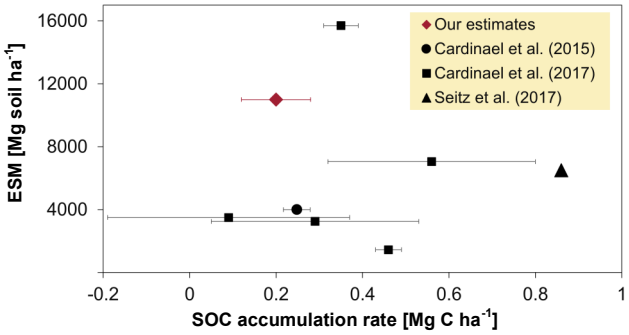

Figure 3 *Overview of field studies that assessed soil organic carbon (SOC) stock accumulation rates on an equivalent soil mass (ESM) basis in temperate alley-cropping systems.*

Conclusion

We detected a moderate SOC stock accumulation within the studied ACS 13 years after implementation. However, this became only apparent when subsoil was included in the analysis. Related biological and chemical drivers for these patterns are currently identified.