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REFOREST

Harnessing soil organic carbon: unlocking benefits for crop productivity and climate resilience with agroforestry systems

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INTRODUCTION AND OBJECTIVE

Soil organic carbon (SOC) is a critical component of soil health and plays a pivotal role in the global carbon cycle. SOC is derived from decomposed plant and non-plant residues, and its presence improves soil physical, chemical and biological properties for better soil health. SOC acts as a significant carbon sink, helping to mitigate climate change by sequestering atmospheric carbon dioxide (CO_2). Understanding the dynamics of SOC is essential for developing sustainable agricultural practices that not only improve crop productivity but also contribute to climate resilience.

The study objective was to investigate SOC contents and evaluate its benefits on alley crop yields in a 30-year-old organic agroforestry system in Taastrup, Denmark.

Figure 1. The SRWC agroforestry system (right) is located in the east of Denmark (left).

STUDY SITE AND METHODOLOGY

The system consists of a 200 m-wide crop alley with short-rotation woody crop (SRWC) belts of willow, hazelnut and alder. The crop rotation includes spring oat, spring barley, winter wheat and a 2-year grass-clover ley, with crop residues and grass cuttings left on the field. The SRWC are coppiced every 4 years and reach an approximated height of 7 meters at the end of the rotation. Soil samples and spring barley crop cuts were taken at 8 different distances from the tree belts up to 100 m, the alley middle. The crop biomass was threshed, and the grain moisture content standardised to 14%. The soil samples were analysed with an AgroCares near-infrared scanner for soil organic matter and converted to SOC assuming a 58% carbon fraction.

The data was analysed using linear mixed effects models, with the log-transformed distance as the independent variable and a random intercept per replication.

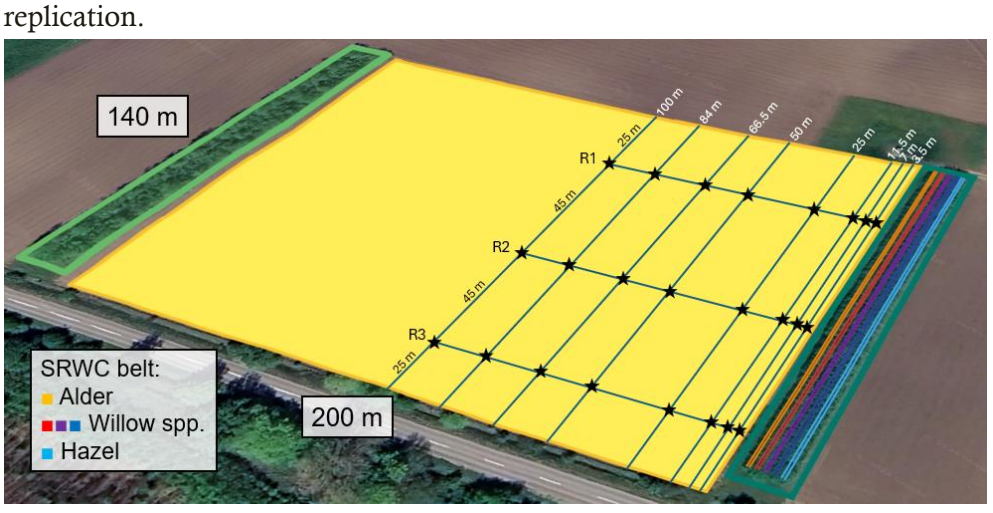

Figure 2. Aerial overview of the alley-cropping agroforestry system. The samples were taken at 8 distances from the trees in three replications.

RESULTS AND DISCUSSION

The SOC% was lowest near the tree belt (1.6%±0.03) and significantly increased ($p<0.05$), further into the alley up to 2.05%±0.15. Grain yields followed a similar trend ($p<0.05$), from 1666.9±353.3 to 3319.2±291.8 kg/ha. This indicated a positive correlation between the SOC content and the crop yield, with lower SOC associated to lower crop yield and vice versa.

Tree resource competition on crop yields is well documented in temperate agroforestry systems (Van Vooren Laura et al. 2017). Our study finds that these interactions drive SOC dynamics in long-term SRWC silvoarable systems:

- Trees of limited size do not significantly affect SOC on adjacent crop areas (Pardon et al. 2017).
- Tree leaf fall and root decay contributions to SOC in the vicinity of tree belts cannot compensate for the lower crop residue input (Cardinael et al. 2017).
- Increasing SOC with distance due to decaying tree-crop interactions further promotes larger amounts of crop organic inputs due to SOC positive effects on plant growth (Oldfield et al. 2019).

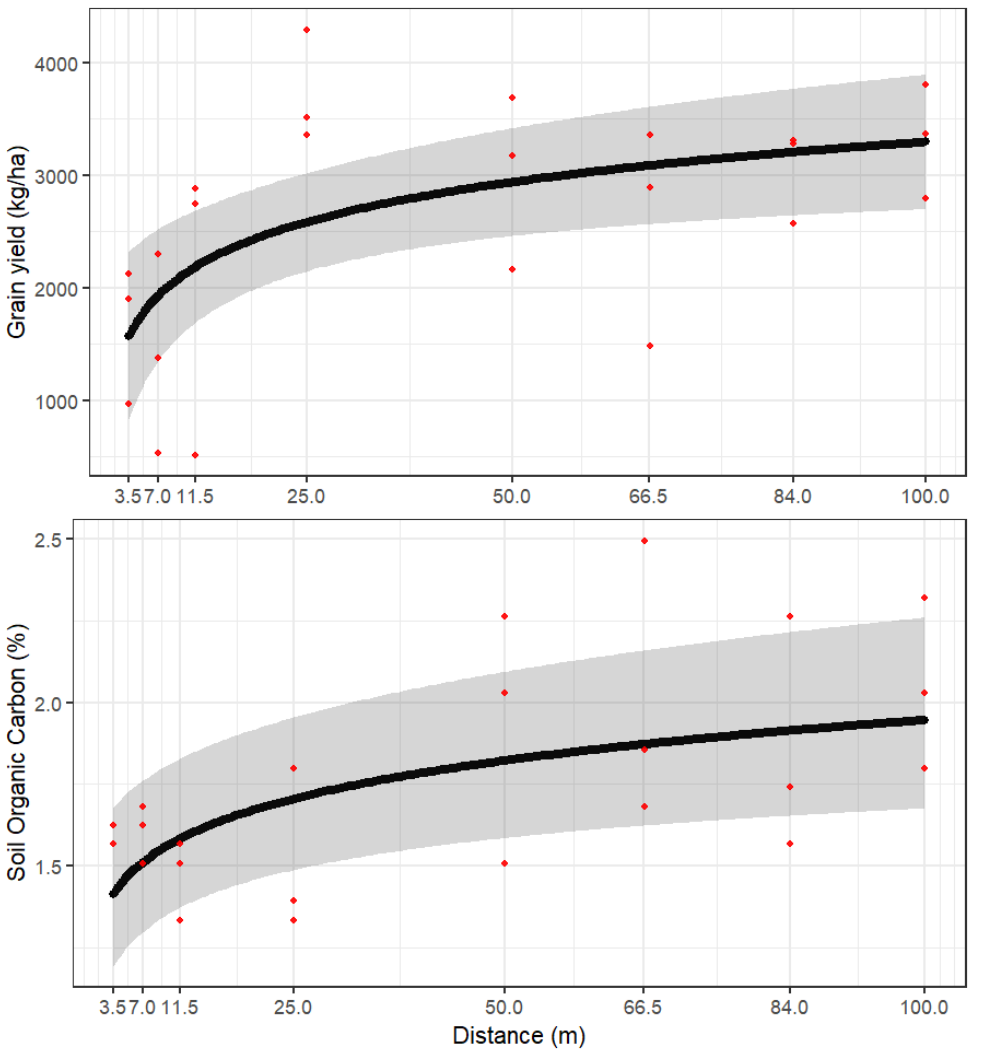

Figure 3. Yield and SOC evolution throughout the crop alley with distance from the SRWC belt, with estimated confidence intervals (grey) and the field observations (red).

CONCLUSIONS

The data demonstrated that yields benefit of higher SOC content, which can be attributed to better nutrient availability, soil moisture content and pH regulation. Improving SOC further mitigates climate change by actively sequestering and storing carbon dioxide from the atmosphere. This study demonstrated the benefits of SOC and can be replicated in other areas to provide robust evidence of agroforestry for informed decision-making.

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