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

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1. 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 crop yields in a 30-year-old organic agroforestry alley-cropping system in Taastrup, Denmark.

Figure 1. The CFE agroforestry system (right) is located in Taastrup, Denmark (left).

2. STUDY SITE AND METHODOLOGY

The combined food and energy (CFE) agroforestry system consists of a 200 m-wide crop alley with short-rotation woody crops (SRWC) belts of willow spp., hazelnut and alder. The crop rotation consists of 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. Soil samples and spring barley crop cuts were taken at 8 different distances from the SWRC belts up to 100 m into the alley. The crop grain yields were adjusted to a 14% moisture content. The soil samples were analyzed with an AgroCares near-infrared scanner for soil organic matter (OM) content and converted to SOC assuming a 58% carbon fraction. The data was analyzed using linear mixed effects models, with the log-transformed distances as the independent variables and random intercepts for each transect.

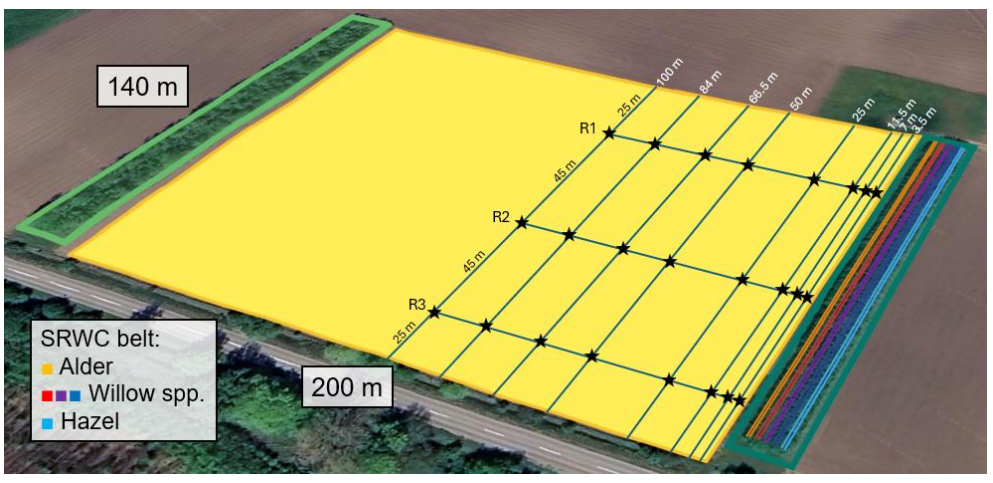

Figure 2. Aerial overview of the CFE agroforestry system. The soil and crop samples were taken at 8 different distances from the SWRC belts.

3. RESULTS AND DISCUSSION

The SOC% was lowest near the SWRC belt (1.6%±0.03) and significantly increased further into the alley up to 2.05%±0.15 ($p<0.05$). 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 competition for resources can affect crop yields, which 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-cropping systems:

- Reduced crop residue inputs near the tree belt results in lower SOC content.
- Due to their limited size (Pardon et al. 2017), SRWC cannot compensate with OM inputs from leaf fall and root decay (Cardinael et al. 2017).
- As resource competition diminishes with distance from the tree belt, increasing SOC further promotes larger amounts of crop organic inputs due to SOC positive effects on plant growth (Oldfield et al. 2019).

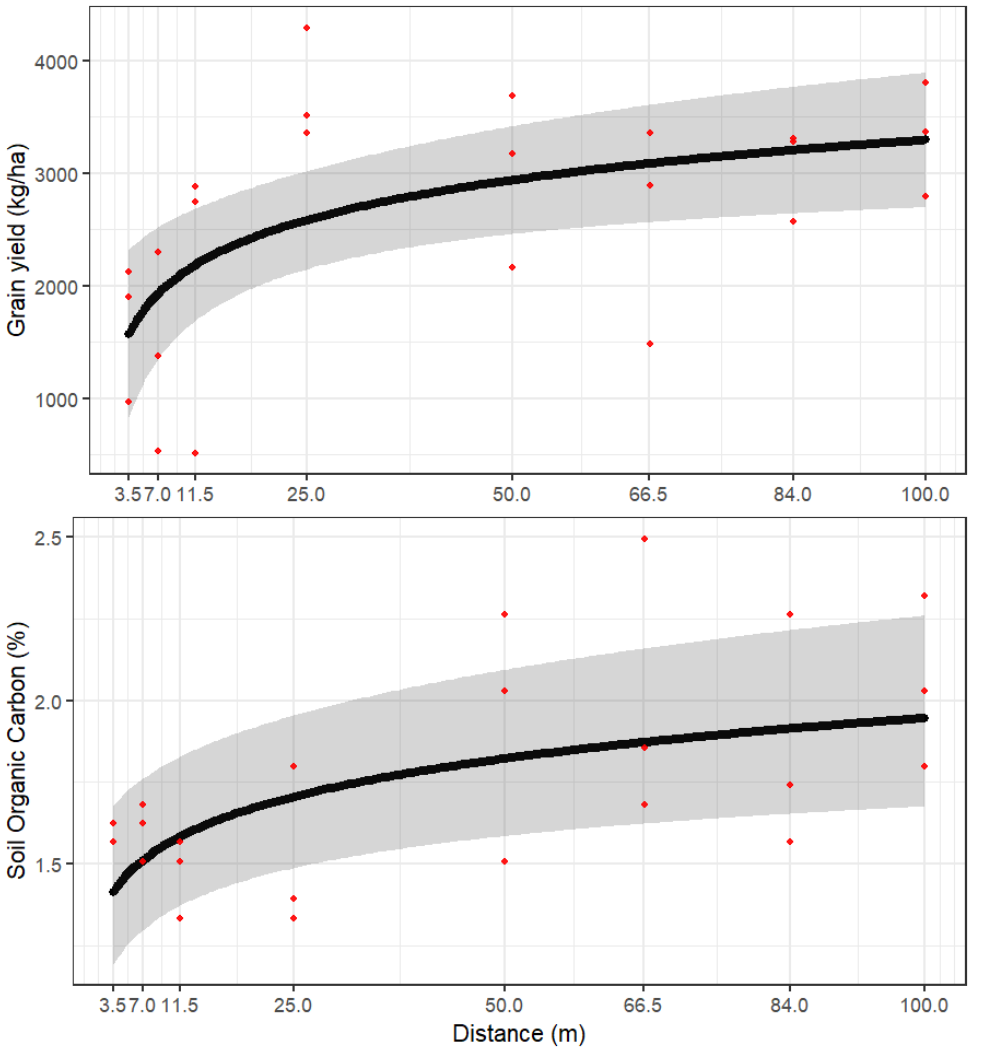

Figure 3. Yield and SOC dynamics in the crop alley at different distances from the SRWC belt, with estimated confidence intervals (grey) and field observations (red).

4. CONCLUSIONS

The data demonstrated increased yields due to 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.

5. REFERENCES

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