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Comparative carbon stock quantification in diverse production systems: Paving the way for sustainable agriculture

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1. Introduction

The necessity to mitigate climate change has highlighted the role of agriculture in carbon sequestration in the soil and biomass. However, there are clear knowledge gaps in quantification of total carbon stocks (TCS) in production systems under diverse management regimes and pedo-climatic zones. Our study goal is to contribute to the knowledge base by quantification of TCS in diverse production systems in Denmark.

2. Objective

To quantify and compare the TCS between organic agroforestry system (AF), conventional winter wheat (CWW) and tree monoculture (TMC) in Denmark.

3. Materials & Methods

The TCS were measured in 4 production systems viz. AF trees (tree belts) and AF alley (alleys with crops) in AF system (Fig. 1), conventional winter wheat (CWW) and tree monoculture practice (TMC). AF system consists of crop alley measuring 200 m wide with tree belts (AF trees) consisting of short rotation woody crops (SRWC) viz. *Salix* spp, alder and hazelnut (Fig.1) and detail information of AF system is provided in Ghaley and Porter (2014). The 200 m crop alley was cultivated with spring barley in 2024. TMC consists of *Salix* spp. monoculture.

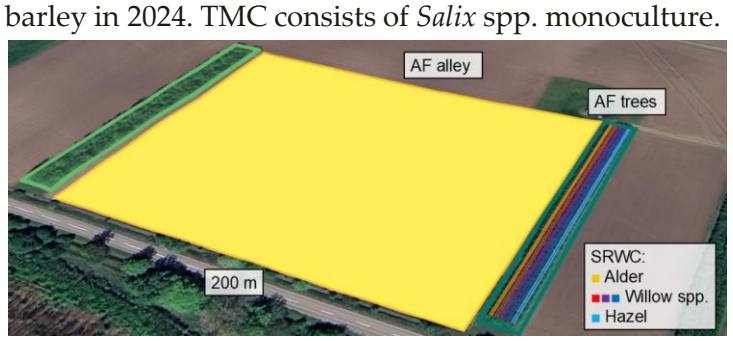

Fig. 1. Aerial view of AF system in Denmark.

The TCS consists of different carbon pools depending on the production system of interest. In TMC and AF trees, TCS consist of above- and belowground biomass, litter layer, and soil organic carbon stock (SOC). In AF alley and CWW, the TCS consists of SOC, root biomass carbon and carbon in ABG biomass and we did not include ABG biomass and root biomass because the leftover crop residues after harvesting and the root biomass is incorporated into the soil during ploughing and hence SOC includes leftover crop residues and root biomass.

4. Determination of carbon pools

Allometric equations (Ghaley and Porter (2014) were used to estimate the ABG of the short rotation woody crops (SRWC). The belowground tree biomass (root system) was estimated using a Root-To-Shoot (RTS) ratio of 0.31, as recommended by the IPCC (2003) guidelines for temperate broadleaf species. The conversion of above- and below-ground dry biomass to C content was done as per IPCC (2006a) for temperate broadleaf species with 48% of the tree biomass considered as C. The litter layer was sampled and oven dried at 80^0 C and the C content was estimated based on its dry weight. C fraction of 0.37 is considered as per the IPCC (2006b) guidelines for litter and dead organic matter. The ABG biomass and C stock in the TMC was estimated with the Woodland Carbon Calculator (WCC 2024). SOC content was measured on fresh soil samples taken from 0-30 cm and SOC was analyzed using Agrocares Soil scanner.

5. Results

- TMC recorded the highest TCS with 243.4 t C/ha, followed by AF trees (121.7 t C/ha), AF alley (93.5 t C/ha), and the CWW (63.6 t C/ha) (Fig. 2).
- High TCS in TMC is due to high carbon pools in aboveground biomass (99.8 t C/ha), roots (30.9 t C/ha) and litter layer (5.8 t C/ha).
- Across the production systems, SOC constituted the highest carbon component viz. 63.6 t C/ha (CWW), 93.5 t C/ha (crop alley), 103.9 t C/ha (AF trees), and 106.9 t C/ha (TMC) (Fig. 2).
- AF systems (AF alley and AF trees) measured higher SOC compared to CWW and this trend of higher SOC in AF systems compared to CWW is in agreement with other field studies (Ivezi´c et al., 2022; Lorenz and Lal, 2014).

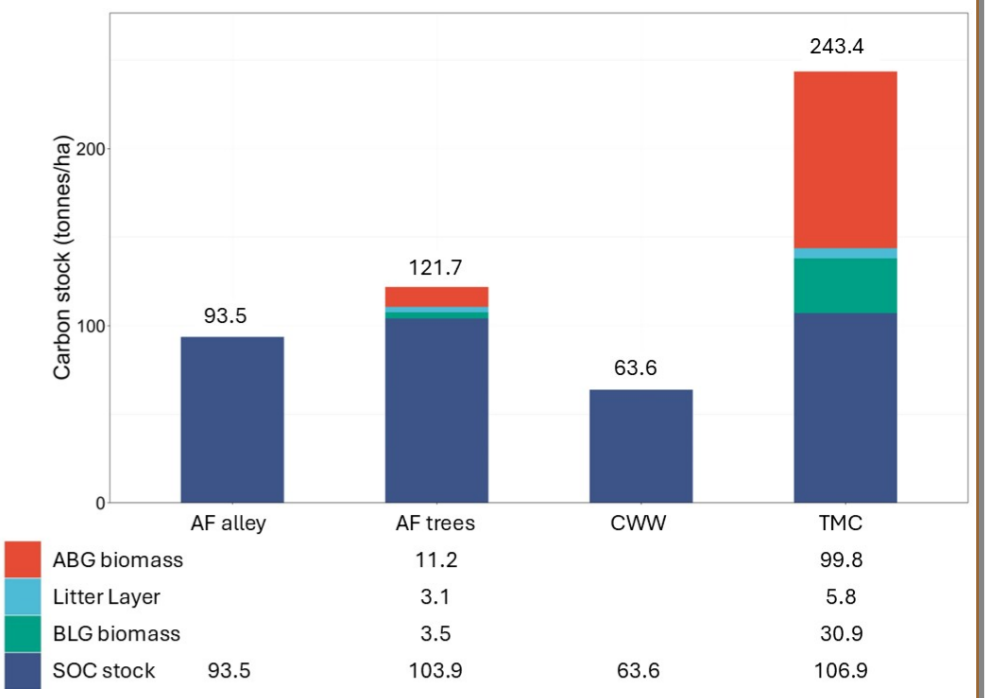

Fig. 2. Carbon stocks in different components of agroforestry (AF trees and AF alley), conventional winter wheat (CWW) and tree monoculture (TMC). ABG biomass: aboveground biomass; BLG biomass: belowground biomass; SOC stock: soil organic carbon

6. Conclusions

- The study provided robust evidence that agroforestry systems can store higher quantity of carbon compared to CWW
- High SOC in agroforestry system provides multiple benefits like enhanced soil moisture, lower soil bulk density, soil temperature moderation and habitat for microbial population, contributing to increased crop yields, provision of ecosystem services and mitigation and adaptation to climate change.
- Quantification of TCS can be used as a tool for rewarding farmers/land managers for payment of ecosystem services and for informed decision-making by policy makers for supporting carbon farming practices.

7. References

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