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

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Introduction: The necessity to mitigate climate change has highlighted the role of agriculture in carbon sequestration in the soil and biomass. However, there is a clear knowledge gap in quantification of total carbon stocks (TCS) in production systems under diverse management regimes and pedo-climatic zones. Our study aim to address this knowledge gap by contributing to quantification of TCS in diverse production systems in Denmark.

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

Materials & Methods

The carbon stocks were measured in 4 production systems. AF trees and AF alley in AF system, CWW and TMC. AF system consists of crop alleys of 50, 100, 150 and 200 m wide (Figure 1) with tree belts (AF trees) consisting of short rotation woody crops (SRWC) and detail information of AF system is provided in Ghaley and Porter (2014). Within AF, AF alley consisted of spring barley in 200 m crop alley and AF trees consisted of SWRC. TMC consists of *Salix* spp. monoculture.

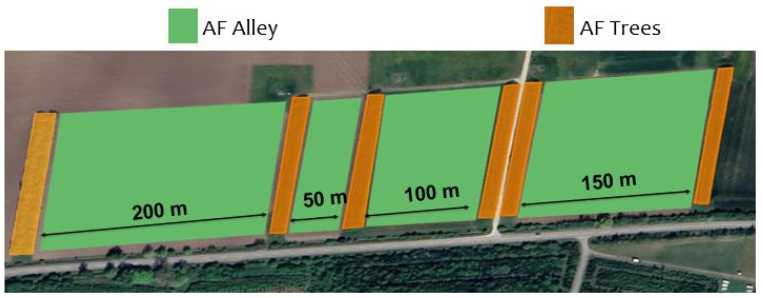

Figure 1. Aerial view of AF system in Denmark.

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 but 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.

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 analysed using Agrocares Soil scanner.

Results

- TMC recorded the highest TCS with 243 t/ha, followed by SRWC (122 t/ha), AF alley (93.5 t/ha), and the CWW (63.6 t/ha).
- 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/ha (SRWC), and 106.9 t/ha (TMC).
- AF systems recorded higher TCS in soil and above-below ground biomass as described by Ivezi´c et al., 2022 and Lorenz and Lal, 2014.

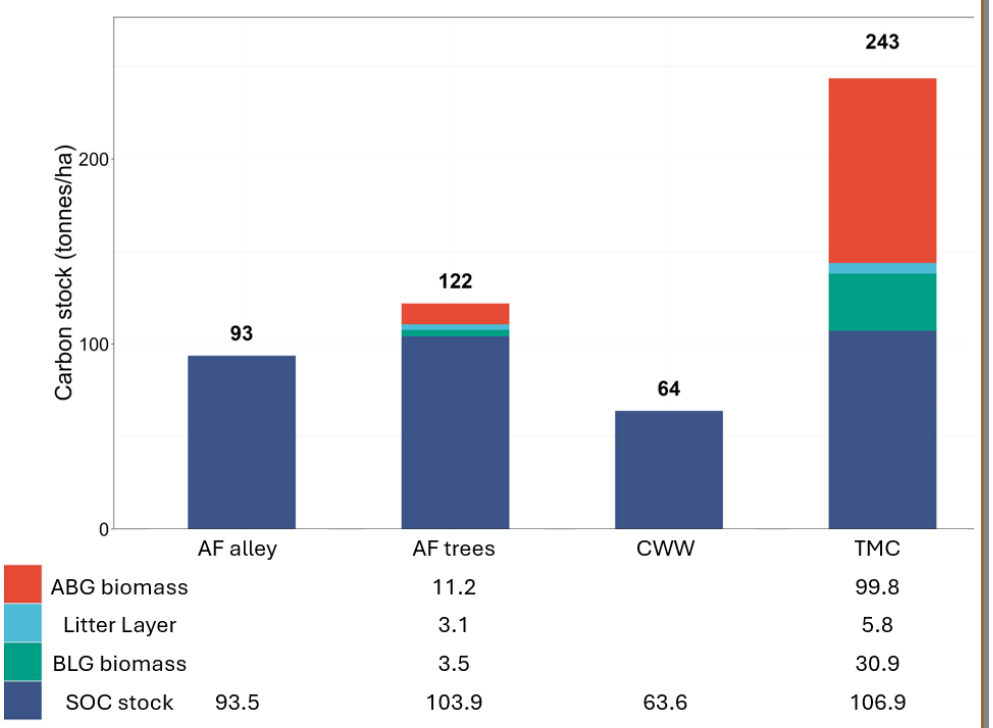

Figure 2. Carbon stocks in different components of agroforestry (AF trees and AF alley), conventional winter wheat (CWW) and tree monoculture (TMC). Where, ABG biomass: aboveground biomass; BLG biomass: belowground biomass; SOC stock: soil organic carbon

Conclusions

- The study provided robust evidence that multifunctional agroforestry systems can store higher quantity of carbon while producing food, fodder and bioenergy.
- The combination of methods, adopted in this study can be applied in other pedo-climatic zones, production systems and management regimes for quantification of TCS for informed decision-making to monitor and reward farmers in adopting carbon farming practices.
- By quantifying TCS, we can provide evidence of sustainable agricultural benefits that enhance carbon storage and mitigate climate change.

References

Ghaley, Bhim Bahadur, and John Roy Porter. 2014. https://doi.org/10.1016/j.biombioe.2014.02.009
IPCC. 2003. https://www.ipcc.ch/site/assets/uploads/2018/03/GPG_LULUCF_FULLEN.pdf.
IPCC. 2006a. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html
IPCC. 2006b. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html
Ivezi´c, V., Lorenz, K., Lal, R., 2022 https://doi.org/10.3390/su14031296
Lorenz, K., Lal, R., 2014. https://hal.science/hal-01234833v1
WCC. 2024 https://www.woodlandcarboncode.org.uk/standard-and-guidance/3-carbon-sequestration/3-3-project-carbon-sequestration

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