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Sustainable intensification of agriculture through agroforestry

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SIGNAL – Sustainable intensification of agriculture through agroforestry

Subproject 3: Yield, Quality and Carbon Storage of Perennial and Annual Plants

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Carbon storage potential of belowground biomass in agroforestry systems vs. annual cropping

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Background

Agroforestry is seen as a measure to adapt agriculture to climate change as well as to have a potential climate protection function. Greenhouse gas emissions may be reduced by removing C from the atmosphere and storing it in biomass and in the soil through accumulation of humus. A form of agroforestry is alley cropping, which combines strips of crops/grassland with strips of fast growing trees, which are harvested every 3 to 7 years for energy or raw materials. Trees as perennial plants store carbon in above and belowground biomass over a specific period of time and can therefore serve as carbon sinks in these systems. In this context, the contribution of root biomass in particular has so far been insufficiently characterized with data.

Objectives

- Quantification of belowground **carbon storage potential** of the **agroforestry system** and its components; **perennial crops (poplar and fibre nettle) vs. annual crops (maize)**

Materials & Methods

- Alley cropping agroforestry system in Northern Germany (east of Braunschweig): strips of poplars, 2.5 year old fibre nettle plants and maize (Fig. 1)
- Alley cropping site characterized by vertic cambisol soil
- Root sampling to measure root dry matter (DM) biomass using a soil coring system (roots with diameter <2mm - 10mm; sampling depth to 160cm) and via soil monolith excavation (poplar roots with diameter >10mm; sampling until no more roots were found -> up to 80cm).
- Analysis of the carbon content of the roots (without stubble of fibre nettle and maize and stump of poplars) -> calculating carbon content in root DM biomass and extrapolating it to the area of the agroforestry system

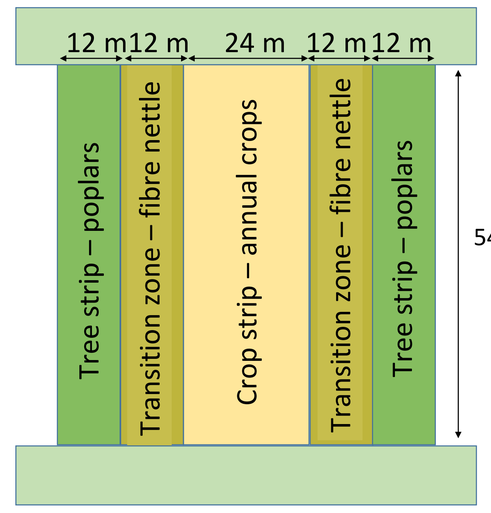

Fig 1. Schematic overview of the Wendhausen study site

Fig 2. Root sampling using a soil coring system and via soil monolith excavation (poplar)

Results

Vertical distribution of root biomass

Tab. 1 Vertical distribution of root dry matter (DM; Mg ha^{-1}) of poplar, fibre nettle and maize in the different soil depths (cm).

Depth	Poplar root DM [Mg ha^{-1}]				Fibre nettle root DM [Mg ha^{-1}]	Maize root DM [Mg ha^{-1}]
	Roots <2mm	Roots <5mm	Roots <10mm	Roots >10mm		
0-10	1.63 ± 0.10	0.37 ± 0.11	0.72 ± 0.36	137.84 ± 48.22	7.04 ± 1.69	6.52 ± 1.72
10-20	0.96 ± 0.09	0.33 ± 0.12	0.65 ± 0.32	79.27 ± 27.89	0.69 ± 0.20	0.82 ± 0.31
20-30	0.54 ± 0.07	0.66 ± 0.23	1.12 ± 0.44	361.48 ± 178.0	0.26 ± 0.03	0.20 ± 0.05
30-40	0.37 ± 0.05	0.36 ± 0.14	0.45 ± 0.33	56.75 ± 30.73	0.24 ± 0.04	0.09 ± 0.02
40-50	0.45 ± 0.08	0.08 ± 0.04	1.30 ± 0.60	115.27 ± 92.83	0.17 ± 0.05	0.08 ± 0.02
50-60	0.40 ± 0.09	0.30 ± 0.22	0.76 ± 0.34	55.02 ± 20.91	0.10 ± 0.01	0.09 ± 0.02
60-70	0.38 ± 0.06	0.14 ± 0.07	0.58 ± 0.28	27.36 ± 26.78	0.11 ± 0.02	0.10 ± 0.01
70-80	0.26 ± 0.04	0.09 ± 0.07	0.16 ± 0.16	3.71 ± 3.71	0.12 ± 0.02	0.09 ± 0.01
80-90	0.23 ± 0.04	0.07 ± 0.04	0.10 ± 0.09	0.00 ± 0.00	0.10 ± 0.01	0.09 ± 0.02
90-100	0.22 ± 0.04	0.07 ± 0.05	0.30 ± 0.15	0.00 ± 0.00	0.09 ± 0.02	0.09 ± 0.02
100-110	0.21 ± 0.03	0.10 ± 0.08	0.09 ± 0.09	0.00 ± 0.00	0.10 ± 0.03	0.06 ± 0.01
110-120	0.11 ± 0.03	0.00 ± 0.00	0.01 ± 0.01	0.00 ± 0.00	0.09 ± 0.03	0.03 ± 0.01
120-130						
130-140						
140-150						
150-160						
Mean sum						

Carbon stored in root biomass

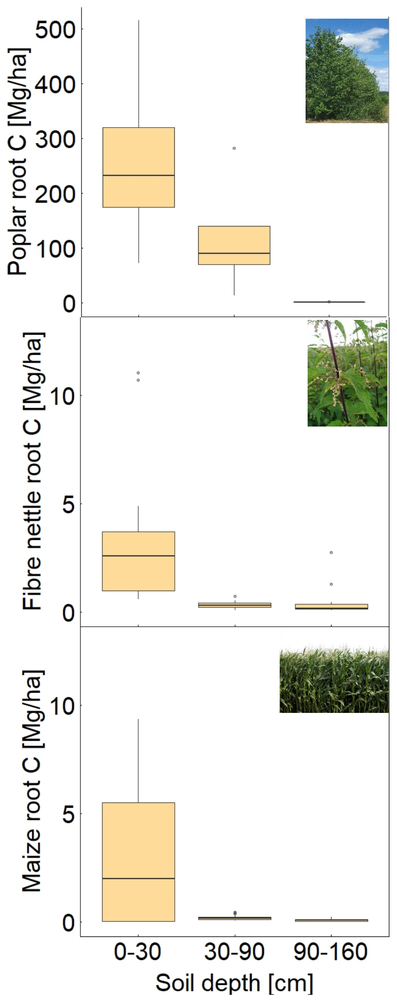

Fig. 3 Carbon content (C; Mg ha^{-1}) in root biomass and standard error of poplar, fibre nettle and maize in different soil depths categories (cm).

Tab. 2 Mean carbon content (C; Mg ha^{-1}) and mean carbondioxid equivalents (CO_2eq) in the belowground biomass (160 cm soil depth) of poplar, fibre nettle and maize.

	Poplar	Fibre nettle	Maize
C content [Mg ha^{-1}]	168.9	4.0	3.4
CO_2eq [Mg ha^{-1}]			

One hectare of the agroforestry system with poplar, fibre nettle, and maize in equal proportions of area stored 58.7 Mg C in belowground biomass (poplar 56.3 Mg, fibre nettle 1.3 Mg and maize 1.1 Mg)

Summary & Conclusion:

- At the Wendhausen agroforestry site, poplars stored 49 and 42 times more carbon belowground than fibre nettle and maize, respectively
- Highest carbon storage potential was found for a cropping system including poplars
- Poplars, compared to fibre nettle and maize, have the potential to store high amounts of C belowground for several years and therefore can serve as carbon sinks in agroforestry systems