BonaRes-SIGNAL
Sustainable intensification of agriculture through agroforestry

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TP 2-1 Factors and magnitude of soil organic matter increases in temperate arable alley cropping systems

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Background

Trees incoporated into agroforestry systems affect C sequestration via litter input, above, below ground biomass and root network possibly extending into crop alleyways (CA). Beuschel et al., (2019) showed significant tree effect on microbial indices in topsoil (0-5 cm depth) under tree rows compared to CA but no effect of trees in the lower topsoil on transect distances in the CA on C-storage and CUE – microbial partition of C into growth or respiration. We therefore repeated soil sampling at these sites 7 years later, addressing the research questions for aged alley cropping systems:

- Do tree effects extend towards crop alleyways and lower depths (5-20 cm)?
- Are these effects a function of abiotic soil properties ?

Material and Methods

- Repeated sampling: Top soils (0-5 cm and 5-20 cm depth) were sampeled at various transect distances and in the middle of tree rows of silvo-arable alley cropping systems at 3 sites (Fig. 1) in years 2015 (Beuschel et al., 2019) and 2021.
- Analyses: Soil organic carbon (SOC), microbial biomass carbon (MBC), Basal respiration and estimation of microbial metabolic quotient (qCO_2).
- Data were analyzed using two-way ANOVA to evaluate the effect of transect distances and years on microbial and physico-chemical parameters at each sampling site.

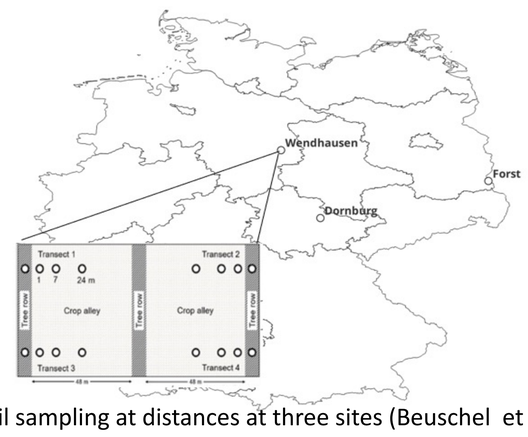

Fig. 1. Soil sampling at distances at three sites (Beuschel et al. 2019).

Results

Tab. 1. Arithmetic means of physico-chemical and microbial biomass carbon (MBC) in 0-5 cm layer at various transect distances and in the middle of tree rows (MT) in alley cropping systems of year 2022* or 2015

Site/Distances	pH*	Clay*	SOC (mg g^{-1})		MBC (% SOC)	
	($CaCl_2$)	(g kg^{-1})	2015	2022	2015	2022
Dornburg						
MT	5,9	264,7	21,2^{b}	23,7^{b}	2,9^{b}	2,1
1 m	6,2	254,6	15,9^{a}	19,2^{a}	2,2^{a}	2,7
7 m	6,2	263,4	15,7^{a}	18,2^{a}	2,1^{a}	2,7
24 m	6,1	264,8	16,4^{a}	19,6^{a}	2,1^{a}	2,0
SD	0,3	15,8	0.9	1,0	0,2	0,4
Forst						
MT	6,5	77,6	12,5	14,0^{a}	3,2^{b}	3,2^{b}
1 m	6,5	94,3	12,7	12,2^{ab}	2,0^{a}	2,2^{ab}
7 m	6,5	83,3	10,7	10,2^{b}	1,8^{a}	2,1^{a}
24 m	6,6	86,1	10,2	10,9^{b}	2,1^{a}	2,2^{ab}
SD	0,1	10,7	1,2	1,3	0,2	0,5
Wendhausen						
MT	7,1^{b}	498,0	29,7^{b}	37,7	2,4^{b}	1,8
1 m	7,2^{ab}	485,8	26,6^{a}	25,4	2,0^{a}	1,5
7 m	7,1^{a}	468,6	25,3^{a}	25,2	1,8^{a}	1,7
24 m	7,2^{b}	501,3	26,9^{a}	30,1	2,1^{ab}	1,8
SD	0,2	47,5	1,1	4,8	0,2	0,2

Means with no letters in common within a site in each column indicate significant differences at P< 0.05 between distances and tree rows. SD = standard deviation of the means between replicate samples (n = 4).

- Significant increase of 17, 3 and 8 % SOC in 2022 in Dornburg, Forst and Wendhausen respectively in the upper most layer of the sampled topsoil (Tab. 1) but no increase in the lower layer.
- Trees have a significant effect on MBC with time in tree rows at all sites in the 0-5 cm layer (Fig. 2a) but not in the 5-20 cm layer (Data not shown).
- Significant increase of qCO_2 in the distances with time (years) indicative of low microbial carbon use efficiency in transect distances compared to tree rows (Fig. 2b).
- High pH and clay content were negatively correlated with microbial biomass-C-to-SOC ratio at all sites in 0-5 cm (Tab. 1) and 5-20 cm layer.

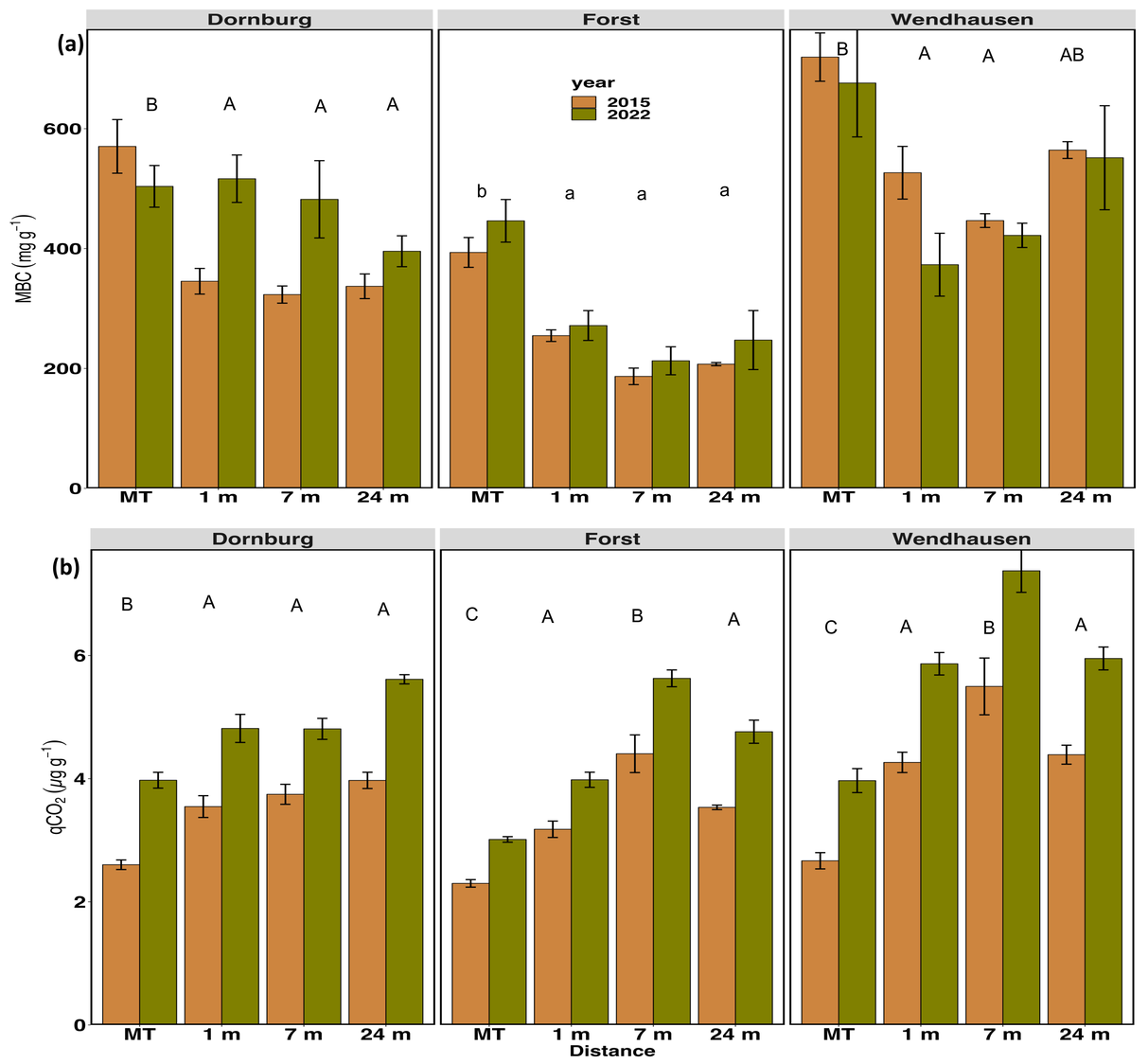

Fig. 2. Mean of microbial indices (a) MBC and (b) Metabolic quotient (qCO_2) at spatial distances (MT: tree rows and 1 m, 7 m, 24 m) in 0-5 cm soil depth at 3 sites. Upper case letters indicate significant interaction effect (distance x year) and lower case letters indicate distance effects. Error bars show standard deviation (n = 4).

Conclusion

- Increased C accumulation in the alleyways with higher microbial biomass-C-to-SOC ratio indicating the importance of SOM for C sequestration.
- Tree effects do not extend to the alleyways nor the lower subsoil in the 15, 14 and 12 year old alley cropping systems of Dornburg, Wendhausen and Forst respectively.

Reference

Beuschel, R., Piepho, H. P., Joergensen, R. G., & Wachendorf, C. (2019). Similar spatial patterns of soil quality indicators in three poplar-based silvo-arable alley cropping systems in Germany. *Biology and Fertility of Soils*, *55*, 1-14.