Effects of different crop management options on SOC stocks and deriving emission factors

Sophia Götzinger (AGES), Taru Sandén (AGES), Lisa Makoschitz (AGES), Katharina Keiblinger (BOKU), Christoph Rosinger (BOKU), Heide Spiegel (AGES),Eugenio Díaz-Pinés (BOKU), Ulises Esparza-Robles (BOKU), Robert Jandl (BFW) Ioanna Panagea (EV-ILVO), Guillaume Blanchy (EV-ILVO), Mariangela Diacono (CREA), Paul Quataert (EV-ILVO), Claudia Di Bene (CREA), María Alonso-Ayuso (CSIC), Laura B. Martinez-Garcia (CSIC), Jorge Álvaro-Fuentes (CSIC), Marjetka Suhadolc (ULBF), Kristina Ocvirk (ULBF), Sonja Kay (AGS), Valerie Viaud (INRAE), Sophie Drexler (Thünen), Felix Seidel (Thünen), Axel Don (Thünen), Greet Ruysschaert (EV-ILVO), Rima Porre (WR), Laura Martinez-Garcia (WR), Jan-Peter Lesschen (WR)

Introduction

The EJP SOIL-CarboSeq project aims to assess the potential of European agricultural soils to sequester soil organic carbon (SOC), considering biological, technical, and economic constraints. The project's WP2 on crop management focused on quantifying potential SOC sequestration across different pedo-climatic regions and agricultural management options by changing crop management practices in European croplands.

Material & Methods

The potential of C sequestration was estimated as the quantitively changes of six established and known agricultural management practices on the SOC stock in European long-term experiments. These practices analyzed were: cover crops, crop diversification, crop residues, tillage, irrigation, agroforestry. This potential was expressed by emission factors (EFs) deriving from the following equation:

$$EF_{relative} = \frac{SOC\ Stock_{treatment}}{SOC\ Stock_{control}}$$

$EF_{relative}$ …emission factor of a measurement

SOC $stock_{treatment}$ …the SOC stock as measured at a specific moment and sampling depth in the management option under evaluation (treatment)

SOC $stock_{control}$ …the SOC stock as measured at the same moment and same soil depth in the control option

Data and metadata was collected from European LTEs (> 5 years) published in the literature, existing databases (e.g. CatchC, haddaway2015, EJP Soil T7.3) and metanalyses as well as from direct communication with LTE owners.

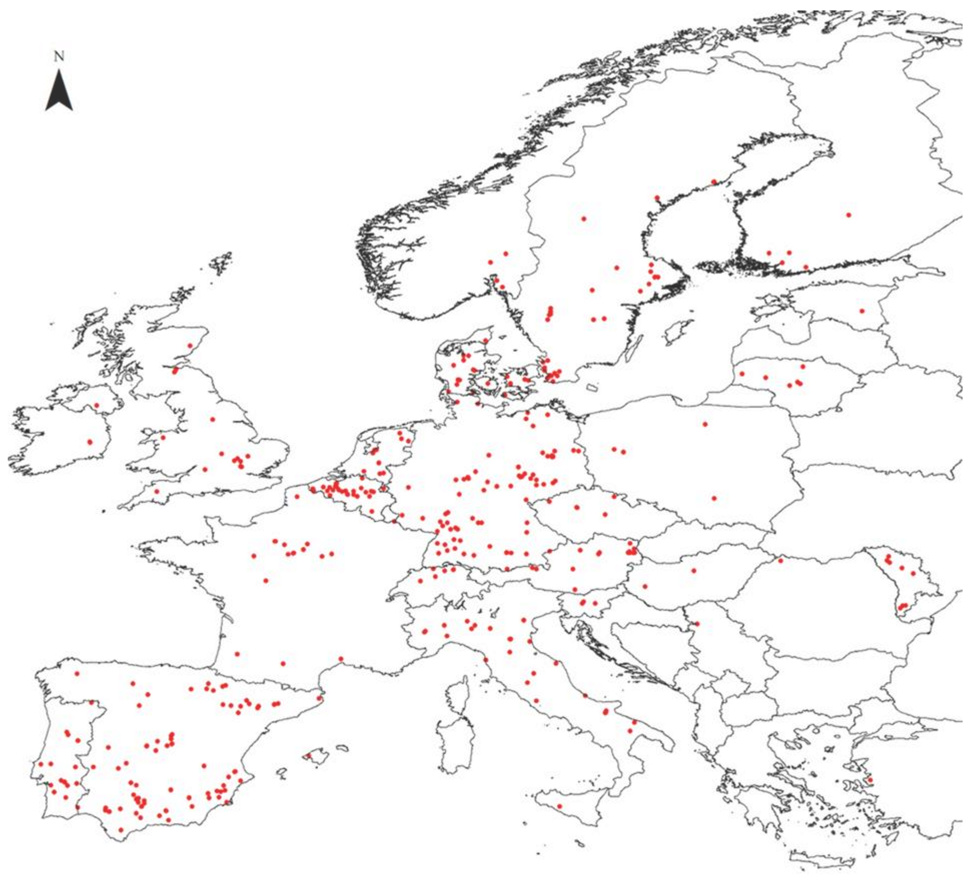

Figure 1: *Distribution of the experiments in the CarboSeq crop and soil management database (version 07.07.2023) across Europe*

Benefits for Austria

The project involved extensive data collection, analysis, and comparison of SOC stocks at a European level.

Inventories of the effects of various management practices on SOC stocks were compiled.

Potential trade-offs were thoroughly evaluated and considered in this context.

Emission factors of selected management practices

Cover crops: no significant difference across climatic zones (Atlantic = 1.05 (SD=0.014), Continental = 1.07 (SD=0.034), Mediterranean = 1.08 (SD=0.025)).
The mean EF was 1.06 (SE=±0.02, SD=±0.08)

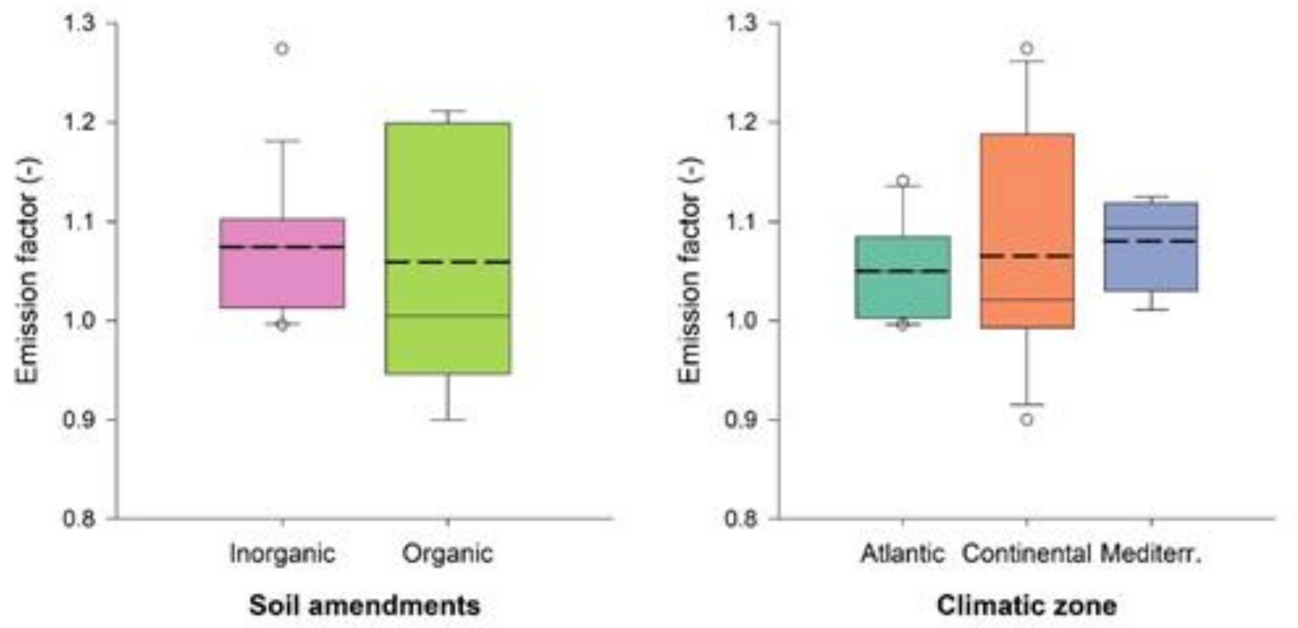

Figure 2: *The distribution of relative cover crop emission factors across different soil amendments (Inorganic, N=16; Organic, N=5) and climatic zones (Atlantic, N=10; Continental, N=11; Mediterranean, N=4). The dashed lines represent the mean, while the solid line represents the median.*

Crop residues: straw left on the field and incorporated vs. removal. The mean EF for retained crop residues is 1 .09 (SD±0.12, SE±0.02)

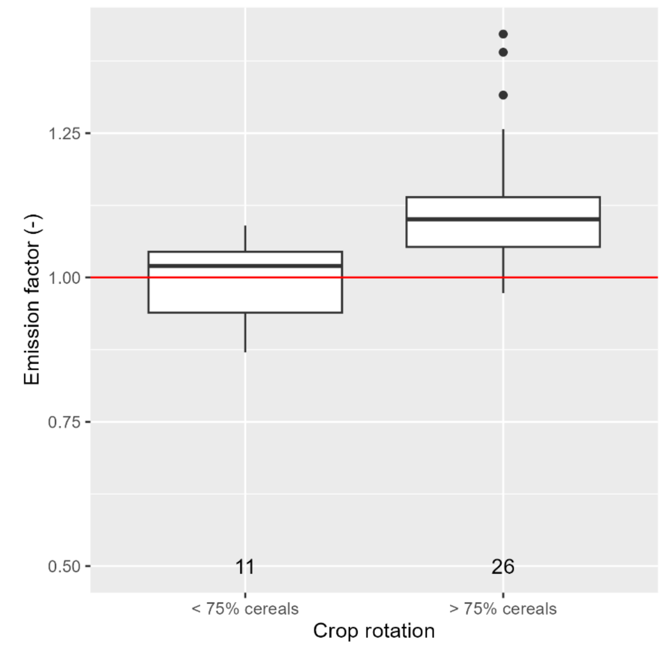

Figure 3: *Distribution of emission factors, grouped by <75 % and >75% of cereals in the crop rotation. The number of observations per group is shown above the x-axis. The black line inside the boxplots represents the median.* Values above the red line represent EF>1 (SOC increase), EF<1 (SOC loss)

Trade-offs of carbon sequestration practices with N_2O emissions

Carbon sequestration measure	% change in N_2O emissions	n	Significance[1]
Tillage:			n.s.
- No tillage	+16 %	45	n.s.
- Reduced tillage	+8 %	41	n.s.
Agroforestry	-54 %	41	**
Land use change:			
- Grassland to Cropland	+105 %	68	*
- Grassland to Energy Crop	-60 %	5	*
- Cropland to Grassland	-95 %	5	***
- Cropland to Energy Crop	-92 %	5	***
Irrigation	+17 %	49	n.s.
Crop residues:			
- Green plant biomass	+161%	37	**
- Mature aboveground biomass	+17%	17	n.s.
- Straw	+22%	10	n.s.
Cover crops as green manure	+34 %	38	n.s.
Organic amendments:			
- Livestock manure	+17 %	10	n.s.
- Slurry	-13 %	44	n.s.
- Compost	+1 %	14	n.s.
- Digestate	+26 %	13	*
- Combinations	-25 %	7	n.s.
Biochar	-32 %	13	**

[1] p<0.05 = *, P<0.01 = **, P<0.001 = ***, n.s. = not significant

Don A, Seidel F, Leifeld J, Kätterer T, Martin M, Pellerin S, Emde D, Seitz D, Chenu C. (2024) Carbon sequestration in soils and climate change mitigation—Definitions and pitfalls. Global Change Biology, 30, e16983. https://doi.org/10.1111/gcb.16983
Sandén, T., Spiegel, H., Stüger, H.-P., Schlatter, N., Haslmayr, H.-P., Zavattaro, L., Grignani, C., Bechini, L., D'Hose, T., Molendijk, L., Pecio, A., Jarosz, Z., Guzmán, G., Vanderlinden, K., Giráldez, J. V, Mallast, J., ten Berge, H., 2018. European long-term field experiments: knowledge gained about alternative management practices. Soil Use Manag 34, 167–176. https://doi.org/10.1111/sum.12421
Haddaway, N.R., Hedlund, K., Jackson, L.E., Kätterer, T., Lugato, E., Thomsen, I.K., Jørgensen, H.B., Söderström, B., 2015. What are the effects of agricultural management on soil organic carbon in boreo-temperate systems? Environ Evid 4, 23. https://doi.org/10.1186/s13750-015-0049-0
Blanchy, G., D'Hose, T., Donmez, C., Hoffmann, C., Makoschitz, L., Murugan, R., O'Sullivan, L., Sandén, T., Spiegel, A., Svoboda, N., Zechmeister-Boltenstern, S., Klumpp, K., 2023b. EJP MTE/LTE metadataset v1.0.1. https://doi.org/10.5281/zenodo.7598122

EJP SOIL has received funding from the European Union's Horizon 2020 research and innovation programme: Grant agreement No 862695