Can we manage soil structure for improved resistance against droughts and extreme rainfall events?

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Soil structure is affected by soil management

Soil structure controls functional soil properties relevant for crop growth, such as water infiltration and retention, or mechanical resistance, which in turn affect water availability and resource accessibility by roots. Soil management impacts soil structure directly by loosening and compaction, and indirectly through management impacts on soil organic carbon (SOC) content, earthworm abundance and activity, and root growth.

Table 1: Site characterization, management and topsoil properties of the investigated LTEs in Switzerland. Symbols represent significant treatment effects determined with a linear model (parameter ~ treatment) within each LTE. The *p*-values are: **** < 10^{-4}, *** < 10^{-3}, ** < .01, * < .05, ~ < .1. Treatment abbreviations: CIT: conventional intensive tillage, CNT: conventional no-till, OIT: organic intensive tillage, ORT: organic reduced tillage, FYM: manure application, MIN: mineral fertilization only, COM: compost application.

		FAST Rümlang 2009 calceric Cambisol / loam					**P24A** Changins 1975 Cambisol / loam			**ZOFE** Zürich 1949 Luvisol / sandy loam		
		CIT	**CNT**	**OIT**	**ORT**		**FYM**	**MIN**		**COM**	**MIN**	
management	**C input** [MgC/ha/year]	3.5	3.4	4.4	4.4	****	3.8	1.8	****	4.0	2.7	****
	STIR	90	13	97	42	****	100	100		84	84	
	soil cover [day/year]	286	329	285	292	****	184	183		272	273	~
soil propert.	**SOC** [gC/kg]	13.6	12.7	14.7	13.6		10.5	7.55	~	10.3	7.25	***
	BD [Mg/m³]	1.33	1.41	1.33	1.36	~	1.4	1.48		1.51	1.57	*
	VESS	3.1	2.3	3.2	2.3	***	2.9	2.6		2.7	2.9	

Soil properties and soil management indicators

32 plots in three Swiss long-term experiments (LTEs) with contrasting soil management were sampled in spring 2023 (Tab. 1). Saturated hydraulic conductivity (K_{sat}), unsaturated conductivity at 5 hPa (K_{unsat}), plant available water (PAW) and bulk density (BD) were measured on intact soil cores at 0.1 m depth. Additionally, earthworm biomass, SOC content, texture and the visual quality of the soil structure (VESS) were assessed. Numeric soil management indicators for tillage intensity (STIR), carbon input (C input) and soil cover were derived with the SoilManageR package in R.

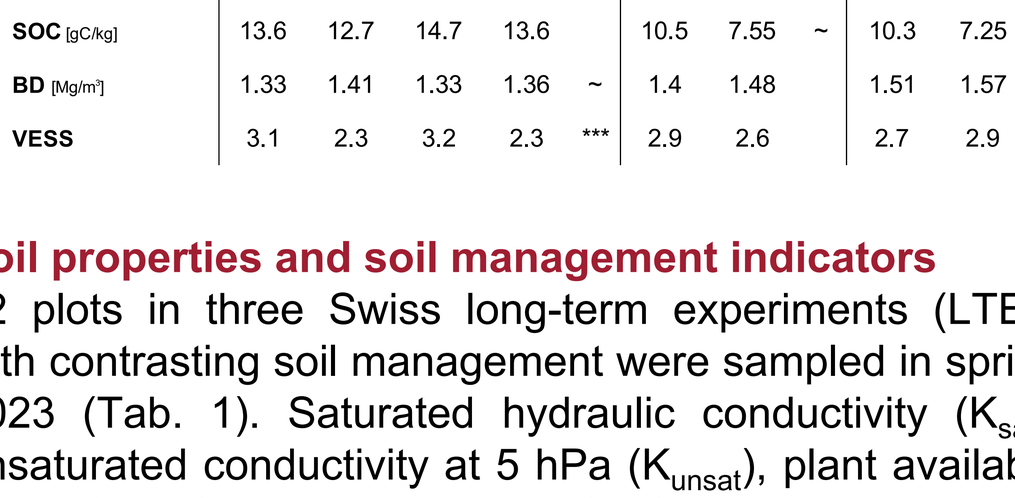

Figure 1: (a) Correlations between tillage intensity (STIR) and earthworm biomass, and (b) between C input and SOC content. The grey area represents the .95 confidence interval of the linear regressions.

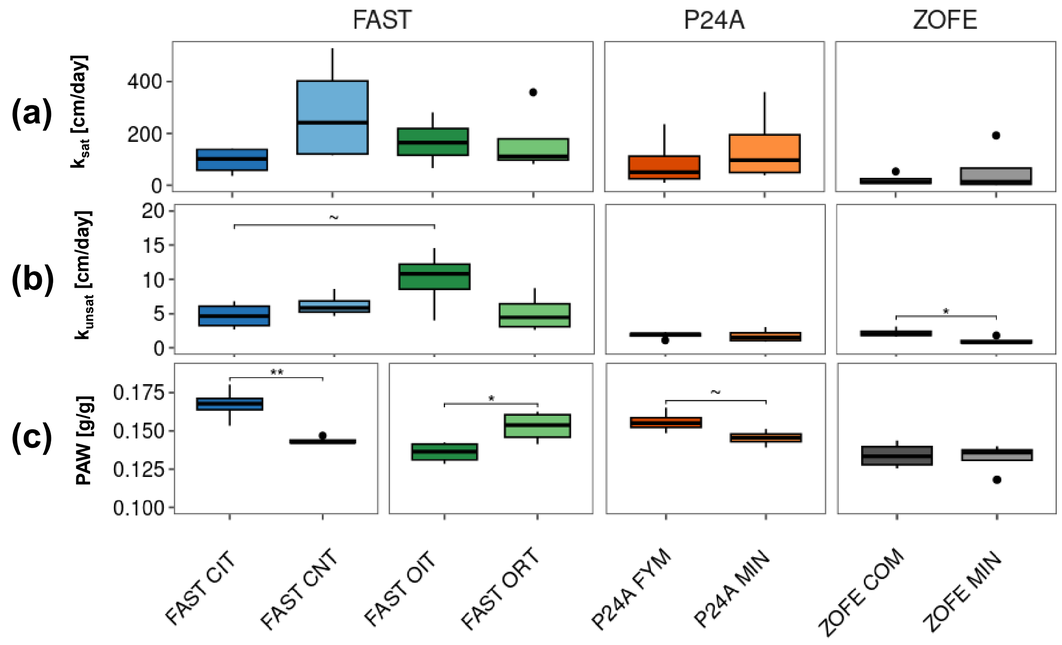

Figure 2: Effects of treatments on soil hydraulic properties: (a) conductivity at saturation (K_{sat}), (b) unsaturated conductivity (K_{unsat}), and (c) plant available water (PAW). PAW was the difference between the gravimetric water content at field capacity (pF = 2) and at permanent wilting point (pF = 4.2). *p*-value and treatment abbreviations are the same as in Tab. 1.

Drivers of soil hydraulic properties

Preliminary results show significant correlation between soil management indicators, intermediaries and soil hydraulic properties (Fig. 1 and 3). K_{sat} was correlated with soil cover, STIR as well as earthworm biomass, while K_{unsat} was correlated with C input, SOC and BD (Fig. 2 and 3). The magnitude of the effects was dependant on site properties (e.g. soil texture) that will be further investigated.

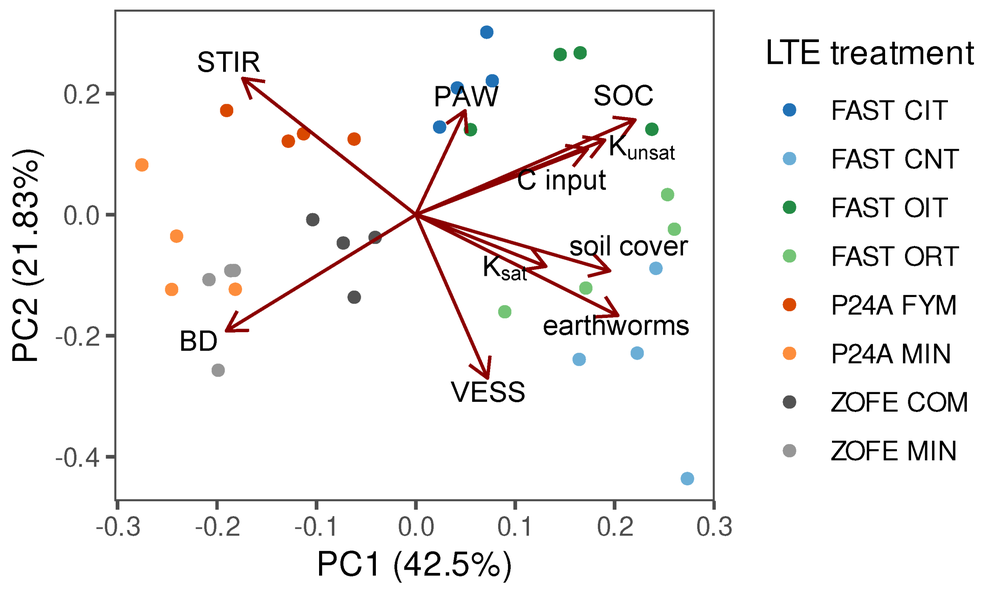

Figure 3: Principal component analysis of a selection of the investigated management intensities, soil structuring factors and soil structural parameters. Abbreviations are in the main text and Tab. 1.

Outlook

- Integration of seven additional European LTEs
- Assessment of penetration resistance, K_{unsat} in the semi-dry range (HYPROP) and aggregate stability.
- Investigation of management impacts on the subsoil.

Summary

Soil structure related hydraulic properties and their drivers were assessed in three Swiss LTEs. Saturated and unsaturated conductivity were correlated with different dimensions of soil management.

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