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Soil structure quality and biodiversity across a range of different practices and tillage intensities

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Context

- Soil quality = "*capacity of soils to function in an ecosystem with a given land management while guaranteeing agricultural production*" (Bünemann *et al.*, 2018)

- Many soil functions depend on **soil's structural state** (Bronick and Lal, 2005; Emmet-Booth et al., 2016) and **SOM content** (Feller & Beare, 1997; Naveed et al., 2016)

= guarantee of soil quality for farmers

- **Still highly contrasting conclusions** regarding soil-improving cropping systems (SICS), particularly with respect to the potential of no-till practices and their influence on SOC loss (Dimassi et al., 2014)

- Need for **on-farm data and large scale survey** :

-to analyze interactions between management strategies (Jian et al., 2020),

-to define various optimal practices or SICS in a systemic and site-adapted perspective.

Context

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Jura region (CH)

Framework:

Ressourcen-Projekt Terres Vivantes 2019-2025

187 cultivated fields
From 88 farms
3'000 ha arable land

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Main objective :

to determine the on-farm long-term effects of farming practices on soil structure quality and vulnerability

Methodology

Assessing soil structure vulnerability

- SOC:clay is considered as an index of the soil structure vulnerability (Fell et al., 2018; Johannes et al., 2017)
- The higher the clay content – the more SOM is needed for the same quality
- **SOM:clay above 17%** : realistic soil management goal & soil structure is not considered vulnerable

Assessing soil structure quality

- A_{-100} : **Air content at -100hPa** (pores >15 µm in equivalent radius) ; trigger value of 0.068 $cm^3\ g^{-1}$ (Johannes et al., 2019)
- W_{-100} : Water content at -100 hPa (pores <15 µm in equivalent radius)
- Bulk density at -100 hPa was also measured for estimating total porosity

Results for soil structure vulnerability assessment

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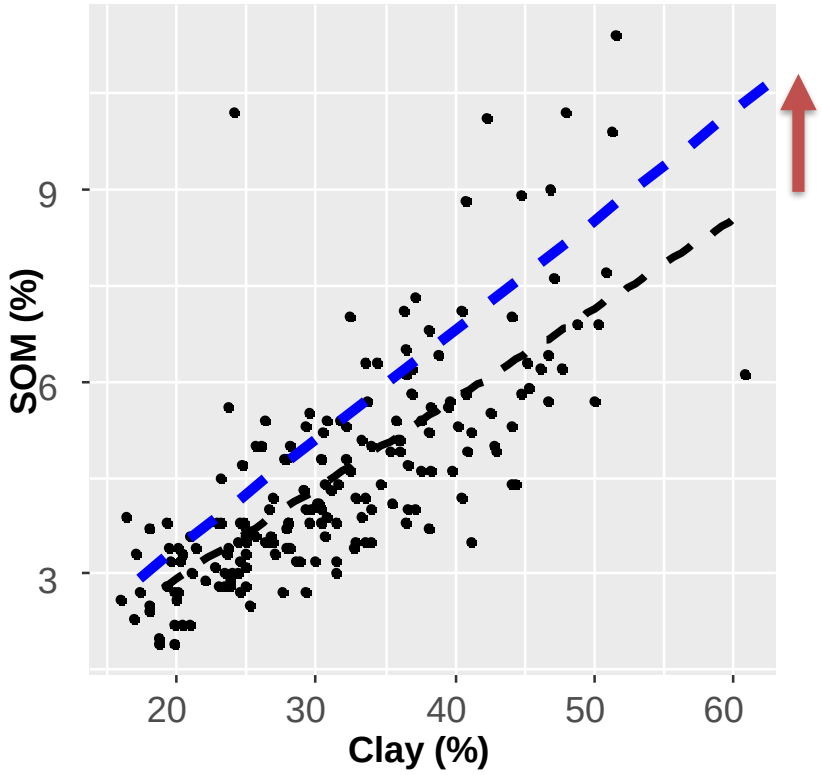


Linear model between soil organic carbon (SOM) and clay content black dashed line: linear regression line ; blue dashed line: 17% SOM:clay ratio

Objective : increasing SOM:Clay to 17%

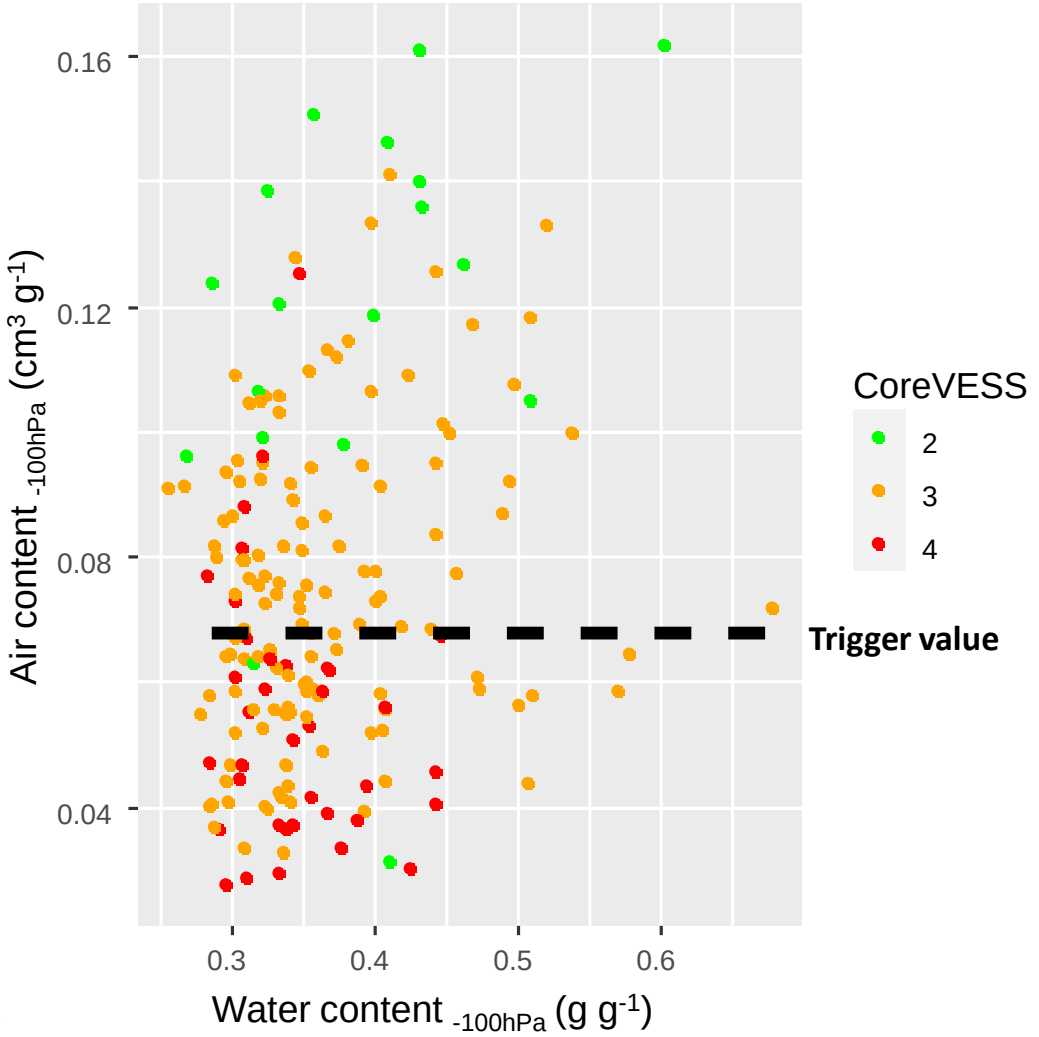
- The soil clay content ranged from 16% to 60% with half part of heavy clay soils
- SOM range: 2-11%
- Median OM:clay ratio of 14% : vulnerable structure

➢ **High risk of degraded structure due to cultivation practices**

Results for soil structure quality assessment

48% of samples below the trigger value

- **Some difficulties in those soils regarding aeration, rapid drainage, air diffusion**



Earthworm populations characteristics

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8206 individuals were classified

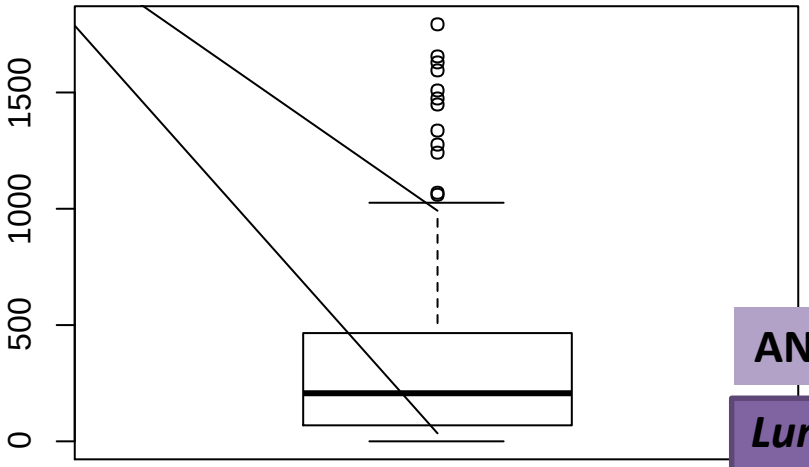
EPIGEICS

Lumbricus rubellus
Lumbricus rubellus rubellus
Lumbricus rubellus castaneus
Eisenia sp.
Dendrodrilus rubidus

ENDOGEICS

Aporrectodea caliginosa
Aporrectodea rosea
Octolasion cyaneum
Octolasion tyrtaeum
Octolasion tyrtaeum tyrtaeum
Octolasion tyrtaeum lacteum
Allolobophora chlorotica
Allolobophora icterica
Allolobophora georgii
Allolobophora cupulifera
Allolobophora antipae
Allolobophora minuscula
Allolobophora riparia
Aporrectodea c. caliginosa
Aporrectodea c. tuberculata
Aporrectodea c. meridionalis

Earthworm surface casts biomass (g.m-2)



ANECICS

Lumbricus terrestris
Lumbricus friendi
Lumbricus centralis
Aporrectodea nocturna
Aporrectodea giardi
Aporrectodea longa
Aporrectodea longa ripicola
Aporrectodea longa longa

Agricultural practices survey design

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The past 5-10 years practices on 159 fields were documented and organized according to 3 categories:

Vegetation intensity
-Proportion of cover crops
-Mean duration of temporary meadows
-Number of different crops
-Proportion of spring crops
-Proportion of row crops

Organic intensity
-Number of organic amendments (solid or liquid)
-Number of crop residue exportation
-Quantity of manure applied

Soil tillage intensity
-Soil Tillage Intensity Rating (USDA)
-Number of tillage and stubble operations
-Mean tillage depth (cm)

Agricultural practices survey results

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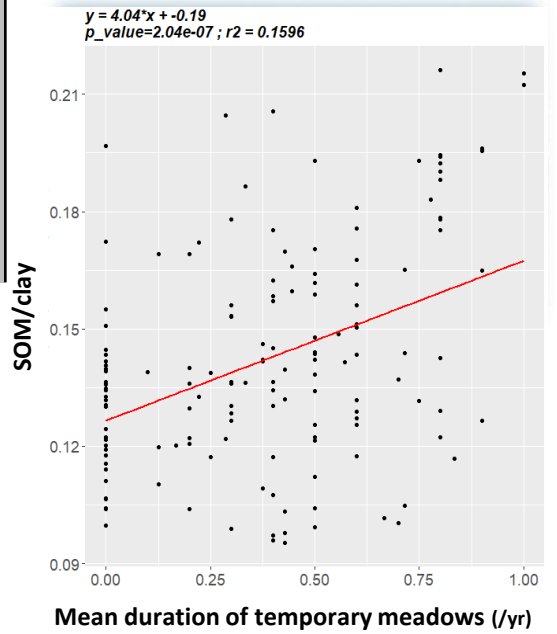
List of the cropping practices used to describe the cropping systems and Pearson correlation coefficients (blue : cor > 0.3) between soil structure quality indicators and agricultural practices indicators with associated p-values (green : p <5%).

Indicator	SOM/clay		Bd_{-100}		W_{-100}		A_{-100}	
	cor	p	cor	p	cor	p	cor	p
Mean duration of temporary meadows (/yr)	0.40	2.04E-07	-0.34	1.91E-05	0.33	3.64E-05		
Proportion of row crops (/yr annual cropping)	-0.21	0.01	0.21	0.01	-0.19	0.02		
Quantity of organic amendments applied (ISMO corrected)(/yr)	0.29	0.001	-0.21	0.02				
Number of organic amendments (solid or liquid)(/year)	0.29	0.0003						



➢ **Temporary meadows already known as a soil regenerating factor** (e.g., Senapati et al., 2014) **but :**

1/highly correlated to organic matter inputs,

2/associated soil carbon dynamics has to be considered (Dupla et al., 2022)

Agricultural practices survey results

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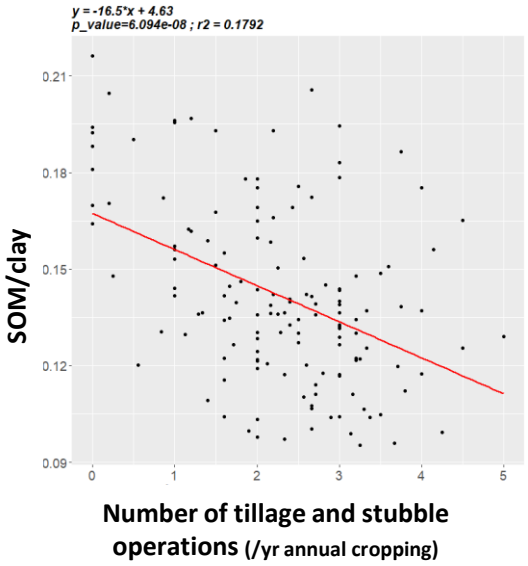
Number of organic amendments (solid or liquid)(/year)	0.29	0.0003						
STIR simplified (/yr annual cropping)	-0.29	0.0002						
Number of tillage and stubble operations (/yr annual cropping)	-0.42	6.09E-08	0.20	0.01	-0.16	0.04		



➢ **Tillage effect contradictory to some findings** (e.g., Powlson et al., 2014) **obtained on long term experiments**

Agricultural practices survey results

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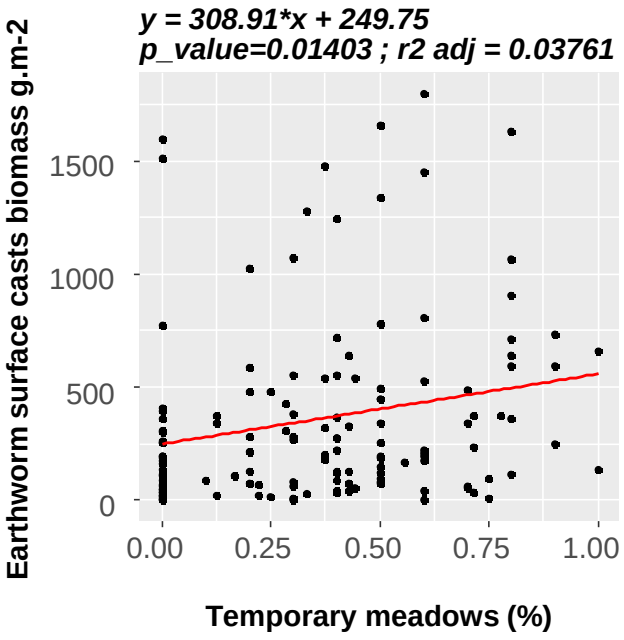
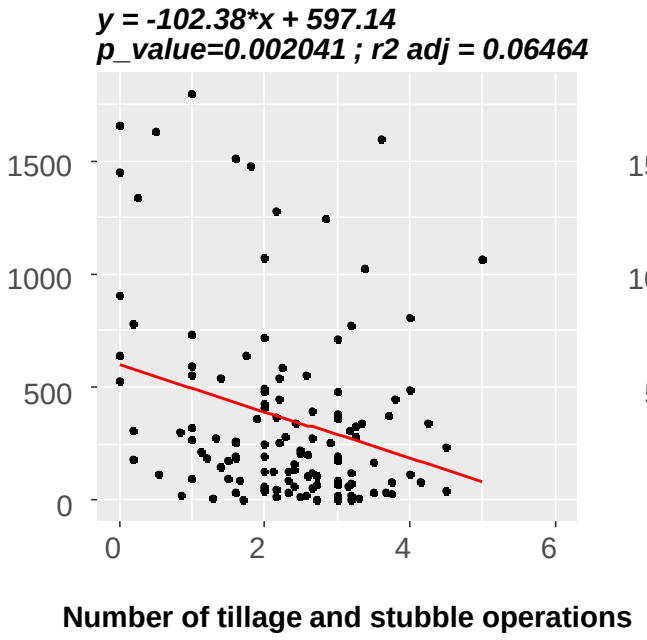
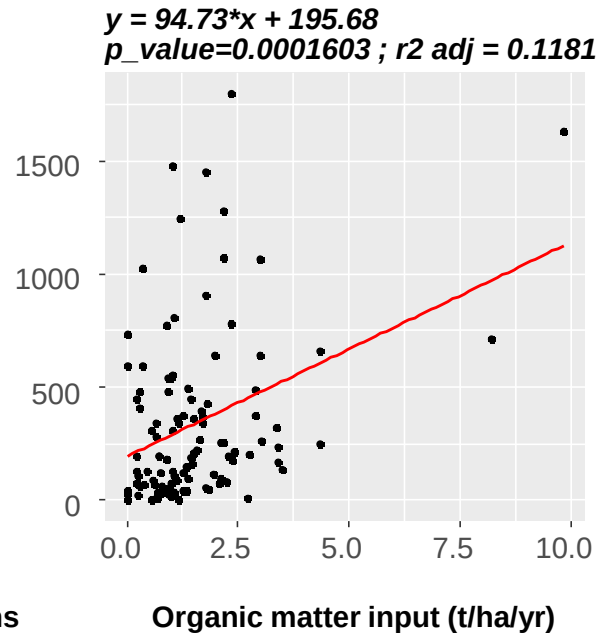
➢ **Coarse porosity (A_{-100}) might be more sensible to short term factors than long term practices** (Kravchenko et al., 2019)

Agricultural practices survey results







Significant predictors of earthworm populations characteristics are also:

- **Organic matter inputs (positive effect)**
- **Temporary pasture duration (positive effect)**
- **Mechanical intensity applied to the annual crops (negative effect)**

➢ **Short term influence of cover vegetation or coarse porosity to be investigated**

Conclusion and perspectives

This study highlights the potential of agricultural practices belonging to the pillars of Conservation Agriculture (Hobbs et al., 2008)

Results can be relativized in regards to soil bioturbation and soil structuration processes dynamics

Results have to be discussed according to :

-their combined effects at farm scale,

-potential antagonistic or indirect effects of some technical choices with respect to soil quality objectives.

To explore earthworm species abundance and their relationships with soil quality and SICS

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