Soil conservation: what is the real importance of soil organisms in soil aggregate stability?

Morgane Roquier[1], Guenola Peres[1], Anna Edlinger[2], Jack Faber[2], Stefano Mocali[3], Mathieu Emily[4]

[1]UMR SAS, Institut Agro Rennes-Angers, INRAE, Rennes, France; [2]Wageningen Environmental Research, Wageningen, the Netherland
[3]Agricoltura e Ambiente (CREA-AA), Cascine del Riccio, Italy; [4]UP Applied Mathematic, Institut Agro Rennes-Angers, Rennes, France

Context & Objectives

Aggregate stability is a key indicator of soil health, particularly its resistance to erosion caused by wind and rain [1]. It depends on various physical, chemical, and biological factors, whether internal (specific to the soil) or external (dependent on climate and land use) [2]. Among these factors, soil organisms, especially earthworms and microorganisms (fungi and bacteria), play an important role [3]. However, their exact contribution is unclear and requires further research.

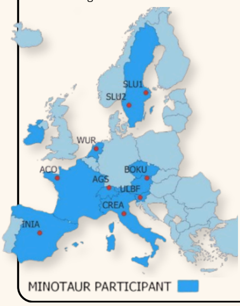
MINAUTOR project (EJP-Soil program) aims to identify the relashionships between soil biodiversity and ecological production functions (EFP). In our case, the objectives are :

- **Identify the relationship between structural stability and soil biological, chemical, and physical parameters**
- **Identify some key erthworm spieces influencing aggregate stability**

Material & methods

- **LTE sites**

9 Long Term Experiments sites (organized in 3 or 4 random blocks) dealing with reduced tillage and fertilization



- **Mesured parameters**

Biological

Agronomical

- Tillage depth
- Fertilization (mineral, organic)
- Crop rotation
- Cover crop

Physico-chemical

- T°, Precipitation
- Soil moisture
- pH
- Mineral elements (eg. Al, Ca, ...)
- Total C (%)
- Texture (% of clay, sand, loam)

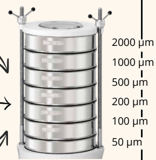
- **3 Soil aggregate stability tests** *([1] Le Bissonnais, 1996)*

Soil samples :
- Dried
- 3-5 mm

1. **Slaking (fast wetting)** Breakdown caused by the compression of the entrapped air during wetting
2. **Mechanical breakdown** Simulate a raindrop impact on a wet soil (shakking after pre-wetting aggregates in ethanol)
3. **Slow wetting** Simulate field condition of wetting under gentle rain (wetted with controled tension)

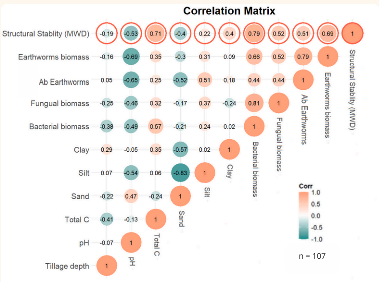
Dried at 40°

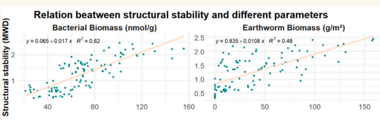
6 Sieves = 7 classes



Mean **W**eight **D**iameter (mm)
= Σ [(mean diameter between 2 sieves) x (% weight of particules retained on the sieve)] / 100

Results - Main drivers





Agregate stability (AS) is positively correlated with biological parameters: **Eartwhorm biomass** and **bacterial biomass** are strongly correlated with AS, and in a less extend **earthworm abundance** and **fungy biomass**

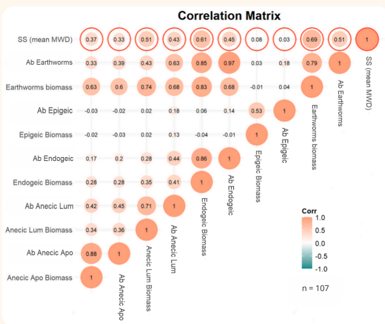
AS is also strongly correlatde with **total Carbon**
By contrast, **soil tillage depth** and **pH** are negatively correlated with AS.

No correlation are observed with climate properties.

	Correlation factor							
	pH	Total C	Sand	Clay	Bacterial Biomass	Fungal Biomass	Earthworm Abundance	Earthworm Biomass
Fast Wetting test	-0,36	0,57	-0,05	0,02	0,84	0,61	0,30	0,62
Slow Wetting test	-0,59	0,60	-0,20	0,17	0,85	0,60	0,52	0,74
Mechanical Breakdown	-0,41	0,70	-0,63	0,66	0,53	0,29	0,47	0,51

Fast and slow wetting tests are strongly correlated with biological parmeters, while mechanical breakdown is mainly correlated with Total carbon and texture (negatively for sand).

Earthworms action



Within ecological groups, **endogeic** and **epi-anecic** (*Lumbricus* genus) are the most correlated with aggregate stability. Epigeic earthworms do not seem to impact structural stability. For all ecological group, it is more relevant to consider **biomass** rather than earthworm abundance when assessing interaction between earthworms and aggregate stability.

	Correlation factor									
	Earthworm Abundance	Earthworm Biomass	Epigeic Abundance	Epigeic Biomass	Endogeic Abundance	Endogeic Biomass	Anecic Lumbricus Abundance	Anecic Lumbricus Biomass	Anecic Aporrectodea Abundance	Anecic Aporrectodea Biomass
Fast Wetting test	0,30	0,62	-0,04	0,08	0,22	0,43	0,32	0,51	0,41	0,47
Slow Wetting test	0,52	0,74	0,05	0,14	0,44	0,59	0,47	0,58	0,43	0,46
Mechancal Breakdown	0,47	0,51	0,00	0,02	0,45	0,56	0,34	0,32	0,12	0,15

Fast wetting test is more correlated with Epi-anecic (*Lumbricus* genus) ecological group, while mechanical breakdown is mainly correlated with Endogeic ecological group.

Slow wetting test is well correlated with both Endogeic and Epi-anecic (*Lumbricus* genus) ecological group.

Conclusions and perspectives

Our study, conducted in 9 sites across Europe covering different pedological and climatical contexts, shows that aggregate stability is clearly driven by biological factors (earthworms, bacteria and fungy). Among earthworms, only endogeic and epi anecic ecological groups are linked to soil stability.

Next steps:

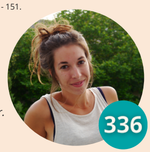
- **Accumulate data from various international projects to expand the existing database and explore the results on a larger scale**
- **go deeper in the analysis of interaction between earthworm and aggregate stability in order to better understand the rôle of earthworm in soil structuration: could we identify key earthworm species invoved in this physical propertie? does AS related to eartwhorm growth stage (juvenile, adult)?"**
- **Explore more parameters such as Na, carbonates, root biomass, plant diversity, previous crop,...**
- **apply some statistical tools to identify causal effect more than correlation**

References

[1] : Y. Le Bissonnais. 1996. Aggregate stability and assessment of soil crustability and erodibility: I. Theory and methodology. Eur. J. Soil Sci., 47, 425-437
[2] : E. Amézketa. 1999. Soil Aggregate Stability: A Review. J. Sustain. Agric. 14, 83 - 151.
[3] : A. Erktan, S. Coq, E. Blanchart, T. Chevallier, J. Trap, L. Bernard, J. Nahmani, C. Hartmann, M. Hedde, P. Ganault, S. Barot et J. Cortet. 2022. Biodiversité et structure physique des sols : Une vision spatialisée du fonctionnement des sols. Étude et gestion des sols. 29, 153 - 167

Aknoledgments

We thank all the MINOTAUR partners for assistance to get the data and metadata of the LTE sites and Ms. Issaga Diallo and Mr. Sylvain Busnot for technical support in soil aggregate stability measurements.



336