



HAL
open science

Effect or organic amendments on soil enzymatic activities. Results of the “Bioindicators” French program

Wassila Riah, Nathalie Cheviron, Jean Trap, Criquet Stéven, Clément Peltre, Sabine Houot, Marc Legras, Jean-François Vian, Antonio Bispo, Cécile Grand, et al.

► To cite this version:

Wassila Riah, Nathalie Cheviron, Jean Trap, Criquet Stéven, Clément Peltre, et al.. Effect or organic amendments on soil enzymatic activities. Results of the “Bioindicators” French program. 15th International Conferences of RAMIRAN (Network on Recycling of Agricultural, Municipal and Industrial Residues in Agriculture), Jun 2013, Versailles, France. hal-01190751

HAL Id: hal-01190751

<https://hal.science/hal-01190751v1>

Submitted on 15 Mar 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Effect of organic amendments on soil enzymatic activities. Results of the French “Bioindicator program”

Riah Wassila^{1*}, Cheviron Nathalie², Trap Jean¹, Criquet Steven³, Houot Sabine⁴, Bispo Antonio⁵, Grand Cécile⁵, Pérès Guénola⁶, Laval Karine¹, Trinsoutrot-Gattin Isabelle¹, Mougin Christian²



(1) ESITPA, Unité ARGITERR 76134 Mont Saint Aignan, FR

(2) INRA, Unité PESSAC 78026 Versailles, FR

(3) Aix-Marseille Université, IMBE UMR CNRS 7263 – IRD 237, 13397 Marseille Cedex 20, FR

(4) INRA/AGROPARISTECH, UMR Environnement et Grandes Cultures, 78850 Thiverval-Grignon, FR

(5) ADEME, 49004 ANGERS cedex 01, FR

(6) Université de Rennes 1, UMR CNRS 6553 ECOBIO, Station Biologique, 35380 Paimpont, FR



- ❖ Soil = a non-renewable resource
- ❖ Soil degradation = still accelerating

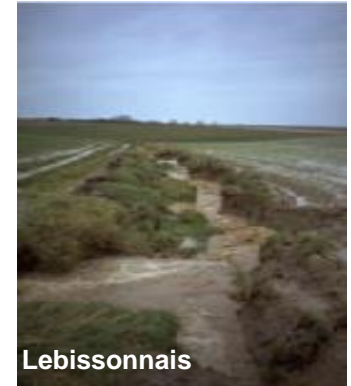
Soil must be protected

Available Tools ?

- ❖ Tools for soil quality assessment
 - ➔ physical and chemical indicators commonly used
 - ➔ indicators based on biological parameters are still rare

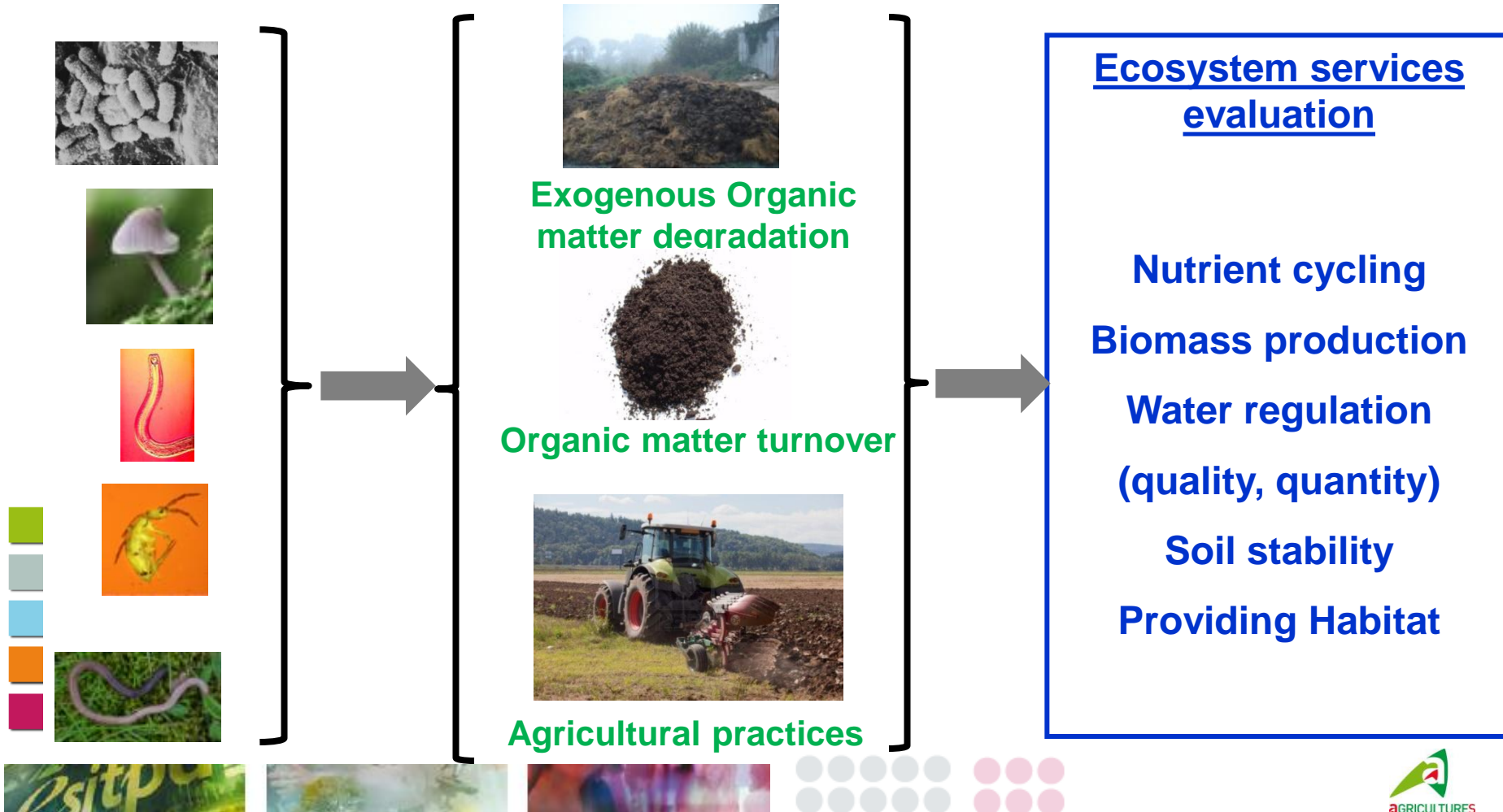
However, soil biota is known to respond to multiple impacts and to react quickly to natural and anthropic stresses

needs of bioindicators



What are the needs in agricultural soils ?

Tools to measure biological state and **soil functions**
and at least to evaluate agricultural soil **ecosystem services**



Ecosystem services evaluation

Nutrient cycling
Biomass production
Water regulation
(quality, quantity)
Soil stability
Providing Habitat

ADEME (French Agency for Environment and Energy Management) initiated a national research program to develop such indicators : **“Bioindicator Program”** (2006-2012).

<http://ecobiosoil.univ-rennes1.fr/ADEME-Bioindicateur>

Objectives

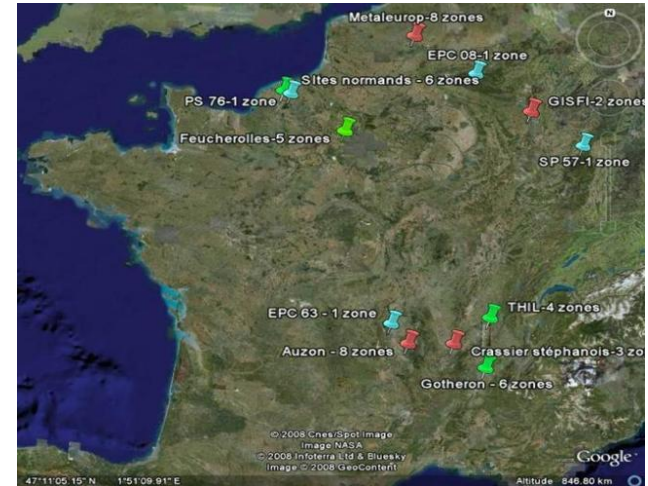
- to **calibrate the bioindicators on the basis of referential values** in order to interpret the results
- to **provide relevant biological tools** (sensibility, accessibility, cost, ...) depending on the purpose :
 - soil monitoring
 - characterization
 - risk assessment
- to **transfer** the tools to stakeholders (policy makers, farmers, technical advisers...)



Strenghts of Bioindicator program

5 Strenghts of Bioindicator program

- Test and comparison of 47 bioindicators (from microflora to fauna and flora)
- Study large number of situations 13 situations (47 plots)
- Homogeneity of procedures and protocoles
- **Development of a data base** to manage a large amount of data (~200.000)



- **Development of a common data mining for data processing**



1) Microorganisms

Parameters of quantity

- Global (MB, DNA)
- Non-global (Fungi, Bacteria)



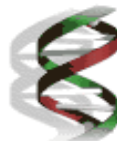
Parameters of activity (examples)

Enzymatic Activities (14)

- Metabolical Functions (mineralization)

Parameters of genetic structure

- PCR TTGE (Bacterial, Fungal)
- PCR Empreinte ARISA (Bacterial)



3) Flora

Parameters -> individual effects

- Lipid Biomarkers (Oméga 3)
- Metal Bioaccumulation
- Free Amino acid content



2) Fauna

Global Parameter

- Total Macrofauna



Parameters -> Community level

- Earthworms
- Collembola
- Nematodes



Parameters -> Individual level

- Molecular earthworm biomarkers (metallothionein coding gene expression, Cd sensitivity)
- Metal Bioaccumulation (snail, micromammal)



What are soil enzymes?

Enzymes are proteins with specific catalytic properties



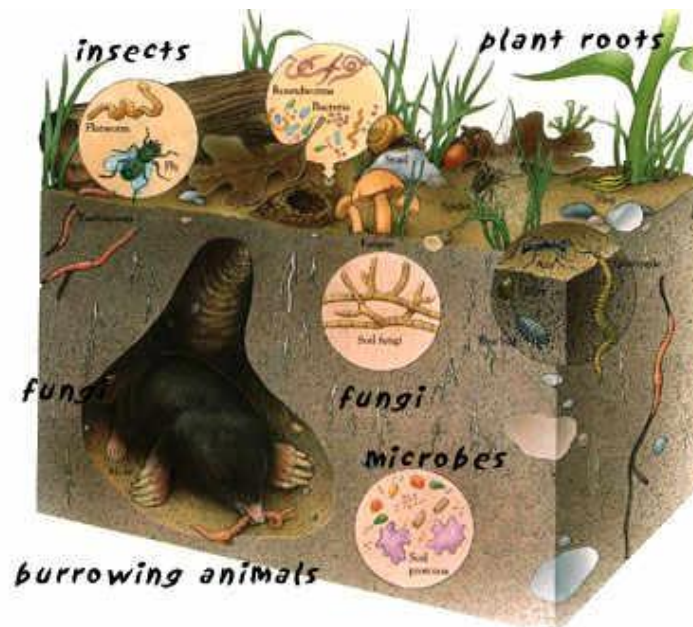
Origin of Soil Enzyme Activity

1. Soil microorganisms - living and dead
2. Plant roots and crop residues
3. Soil animals

an integrative Indicator...

Why it is important?

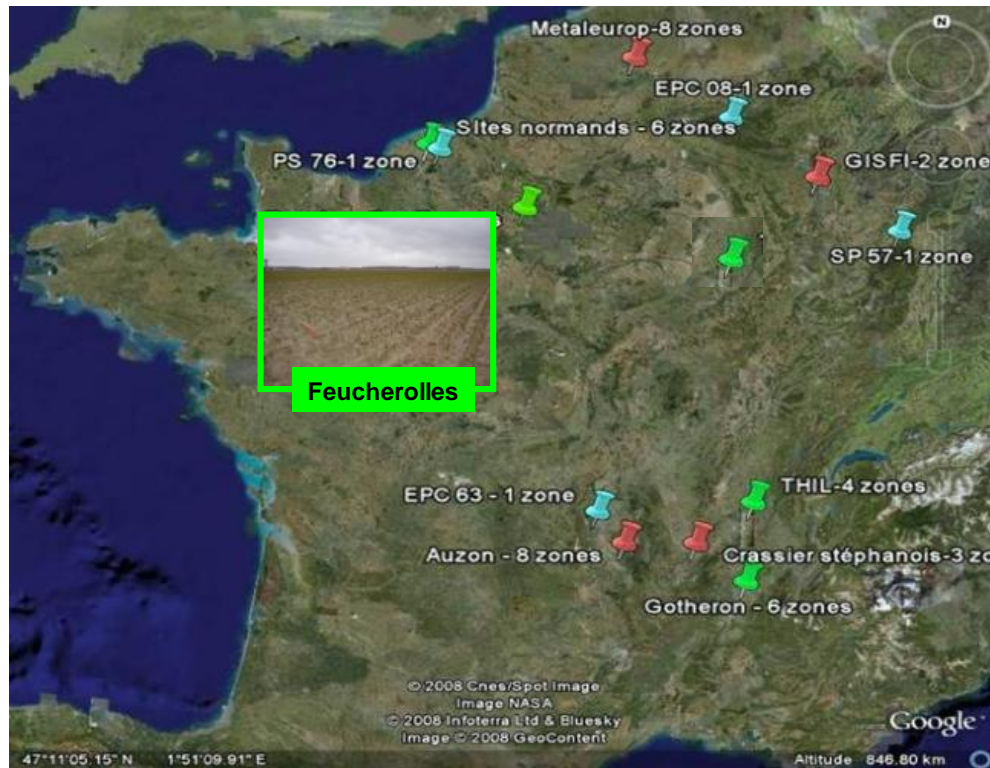
- Soil enzymes play an important role in organic matter decomposition and nutrient cycling
- Enzymes are recognized as early indicators of soil functioning changes due to modifications of soil management or agricultural practices
- **40 to 60% of enzyme activity can come from stabilized enzymes**
- **not necessarily highly correlated with microbial biomass or respiration**



Do enzyme activities reveal changes in the biological functioning of soils caused by organic amendment ?

Could soil enzyme be indicators of soil organic matter quality or organic products stability ?





QualiAgro-Feucherolles site *S. Houot (INRA Grignon)*

- Located at Feucherolles, in north-western France (50 km west from Paris)

- The climate is oceanic



-The soil is cultivated following a wheat–maize rotation



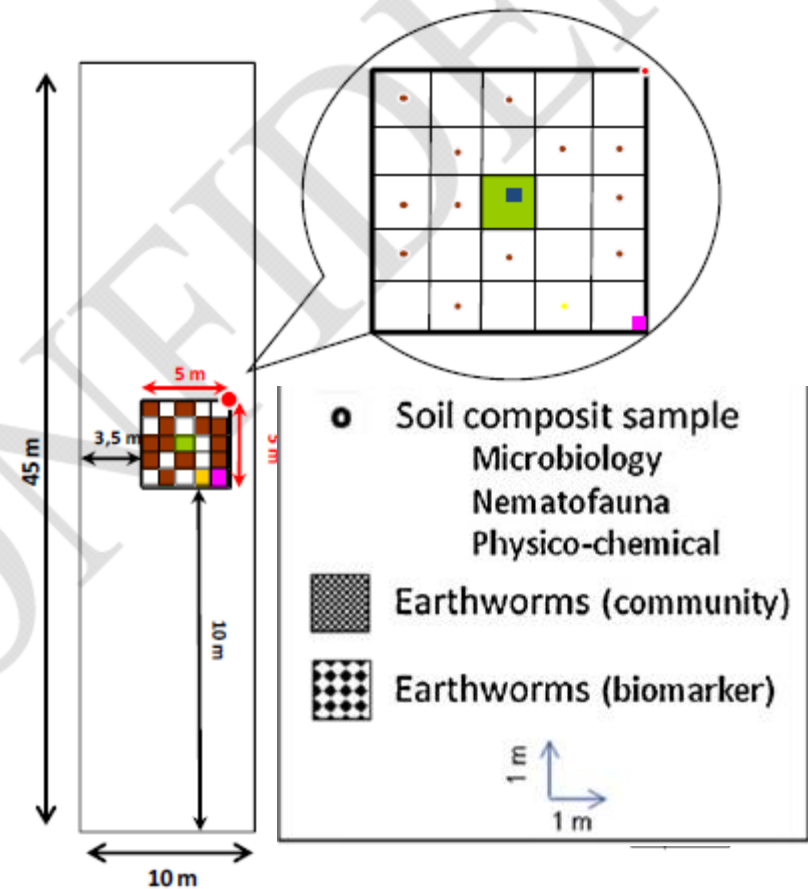
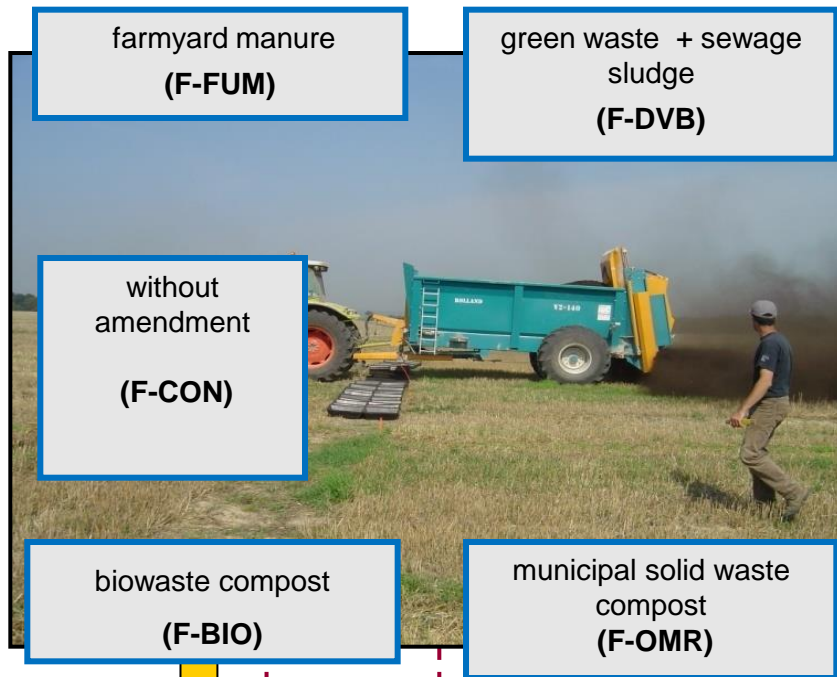
-At the date of sampling soils were cultivated with wheat



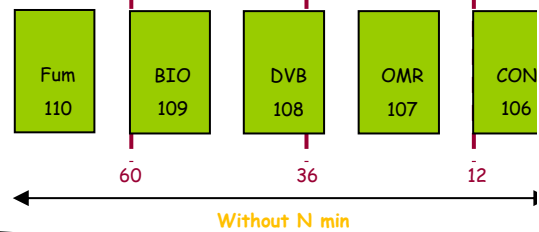
- The last inputs have been made 18 months ago



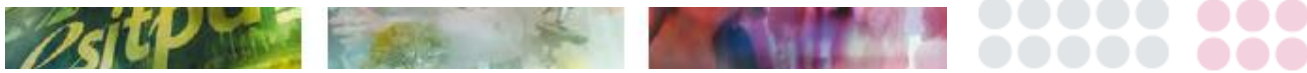
Sampling Protocols and Procedures



Block 1



The organic amendments have been applied every two years in September



Fourteen enzyme activities involved in the different nutrient cycling were measured by the spectrophotometric methods

Table 1: E.C. numbers, specific substrates (concentrations and pH buffers) , references of protocols used to measure enzyme activities

Enzymes	Codes	E.C. number	Substrates (buffer pH and concentration)	References
<u>Global activities</u>				
Dehydrogenase	DEH	1.1.1.1	2,3,5 triphenyltetrazolium chloride ((pH 7; 0.12M)	Schaefer et al, 963
Fluorescein diacetate	FDA	209.877.6	Fluorescein diacetate (pH 7.6: 1000 $\mu\text{g}\cdot\text{mL}^{-1}$)	Adam & Duncan. 2001

NP: nitrophenyl

Soil enzymes assays are based mostly on the quantification of the product released after adding known amount of substrate to the soil



1. Homogenizing, sieving and weighing soil
2. Preparation of soil solution
3. Addition of a specific substrate and incubation
4. Stop the enzymatic reaction and measure absorbance with a spectrophotometer
5. Data analysis

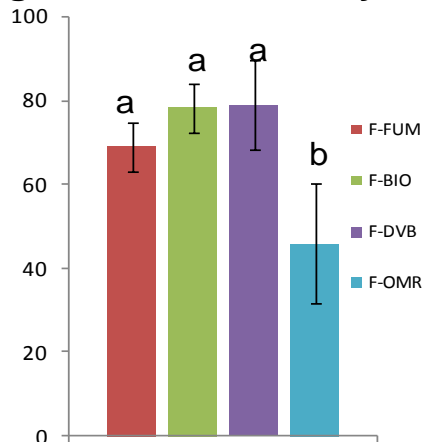
Enzyme activity expression :

nmole of hydrolyzed or oxidized substrate / min / g of dried soil



1. Organic matter stability index and organic carbon content in Feucherolle site

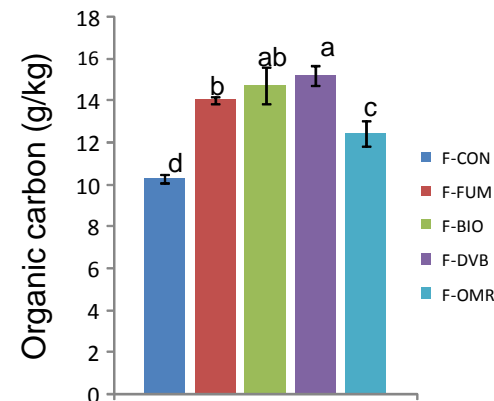
Organic matter stability index



➤ FUM, BIO and DVB exhibited the same OMSI

➤ The lowest OMSI was obtained for OMR

Organic carbon content



➤ all organic amendments drive to an increase in soil organic carbon content by comparison with the control

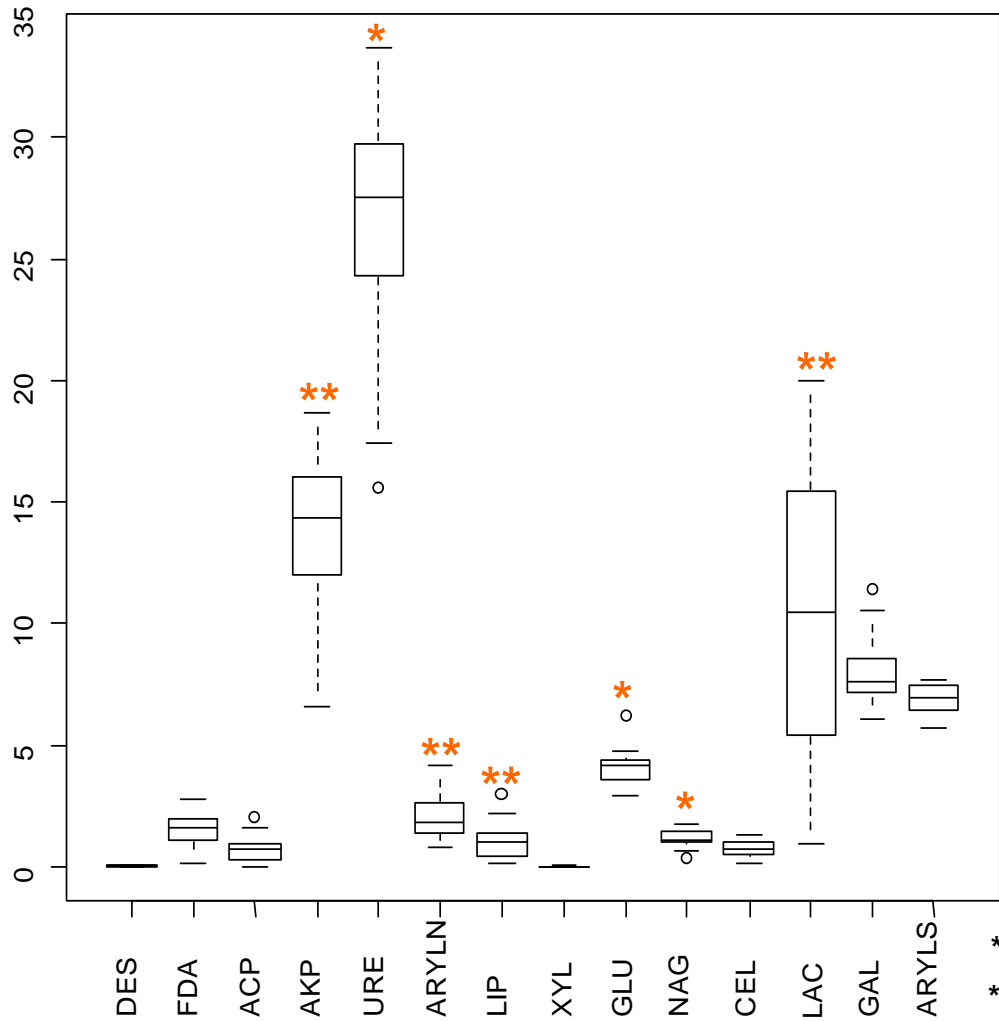
➤ FUM, BIO and DVB have the highest effect.

➤ OMR is intermediate between control and other organic treatments.

Organic amendments influence soil organic carbon, in relation to their initial stability



2. Variation of soil enzymatic activities in Feucherolle site



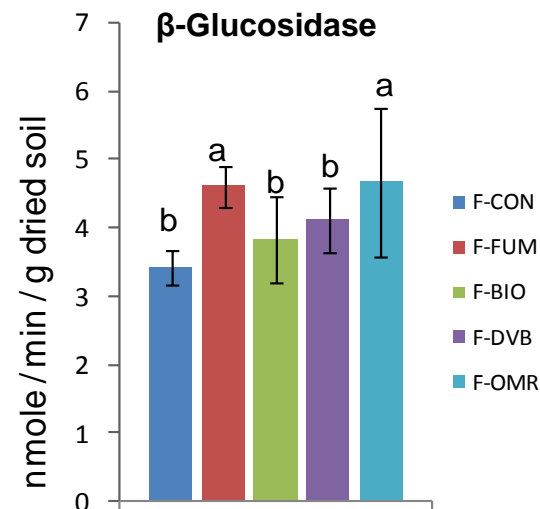
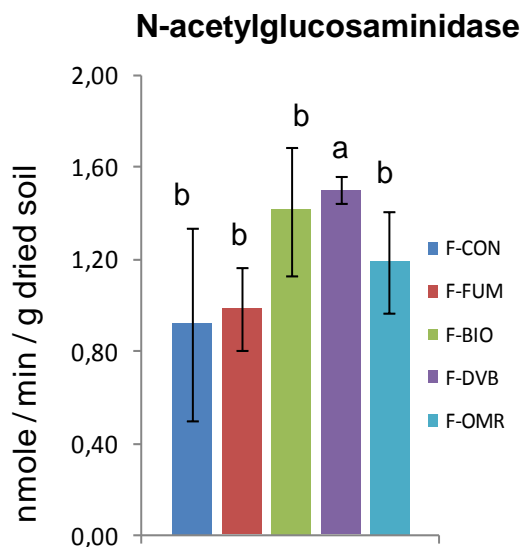
Lipase, β -glucosidase, N-acetylglucosaminidase, laccase, arylamidase, urease and alkaline phosphatase were **modified according** to the spreading of **organic amendments** onto the soil

* $P < 0.05$
 ** $P < 0.01$

Synthesis of enzymatic activities response to organic amendment according to Kruskal-wallis test n=4



3. a Variation patterns of enzymatic activities affected by organic amendments



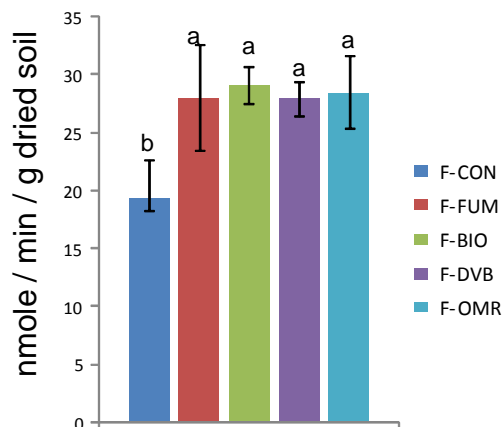
18 months after organic amendment spreading :

- **NAG and GLU enzyme activities did not reflect the soil organic matter content**
- **The effect of exogenous organic matter (EOM) on GLU and NAG activities was transient**
- **These enzyme activities are less suitable for monitoring long-term effect of OM**



3. b Variation patterns of enzymatic activities affected by organic amendments

Urease

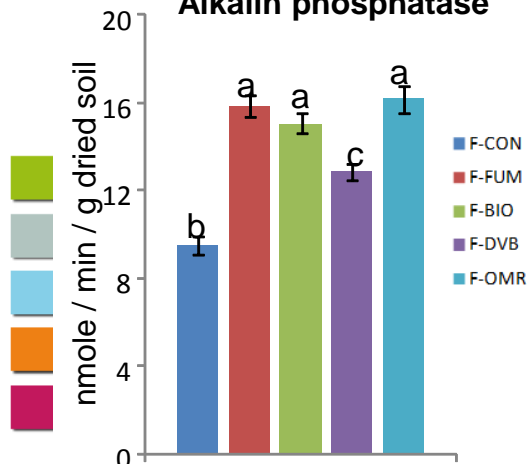


➤ Significant increase of URE activity in the soil regardless of addition of compost or manure

➤ No significant difference appears between organic treatment

**18 months after compost and manure spreading:
URE and AKP activities were stimulated by organic amendements.**

Alkaline phosphatase



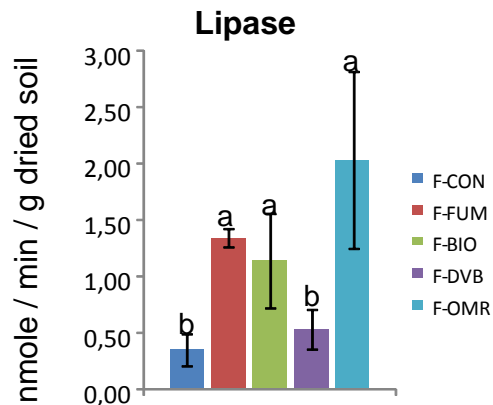
➤ All treatments increased AKP activity

➤ The increases in AKP activity was similar in the soils amended by OMR, BIO and FUM

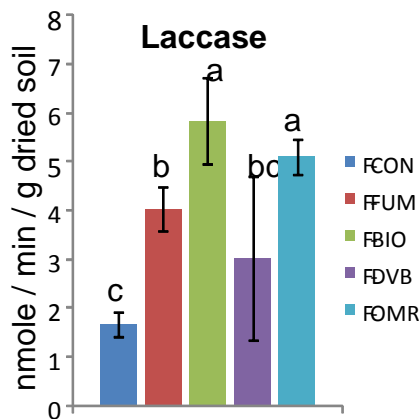
Link with biomass stimulation due to an increase of organic C content in soils?



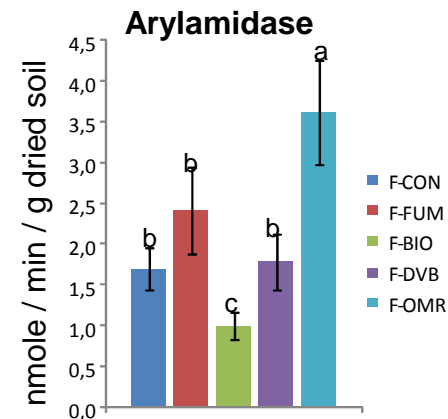
3.c Variation patterns of enzymatic activities affected by organic amendments



- All treatments increased LIP activity
- No significant difference between DVB compost and CON

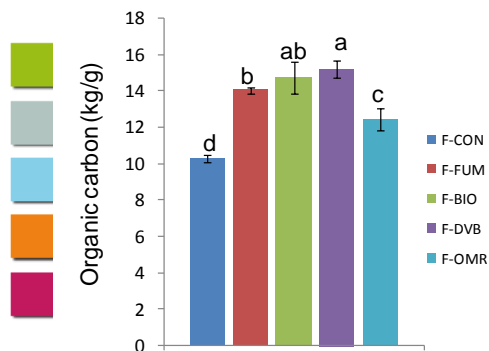


- All treatments increased LAC activity
- The largest increases in LAC activity was observed in BIO



- BIO exhibited the lowest ARYLN activity
- OMR exhibited the highest ARYLN activities
- No difference in ARYLN activity between FUM, DVB and CON

Organic carbon content



➤ **No relationship between levels of enzyme activities variation and organic C content patterns**

More specific activities ?

Link to amendment chemical, physical and biochemical nature?

Link to soil organic carbon composition?



Effect of organic amendment on soil enzymatic activities

- Organic amendments drive to an increase in soil organic carbon content, as exogenous organic matter added is stable.
- ACP, FDA, DEH, CEL, GAL, XYL and ARYLS activities were not affected by organic amendments, 18 months after the last input.
- Organic amendments seem to have transient effect on β -glucosidase, N-acetyl-glucosaminidase. **These enzyme activities are less suitable for monitoring long-term effect of OM**
- Lipase, laccase, arylamidase, urease and alkalin phosphatase activities were **modified** according to the spreading of organic amendments into soil
- Lipase, laccase, arylamidase activities may be linked to organic matter biochemical state or the composition of the soil organic carbon
- The municipal solid waste compost (F-OMR) plot that have the lowest OMSI and organic carbon content exhibited in average the highest enzymatic activity values (AKP, LIP, GLU, URE and ARYLN)



Bioindicator program : A large research network

