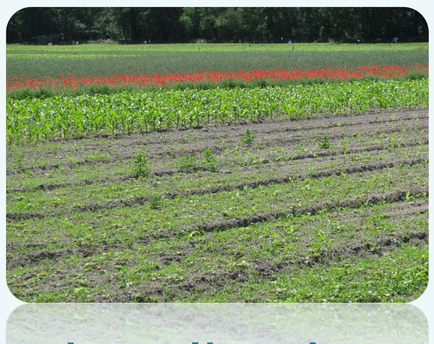
Soil enzyme activities reveal re-functionalization of trace metal agricultural contaminated soils after Miscanthus giganteus plantation

Nathalie Cheviron, Christelle Marrauld, Isabelle Lamy



Soil enzyme activities reveal re-functionalization of trace metal agricultural contaminated soils after *Miscanthus giganteus* plantation

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Abstract

Context: The use of contaminated soils for non-alimentary cultures is gaining importance in view of the scarcity of agricultural surfaces and the presence of some potential harmful pollutants in surface horizons that could impact the food chain. But in the case of trace metal contaminated soils few information are available on the effects of land use and soil management changes on soil quality parameters and/or soil health. Suggestion was made in literature that enzymatic activities could be good indictors of soil functioning, providing special attention to confounding effects. In this work the objective was to assess the impact of change of cultural practices on the soil quality, as seen by soil enzyme activities.

Results: Results for the diachronic follow up in surface horizons showed that soil urease activities under miscanthus differ clearly from those under annual culture with higher values under perennial culture. This was particularly observed as the setting-up of miscanthus was former. β-Glucosidase activities, while less indicative, also suggested an enhancement of microbial activities under miscanthus.

When normalizing with the enzymatic activities of the parcel under annual culture, results clearly show the effect of the plantation duration on the re-functionalization of the soil. But despite the rapid answer of the indicators, three years were necessary to significantly quantify an evolution. N cycle was more sensible to point out the re-functionalization of the contaminated soil.

In the soil profile results of the enzymatic activities under miscanthus highlighted the evolutionary structuration of microorganisms in contaminated soil. This evolution was faster near the soil surface than in subsurface horizons and better assessed for N cycle.

OBJECTIVES

Assess the **effects of Miscanthus x giganteus cropping** on the re-functionalization of a long-term contaminated soil, in relation with the **C and N cycles** with **urease and β-glucosidase** activities

Investigations : real-field location close to Paris (France)

(1) **Synchronic comparative study** of plots planted with Miscanthus and a plot under a conventional annual crop system

(2) **Diachronic study monitoring** enzymatic activities dynamics during a 3-year period following the planting of Miscanthus

HYPOTHESIS: Miscanthus crop, would stimulate microorganisms, ie enzymatic activities, in this polluted soil by providing new soil habitats and inputs in organic carbon, limiting the influence of metal contamination

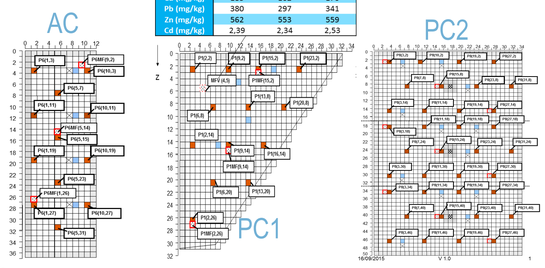
METHODS

PLOTS AND SOILS

1 Annual culture plot,(AC, n = 12)

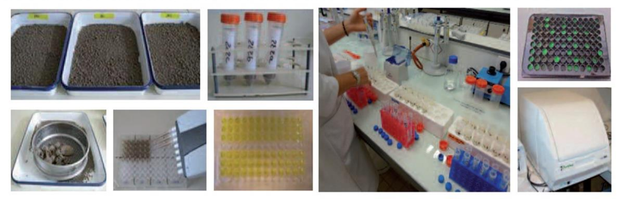
2 perennial plots (Miscanthus) (PC1, n =13, PC2 n=36)

SOIL PARAMETERS	Annual culture	perennial culture 1	perennial culture 2
n	12	13	36
Clay		7,90%	
loam		9,90%	
sand		82,20%	
OC (g/kg)	49,7	49,1	43,6
Ntot (g/kg	2,04	2,18	1,89
pH	7,4	7,5	7,7
Cu (mg/kg)	185	162	170
Pb (mg/kg)	380	297	341
Zn (mg/kg)	562	553	559
Cd (mg/kg)	2,39	2,34	2,53



ENZYMES

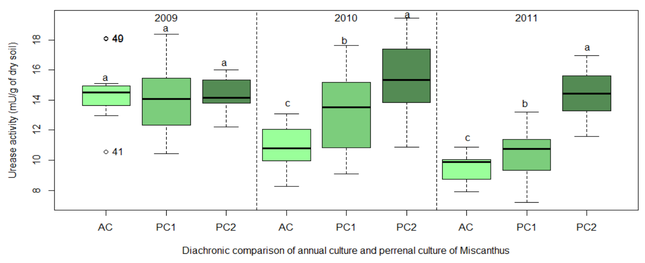
Soil enzymes assays are based on the quantification of the product released after adding known amount of substrate to the soil



Enzymes	Code	EC number	Substrates	reference
C cycle				
β-Glucosidase	b-GLU	3.2.1.21	p-NP-β-D- glucopyranoside (50 mM)	de Santiago et al, 2012
β-Galactosidase	b-GAL	3.2.1.23	p-NP-β-D- galactopyranoside (20 mM)	Eivasi & Tabatabai, 1988
n-acetyl-glucosaminidase	NAG	3.2.1.30	p-NP-N- acetylglucosaminide (10 mM)	Parham & Deng, 2000
N cycle				
Urease	URE	3.5.1.5	Urea (50 mM)	de Santiago et al, 2012
P cycle				
Acide phosphatase	PHOS	3.1.3.2	p-NP-phosphate (50 mM)	de Santiago et al, 2012
S cycle				
Arylsulfatase	ARS	3.1.6.1	p-NP-sulfate (25 mM)	de Santiago et al, 2012

MAIN RESULTS

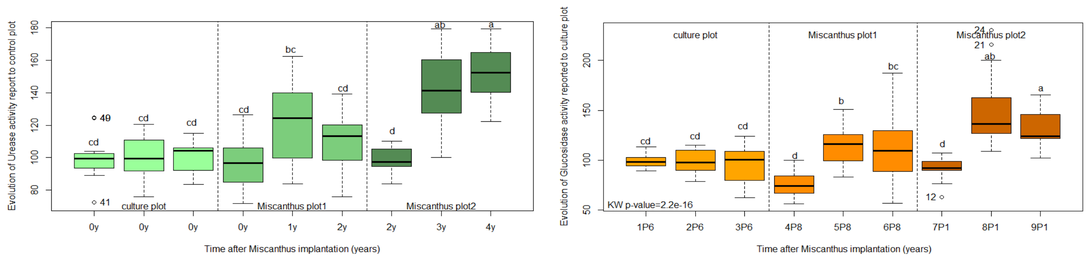
Evolution of surface enzymatic activities



Diachronic comparison of annual culture and perrenal culture of Miscanthus

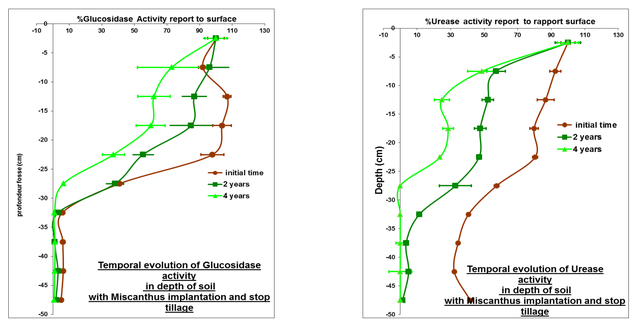
Annual cultures: decrease in biochemical parameters (lost of organic matter, tillage, re-distribution of contaminants)

Perennial cultures: preservation or increase in biological functioning parameters with the stop of the plowing, more culture residues, growth of rhizosphere microorganisms, modifications of contaminants around miscanthus)



Evolution of enzymatic activities of C and N cycles with perennial culture of miscanthus:
Three years are necessary to point out a significant evolution of nitrogen and carbon cycles

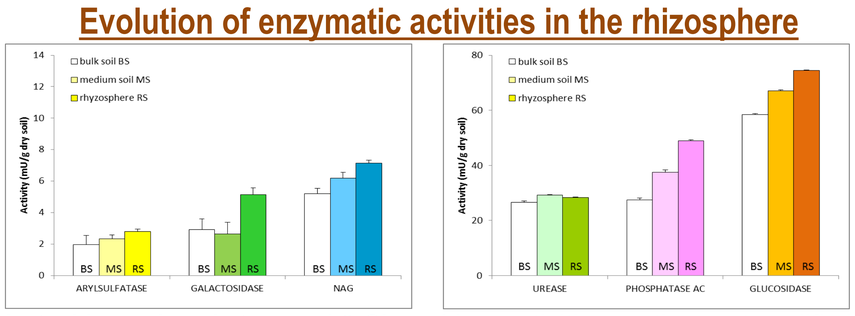
Evolution of enzymatic activities in soil profile



Urease and β-Glucosidase activities in soil profile are modified under perennial culture implantation

Urease activities decrease more quickly than **β-Glucosidase** activities in soil profile

Evolution of enzymatic activities in the rhizosphere



β-Galactosidase, phosphatase and β-Glucosidase activities are the most modified in the rhizosphere

Urease activity is not modified in the rhizosphere

CONCLUSIONS

Perennial Miscanthus crop was shown to stimulate microorganisms (real-field metal contaminated conditions and in comparison with annual conventional cropping)

- in the **surface 0-10 cm layer**
- along the **soil profile.**

Urease activities were the most sensible to the short-term changes induced by the Miscanthus establishment **in the bulk soil but not in the rhizosphere**, may be due to the specific management of nitrogen by this crop.

Soil enzymatic activities were able to **reveal soil re-functionalization in contaminated soil under Miscanthus**

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