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Long-term effect of organic amendments on soil enzymatic activities

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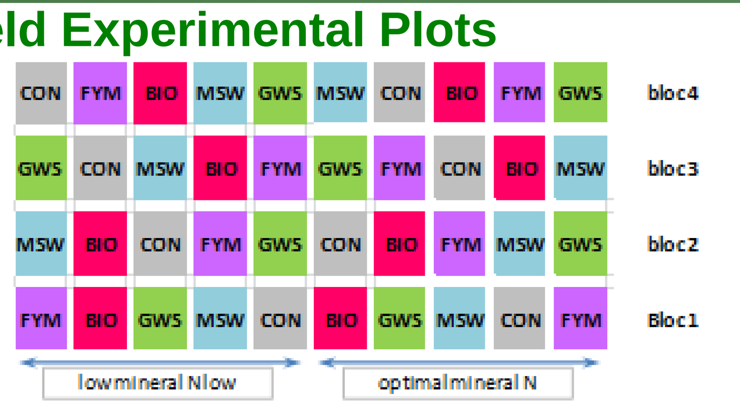
Abstract

Microbial ecology provides tools to understand the effects of organic matter application on soil microbial functions, following soil amendment with organic waste products. Here we studied the long-term effect of soil amendment with composts and manure on different soil enzyme activities involved in the C (β-glucosidase), N (urease), S (arylsulphatase) and P (phosphatase) biogeochemical cycles. The amended plots showed higher enzymatic activity than the unamended ones. Our results demonstrate that organic amendments had a noticeable long-term effect on enzyme activities, depending on the cycle considered. Clearly, the dynamics of microorganism response is closely related to organic matter nature, and more precisely to its degradability.

Field Experimental Plots



No organic amendment (CON), farmyard manure (FYM), biowaste compost (BIO), co-compost of green wastes and sludge (GWS) and municipal solid waste compost (MSW)

QUALIAGRO (Feucherolles - Yvelines; France), is a long-term experiment network to observe and understand the effects of OWP amendments on cropped soils to investigate the environmental impacts of recycling organic residues on soil biochemical properties, as well as the possible resilience of the agrosystems, to assess cost/benefit balance, and to improve agricultural practices. Since 1998, Qualiagro allows to study the effects of fertilizationcomposts and manure) in relation with two levels of nitrogen.

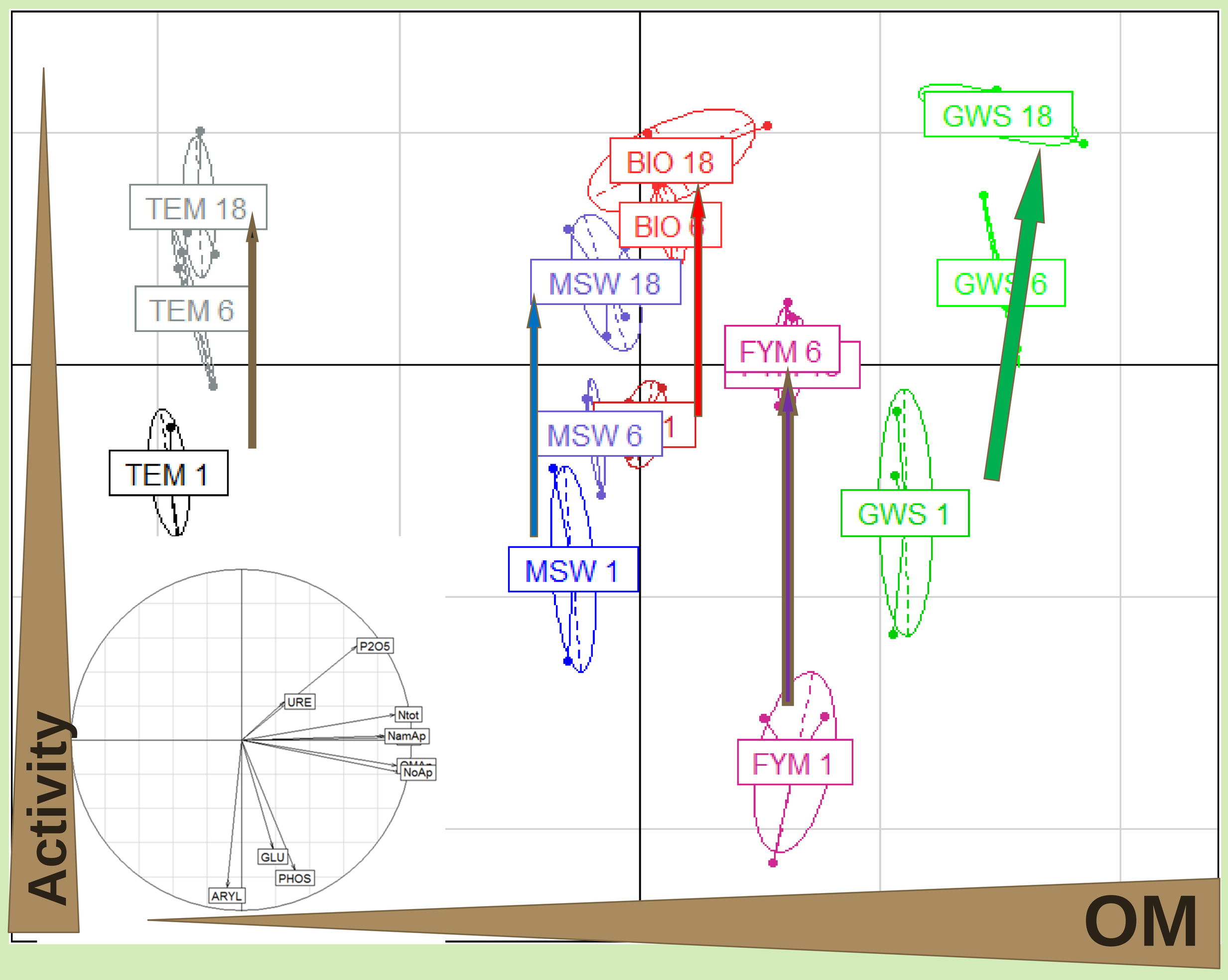
Average physico-chemical characteristics of organic amendments applied in 1998, 2000, 2002, 2004, 2006, 2007, 2009 and 2011,

	GWS	MSW	BIO	FYM
Dry matter, g kg^{-1} fw	633 (±9)	678 (±129)	700 (±91)	396 (±97)
OC, g kg^{-1} dw	265 (±48)	308 (±48)	208 (±50)	320 (±72)
C/N_{tot}	10.7 (±2.2)	15.6 (±2.8)	11.7 (±1.9)	14.0 (±3.0)
pH (in H_2O)	7.7 (±0.8)	7.4 (±0.4)	8.5 (±0.2)	9.0 (±0.2)
Potentially Mineralized Carbon[b], %OC	12 (±5)	44 (±11)	16 (±6)	20 (±10)

[a] fw, fresh weight; dw, dry weight; OC, organic carbon content; ON, organic nitrogen content ; C/N_{tot}, organic C to total N ratio

[b] The excess mineralized carbon after 91 days in the soil-organic amendment mixtures was expressed as a percentage of the amendment organic C applied during incubation (after subtracting mineralized C of the control treatment)

RESULTS



GWS: pool of degradable (sludge), and few degradable (Green Wastes)

BIO: contains lots recalcitrant organic coumponds; thin mineralisation, poor disponibility of nitrogen

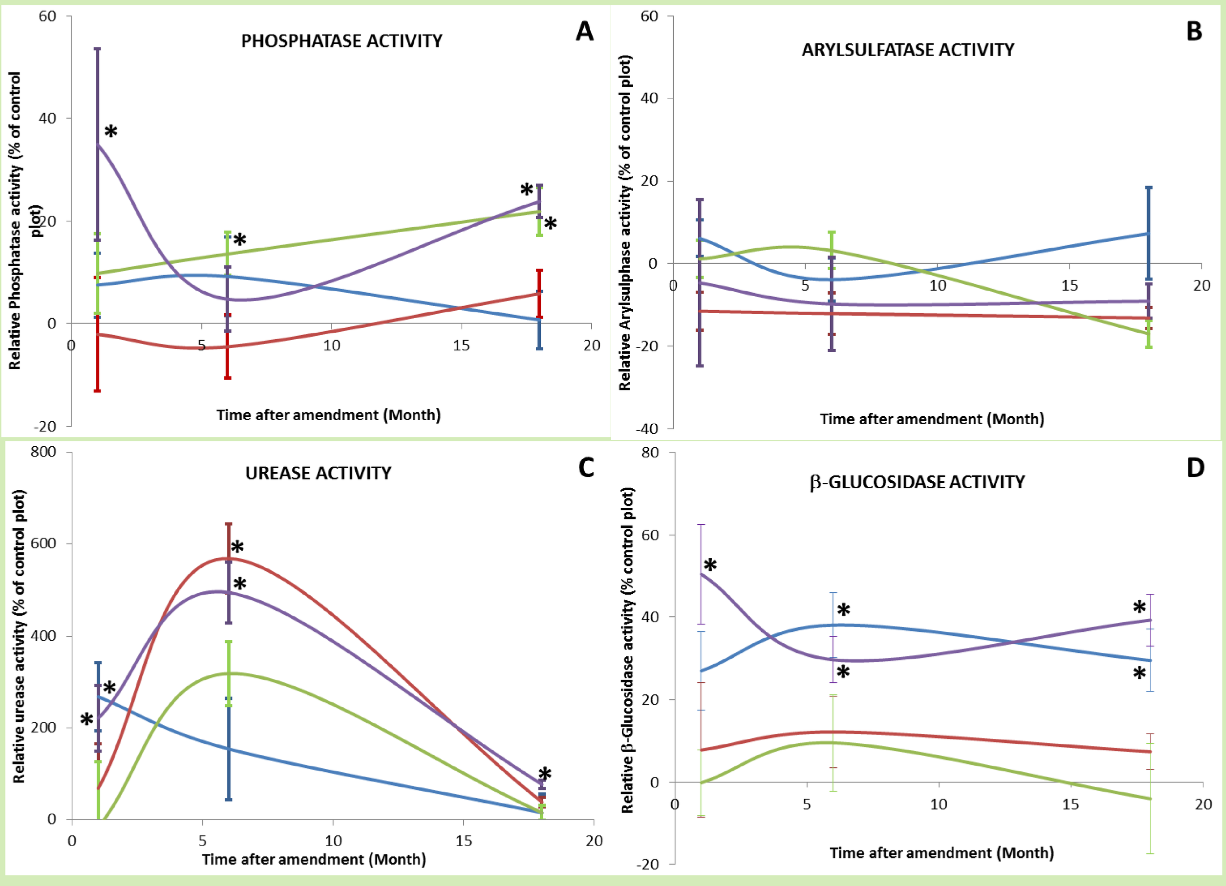
FYM exogen microorganism input, very degradable

MWS high biodegradability, very thin, rapidly incorporated and mineralised

-The level of β-Glucosidase, Phosphatase and Urease activities increases depending on the nature of the amendment, more especially on the status of organic matter added, its availability and degradability.

- Arylsulfatase activity does not respond to these amendments

- Organic amendments could promote stability of enzymes which could strongly affect soil quality



Time-course of hydrolase activities (expressed in % of control plot)

A: phosphatase activity
B: arylsulfatase activity
C: urease activity
D: b-glucosidase

Amendments were:
Farmyard manure: FYM (purple lines),
Biowaste compost: BIO (red lines),
Municipal solid waste compost: MSW (blue line)
Co-compost of green wastes and sludge: GWS (green line).

Significant differences between control and amended plots are with (*).

CONCLUSIONS

Organic amendments have noticeable long-term-effects on enzymatic activities.

Soil microbial processes are sensitive indicators for monitoring changes of soil biological properties due to amendments by organic waste and for assessment of Organic Matter status

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MATERIALS AND METHODS

For each treatment, the Qualiagro site (INRA and Veolia Environment collaboration) comprised four replicates of plots (45 m x 10 m, 450 m^2). The treatments were: no organic amendment (CON), farmyard manure (FYM), biowaste compost (BIO), co-compost of green wastes and sludge (GWS) and municipal solid waste compost (MSW)(Figure 1). The present study was managed on plots with optimal mineral nitrogen fertilization. In the site, the luvisol was a silt loam comprising 15% clay, 78% silt, and 7% sand. Its initial pH value was 6.9 and initial organic matter was 1.8%. During the past twenty years, the average annual precipitations amounted to 582 mm, and the average annual temperature was 11°C. The soils were collected at different times (at T0, then 6 and 18 months after amendments from) 2011 to 2013 at a depth of 0-10 cm. Samples were sieved through a 5 mm mesh, and stored at 12 °C before use. Soil water content was determined by drying 5 g of soil at 105 °C for 48 H.0 Phosphatase, b-glucosidase, arylsulfatase, and urease activities were performed in microplate according to modified protocols [16, 17, 18, 19] less than 48 hours after sample collection. Briefly, hydrolases were measured in triplicates in 4 g soil samples mixed during 10 min at 250 rpm with 25 ml water. For phosphatase, b-glucosidase and arylsulfatase activities, soil solutions were incubated with specific substrates (Sigma chemicals) (Tab.2). Reaction was stopped with 0,5 M $CaCl_2$ and 0,1 M Tris at pH 12. For urease activity, soil solutions were mixed with 0,4 M urea. NH_4 formed was revealed with ammonium salicylate and ammonium cyan rate (Hach reagents). After the reactions, each plate was centrifuged 5 min at 2000 g, and absorbance was measured on a microplate reader Genius (SAFAS). The amounts of p-nitrophenol (PNP) and NH_4Cl formed were obtained by the absorbance at 405 nm and 610 nm.