Effect of repeated organic residue applications on soil microorganisms involved in N cycle and their activities at the plot scale: consequences on ecosystem services

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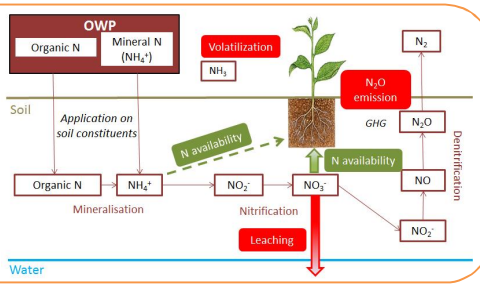
Introduction

Use in agriculture of municipal or agricultural residues (Organic Waste Product, OWP) :

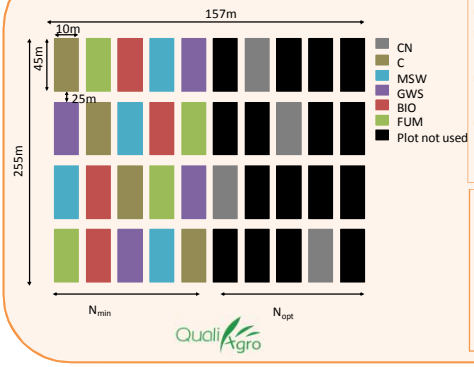
- addition of mineral and organic N in soil
- impact on N cycle and associated ecosystemic services (soil fertility, water quality, air quality, climate regulation)?



Questions

- **Short term (STE) and residual effects (RE)** of OWP amendements to soils on:
  - Soil organic matter stocks and dynamics
  - Soil microorganisms (bacteria and fungi)?
  - Nitrifiying and denitrifying populations?
  - N_2O emissions?
- N stocks in soil and availability for cultures?
- Impact **on associated ecosystem services**?

Material and Methods: the field experiment QualiAgro (78, France)



- Loamy soil on carbonated loess
- Initial characteristics (1998): pH=6.9, organic N=1.1 $g.kg^{-1}$, C/N=9.5
- Crop succession: wheat-corn (residues exported for wheat, incorporated for corn)
- OWP application after wheat in September **every 2 years;** Doses equivalent to **4t C/ha (10 à 20 t DM/ha)**

Treatments:

C: Control without OWP application

CN: Control without OWP application enriched with N

MSW: Municipal solid waste compost

GWS: Co-compost of green waste and sewage sludge

BIO: Biowaste compost

FUM: Farm yard manure

Sampling, methods and measures

2 dates of sampling (01/09 et 14/10/2011):

- 3 weeks before the 8th OWP application → **Residual effect = RE**
- 3 weeks after the 8th OWP application → **Short term effect = STE**

Trade off / Benefits

Climate regulation

- Emissions of N_2O (soil mixtures measuring during 72 days)

Biodiversity → Abundance of

- Total microbial biomass (Fumigation-Extraction)
- Fungal biomass (DNAr 18S)
- Total bacteria (DNAr 16S)
- Fungi and bacteria nitrifying (*amoA* qPCR)
- Denitrifying microorganisms (*nirK, nirS* qPCR)

N availability

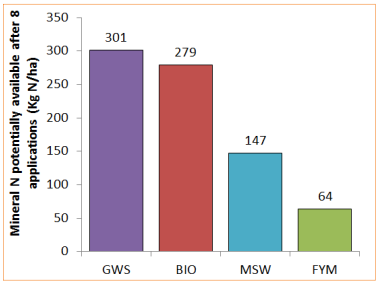
- N Mineralisation during lab incubations

Table 1. Average characteristics of OWP applied on QualiAgro site between 1998 and 2011

	units	MSW	GWS	BIO	FYM
Dry Matter	% FM	69 ± 12	63 ± 8	70 ±8	40 ± 9
Applied quantity	t DM.ha^{-1}	12.0 ± 3.2	16.4 ± 2.7	19.1 ± 4.2	13.2 ± 2.0
Organic Carbon	g.kg^{-1} DM	308 ± 45	265 ± 44	208 ± 47	320 ± 67
Total Nitrogen	g.kg^{-1} DM	17.6 ± 2.0	23.5 ± 2.7	17.4 ± 4.5	21.9 ± 3.1
Mineral Nitrogen	g.kg^{-1} DM	0.4 ± 0.2	2.6 ± 0.9	0.5 ± 0.3	0.7 ± 3.0
Organic Nitrogen	g.kg^{-1} DM	17.2 ± 1.9	20.9 ± 2.5	16.9 ± 4.2	21.2 ± 3.0
I_{ROC}[1]	%OM	48.8 ± 13.1	77.6 ± 8.7	75.5 ± 6.3	66.5 ± 7.1

[1]Lashermes et al. 2009. I_{ROC} = 44.5 + 0.5 SOL ï 0.2 CEL + 0.7 LIC - 2.3 MinC3 (expressed in % OM)

Potentially available N 3 weeks after the 8th application of OWP



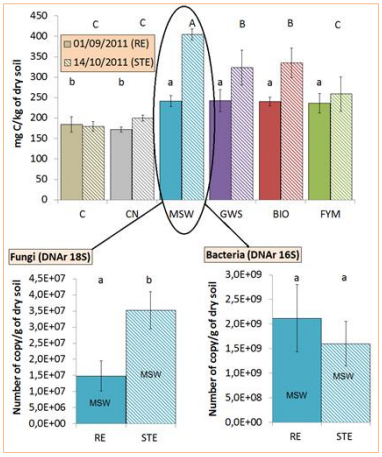
- Most efficient OWP = **GWS** and **BIO** → potential substitution of mineral fertilizer.

Increased mineral N available compared to control (Kg N/ha) = increased mineral N at sampling + enhanced organic N mineralisation from increased soil organic matter and from recently applied OWP.

Effects of OWP on denitrifying populations

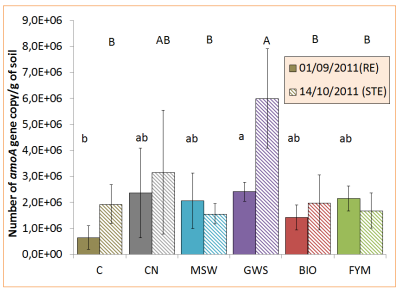
- No significant effect at short and long term.

Effects of OWP on total microbial biomass (MB), bacteria and fungi



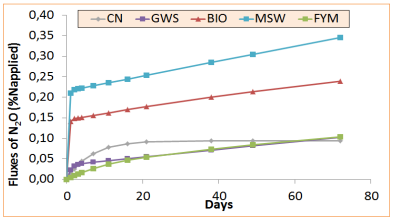
- ↗ of MB in OWP amended plots at short term and particularly in **MSW** (high proportion of easily degradable C, Table 1). Long lasting effect in amended plots (RE).
- In MSW plots, ↗ of MB at short term explained **by growth of fungi rather than bacteria.**

Effect of OWP on nitrifying bacterial populations (AOB) carrying *amoA* gene



- Stimulation of nitrifying bacterial populations at short term in **GWS** plot probably because of the high initial proportion of **N-NH_4^+ in the GWS compost** (Table 1).

N_2O emissions



- **Very low fluxes of N_2O** : 0.02 to 0.3 % of N applied after 72 days.
- **MSW>BIO>GWS=FYM=CN.**

Conclusions

Repeated applications of OWP

+ Stimulate the growth and the activities of microbial communities

+ but intensity and duration of the effects vary with the type of organic amendments (quantity and quality of the OM in the OWP): strong short term effect for easily biodegradable OWP (i.e MSW) and longer lasting effects for more stable OWP (i.e GWS).

+ Increase total and available N in soil and so improve soil N fertility (saving mineral fertilizers)

- but may also impact water quality with nitrates leaching (particularly GWS) or air quality with NH_3 volatilization.

- Weak impact N_2O emissions.

Perspectives

Measure of the potential NH_3 volatilization and estimation of nitrates leaching following OWP application to be able to make the environmental balance of this practice.

This work was granted by ADEME within ECOSOM-SNOWMAN project. The field experiment is carried out in partnership with Veolia Environnement R&D.