Impact of continuous application of papermill and liming materials on soil microbial community structure and biomass C, N and P

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Introduction

- Soil microorganisms play an important role in the cycling of nutrients by acting as a sink or a source of carbon, nitrogen and phosphorus.
- Microbial biota of soil receiving industrial by-products such as papermill biosolids (PB) and liming materials can be positively affected, but little is known about PB effects on the microbial community structure and biomass carbon (MBC), nitrogen (MBN) and phosphorus (MBP).

Objective

- Evaluate the residual effect of nine annual applications of PB and different liming materials on soil microbial community structure and MBC, MBN and MBP.

Materials and Methods

- A field study was conducted from 2000 to 2008 (9-yrs) at Yamachiche, QC, Canada, on a loamy soil (Gleysol) cropped to grain corn, dry bean and soybean.
- Soil pH (0 - 15 cm) : 6.2.
- Treatments, in a RCB design with 4 replicates, were surface applied annually to the same plots at post-seeding.
- Treatments consisted of :
  - ✓ 4 PB rates: **0**, **30**, **60**, and **90** Mg wet ha^{-1}.
  - ✓ 3 liming by-products: calcitic lime (**CL**), lime mud (**LM**), and wood ash (**WA**), each at 3 Mg wet ha^{-1} with 30 Mg wet PB ha^{-1}.
  - ✓ Mineral N fertilization (**MIN**): 120 kg N ha^{-1} in grain corn and 20 kg N ha^{-1} in leguminous.
- Three years after treatments application ending (fall 2011), soils were sampled (**0 – 15 cm** and **15 – 30 cm)** after harvest, and analyzed for the phospholipids fatty acids (PLFA) (Lalande et al., 2005) and their contents in MBC, MBN (Voroney el al., 1993) and MBP (Brookes et al., 1982).
- PLFA was analyzed with SAS software (SAS Institute, Inc. 2004) using **principal component analysis (PCA)**.
- ANOVA was performed with the GLM procedure (SAS Institute, Inc. 2004) to compare the treatment effects on MBC, MBN and MBP.

Results and Discussion

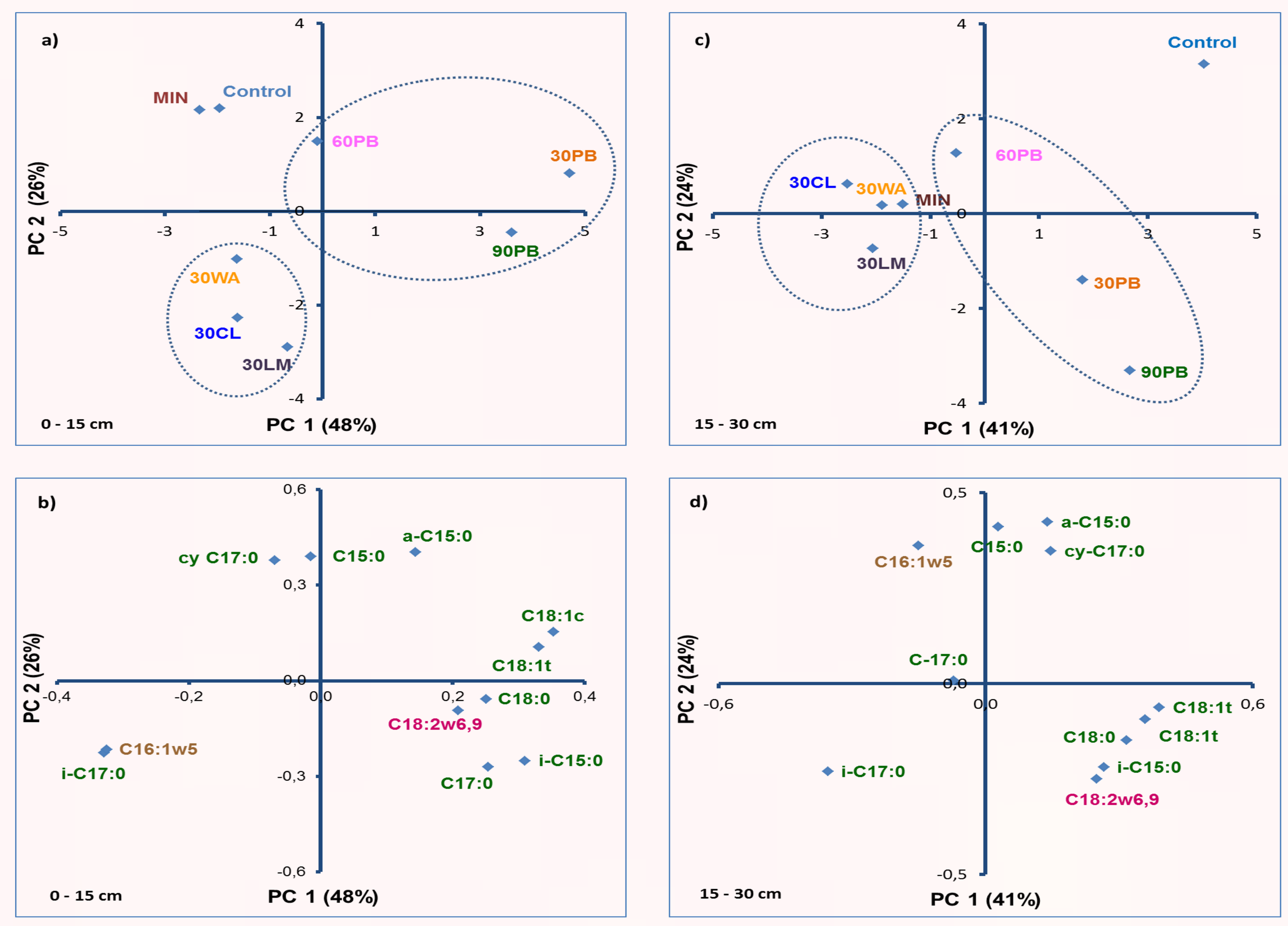

Figure 1. Ordination plots of the microbial community composition (based on phospholipids fatty acids) as determined by principal component analysis (PCA) at 0-15 cm (a, b) and 15-30 cm (c, d) soil depths after continuous application of papermill biosolids (PB) and liming materials.

- Liming by-products supplemented with 30 Mg PB ha^{-1} were significantly separated from PB applied alone in both soil layers (Fig. 1a,c).
- Mineral N fertilization tended to cluster with control (0 PB) in the 0-15 cm layer (Fig. 1a) and with the liming by-products in the 15-30 cm layer (Fig. 1c).
- PB application was mostly driven by bacteria and fungi (**C18:2w6,9**), whereas liming materials were primarily driven by arbuscular mycorrhizal fungi (**C16:1w5**) in both soil layers (Fig. 1b,d).

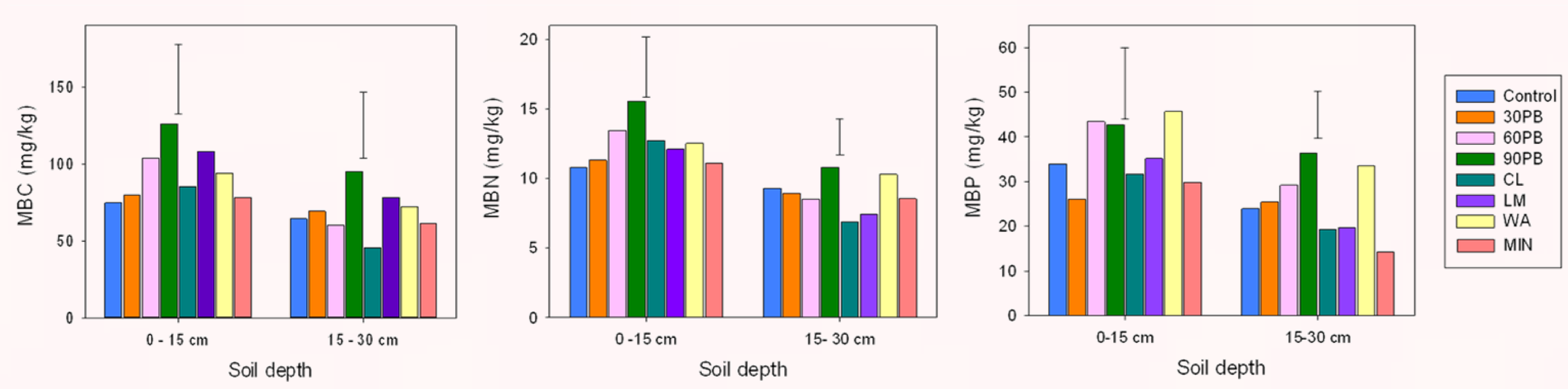

Figure 2. **Residual effects of papermill biosolids and liming materials addition on MBC, MBN and MBP contents of two soil layers**

- MBC, MBN, and MBP were higher in the surface horizon (0-15 cm) than in subsurface (15-30 cm).
- The application of 90 Mg wet ha^{-1} of PB is the best treatment enhancing soil MBC, MBN and MBP.
- The treatment of WA with PB largely increased MBP at both depths.
- The PB application rate significantly increased MBC and MBN in the top soil layer only.
- The PB rate had no effect on MBP in the 0-15 cm but increased its level in the subsequent layer.

Conclusions

- ➢ The community structure (bacteria, fungi, arbuscular mycorrhizal fungi) was specific to treatment.
- ➢ After three years of material application ending, soil microorganisms immobilize C, N, and P in their biomasses with increasing rates of added PB.
- ➢ Nine annual application of PB alone or combined with liming materials resulted in an improvement of soil MBC, MBN and MBP which can be sustained for years for this site.

References

Brookes et al. 1982. Soil Biol. Biochem. 14, 319–329. ***Lalande et al. 2005.*** Can. J. Soil Sci. 85, 27–38. ***SAS Institute, Inc. 2004***. SAS Institute Inc., Cary, NC. ***Voroney et al. 1993***. Soil sampling and methods of analysis. pp. 277– 283.

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