Changes of the plant available soil phosphorus in the Qualiagro experiment for 13 years of cropping and repeated application of different urban composts

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Context

Sustaining crop yields requires fertilisation of cultivated soils with phosphorus (P). But modern agriculture is dependent upon non renewable phosphate rock deposits. Recycling urban, agricultural and industrial organic residues is a way to sustain food production in the long term.
However, the effects of repeated application of such nutrient sources on P cycling (i.e. pools and fluxes) in cropped ecosystems (fig. 1) are not well understood.

Objectives

To understand soil plant-available P variation, and to elucidate P cycling, under repeated application of different urban composts.

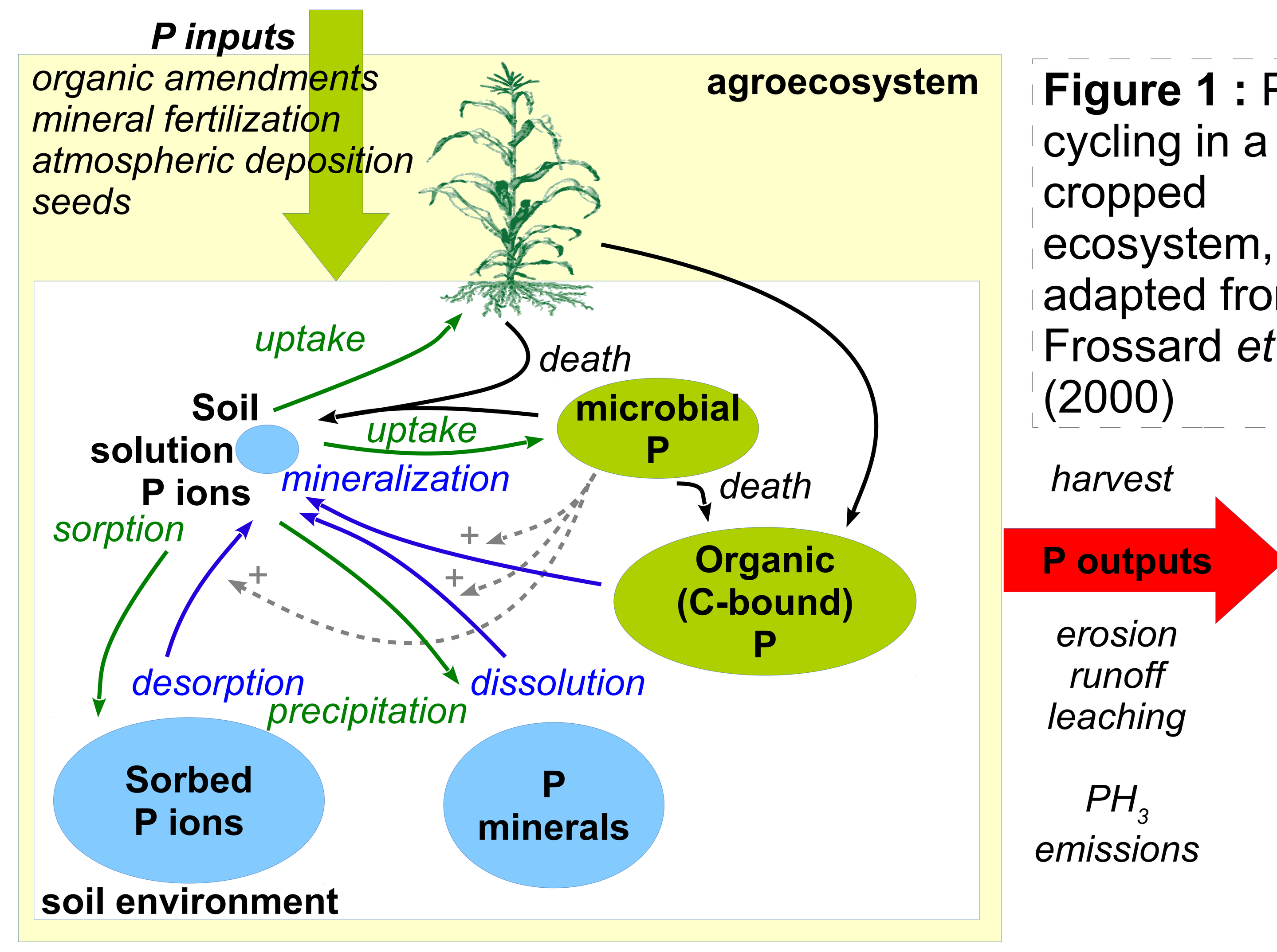

Figure 1 : P cycling in a cropped ecosystem, adapted from Frossard *et al.* (2000)

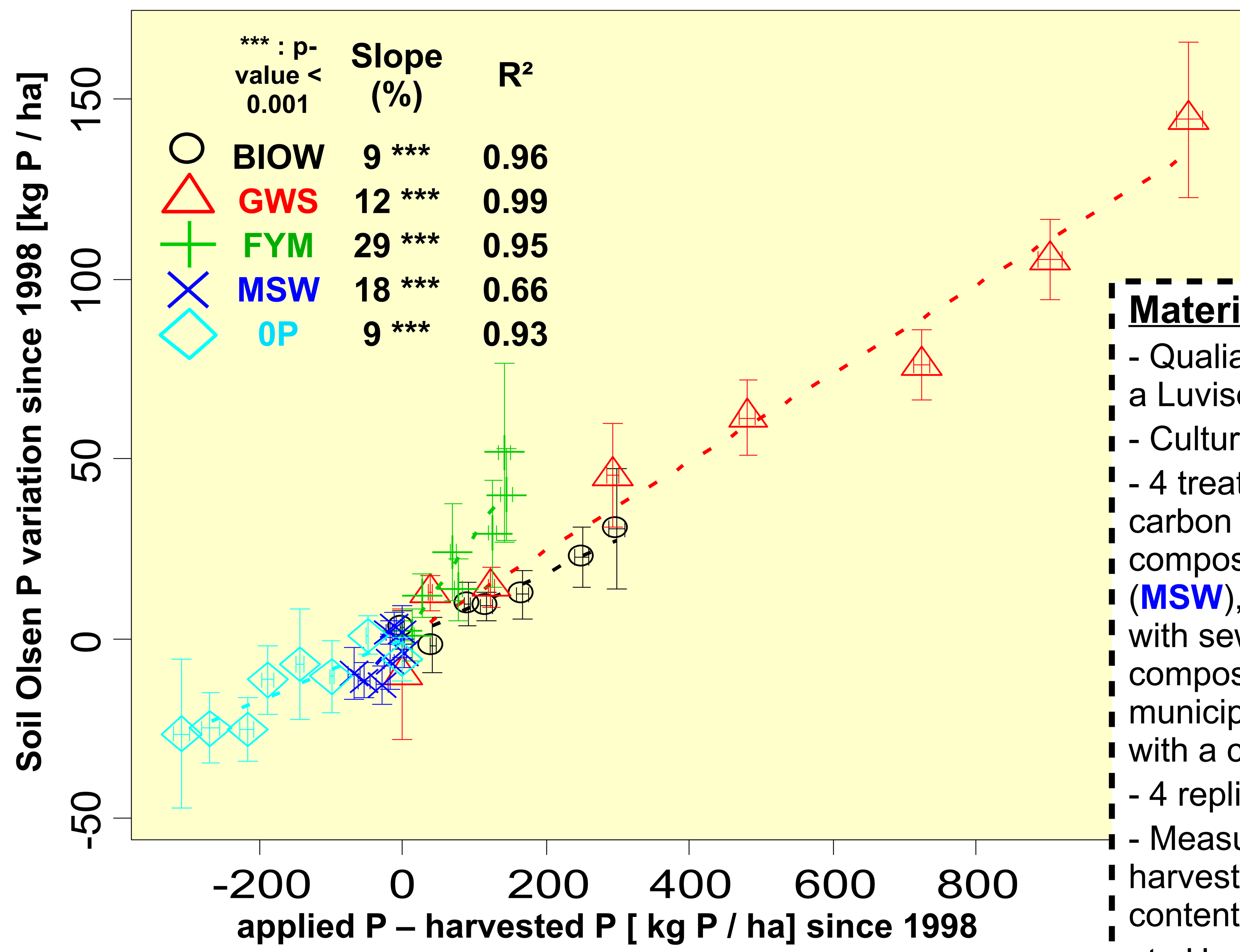

Figure 2 : Olsen P pool (0-28 cm) variation with P balance (Σ(applied P – harvested P)) between 1998 and 2011

Materials & Methods

- Qualiagro : a long term field experiment (Houot *et al.*, 2002) since 1998 on a Luvisol (WRB 2006)
- Culture : Maize - Wheat rotation since 1999
- 4 treatments applied every 2 years since 1998 on a 4 metric tons of organic carbon per hectare basis ((i) a municipal solid waste compost obtained by composting solid municipal wastes after removal of dry and clean packaging (**MSW**), (ii) a compost derived from co-composting a mix of green wastes with sewage sludge (**GWS**), (iii) a biowaste compost produced by co-composting green wastes with a source-separated organic fraction of municipal solid wastes (**BIOW**), (iv) a cattle farmyard manure (**FYM**)), along with a control treatment without any P application since 1998 (**0P**)
- 4 replicates / treatment (10*45 m² plots)
- Measurements : P content and quantity of applied organic residues and harvested grains and crop residues ; soil plough layer (0-28 cm) Olsen P content (1 g of soil mixed for 30 minutes in 20 ml of 0.5 M $NaHCO_3$ solution at pH of 8.5 before filtration), soil density and physico-chemical properties

Table 1 Qualiagro 2011 results (Optimal N fertilization)		Olsen P content mg / kg DM 105°C	Organic C content g / kg DM 105°C	pH_{water}	CEC cmol+ / kg DM 105°C Cobaltihexammine	Exchangeable Ca cmol+ / kg DM 105°C Cobaltihexammine
1998	all	39.8	10.6	7.1	9.7	8.3
2011	0P	28.6 d	10.4 e	6.7 e	8.4 b	8.3 d
	GWS	76.6 a	15.6 a	6.9 d	10.1 ab	9.6 bc
	MSW	33.1 d	12.8 d	7.5 b	9.9 ab	9.9 b
	FYM	52.9 b	14.4 bc	7.3 c	10.3 ab	9.0 bcd
	BIOW	48.5 bc	15.2 ab	7.8 a	11.3 a	11.0 a

Results

P balance : the cumulated P balance (kg P/ha) from 1998 to 2011 was significantly affected by treatment : **GWS** (+1097) > **BIOW** (+299) > **FYM** (+142) > **MSW** (-68) > **0P** (-309).

Soil Olsen P pool variation with P balance (fig. 2) : On average, without P input (**0P**), the harvest of 100 kg P / ha caused soil 0-28 cm Olsen P pool to decrease by 9 kg (9 % slope). Under **BIOW**, **GWS** and **FYM** and **MSW**, the observed variations of soil 0-28 cm Olsen P pool with P balance were significant (9 %, 12 %, 28 % and 18 % slope, respectively).

Soil physico-chemical characteristics : During the experiment, some soil plough layer's physico-chemical characteristics, known to affect soil P availability, were affected by the treatments (see table 1 for details).

Discussion

In Qualiagro, the observed rate of variation of Olsen P pool in the plough layer with cumulated P balance, under amendment treatment, was equal to, or greater than under control treatment (whose slope is actually supposed to be equal to the slope under hypothetical mineral P fertilization (e.g. Messiga *et al.*, 2010)). Organic residues amendment is thus, as seen from Olsen P datas, at least as, or even more efficient than mineral P fertilization at replenishing Olsen P pool in the plough layer. Moreover, we can hypothesize that a fraction of organic residues' organic phosphorus may be unavailable to plants in the long term. These apparently paradoxical results can only be explained in the light of significant modifications of soil physico-chemical properties (affecting P availability), due to repeated application of organic residues, with an increase in soil P availability as a consequence. Furthermore, after repeated application of organic residues, soil organic P may represent a significant fraction of soil total P and of plant available P, but organic P can't be accounted for by simple Olsen extraction.

Conclusion & Perspectives

The effects of organic residues application on plant-available P pool and P cycling in cropped ecosystems are more complex than those of mineral P fertilization. Transfer of phosphate ions at the solid-to-solution interface will be determined to analyze their modifications in relation with soil properties inside and under the plough layer. Relationships between variations of soil physico-chemical characteristics and physico-chemical properties of organic residues will be investigated.

Bibliography

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