Impact of long-term application of composted organic residue on soil organic and inorganic phosphorus dynamics

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Introduction

❑ In recent years, use of urban composts as fertilizers or organic amendements has been widespread.

❑ They represent a significant resource of phosphorus (P) for agriculture soils (3.5 to 5.7 g P/kg dw) mainly as inorganic P (InorgP) forms (Cabrera et al., 1991).

❑ Many studies showed positive effects of urban composts in soils properties and plants P nutrition (Cabrera et al., 1991; Mkhabela et al., 2005; Annabi et al., 2007).

❑ However, little is known about the impact of their long-term application on dynamics of soils P stocks.

Objective

❑ To investigate the effect of repeated applications of urban composts and manure on the dynamics of soil organic P (orgP) and inorganic P (inorgP) stocks in relation to the P input/output balance at the plot scale.

Materials and Methods

❑ A long term field experiment (1998-2013) was conducted in Yvelines (France). It was a randomized block with 4 replicates, grown in a corn / wheat succession.

❑ Five treatments were used: control without P (0P), cattle manure (MANURE) and three urban composts: compost green waste + sludge (GWS), biowaste (BIOW) and municipal solid waste (MSW). Products were applied approximately at 4 t C /ha /2 yrs.

❑ Soils in plough layer (0-28cm) were sampled before each application.

❑ Soil total P (totP-HF) contents were analysed for six dates between 1998-2013 by the HF dissolution method.

❑ Soil orgP was determined by ignition method (orgP-SW) (Saunders and Williams (SW), 1955) and inorgP = totP-HF - orgP-SW. They were converted to stocks using soil bulk density for each date.

❑ TotP-HF, orgP-SW and inorgP contents in applied products between 1998-2013 (9 application dates) was determined by the same methods.

❑ Soil P budget (1998-2013) was calculated as : P applied - P export. Cumulative P budget = Σ(P applied)- Σ(P export)

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Results and discussion

P contents and P forms of applied products (means of 9 years)

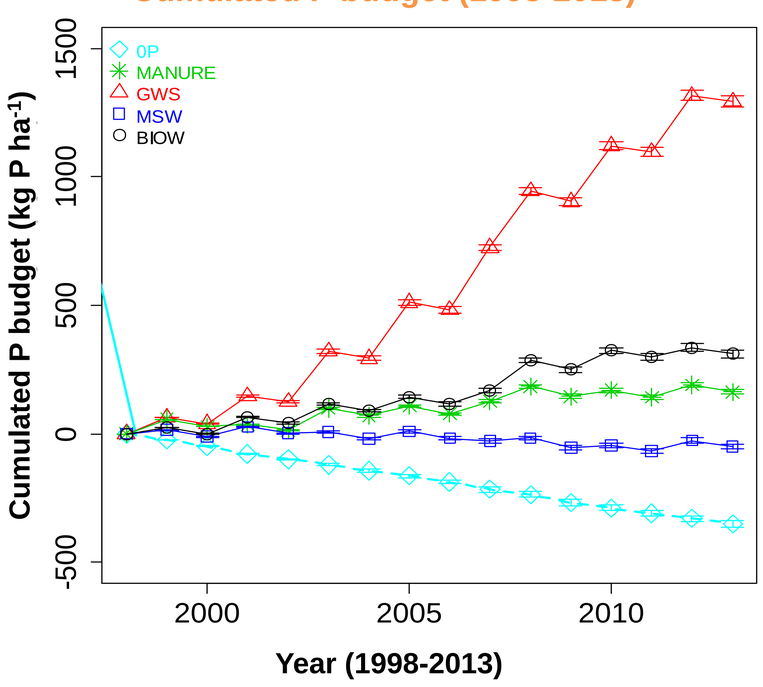
	totP-HF g kg^{-1}	inorgP g kg^{-1}	orgP-SW g kg^{-1}
MANURE	5.5 ± 1.1	3.7 ± 0.7	1.9 ± 0.5
GWS	13 ± 3.7	10.4 ± 3.6	2.1 ± 0.7
MSW	3.5 ± 0.8	3.3 ± 0.8	0.3 ± 0.2
BIOW	4.8 ± 1.7	3.9 ± 0.9	0.3 ± 0.2

❑ Total P contents varied from 3.5 g kg-1 (MSW) to 13 g kg-1 (GWS).

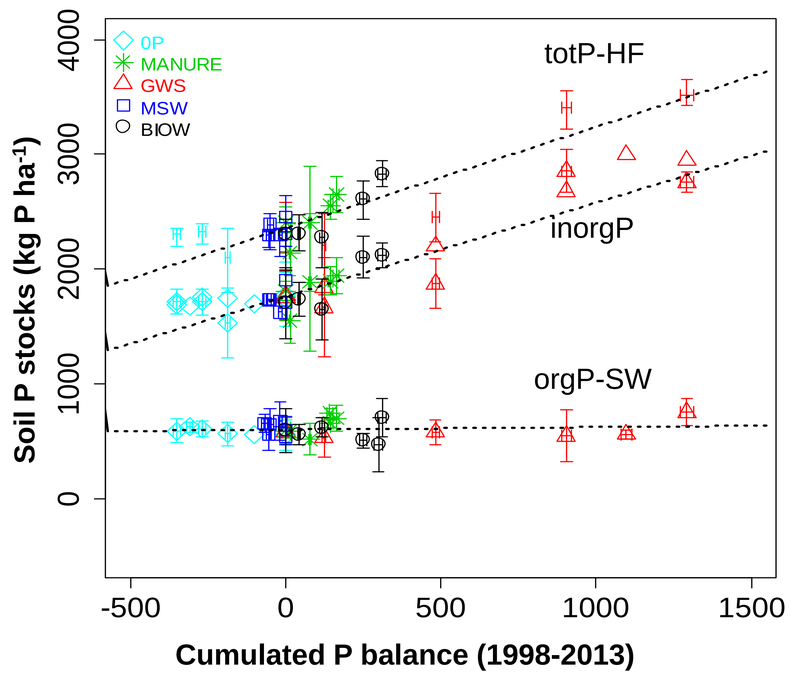
❑ In average, all products contained mainly P as inorgP forms (82%) whereas orgP-SW forms were only 18% of totP-HF.

❑ These values agree with previously studies (Cabrera et al., 1991; Requejo and Eichler-Löbermann, 2014).

Cumulated P budget (1998-2013)



Dynamics of soil P stocks (1998-2013)



❑ After 15 years, cumulated P budget is highly positive for the GWS (1292 ± 21 kg P ha^{-1}) slighly positive for BIOW and MANURE, almost nul for MSW and negative for 0P.

❑ Considering all treatments, variations of totP-HF stock accounted for 88% of the P budget. 93% of these total changes were explained by inorgP stock and only 2 % by orgP-SW.

❑ The totP-HF vs cumulated soil P budget less than 1 might be due to a significant increase of P content in the firsts cm of the ploughed layer (Morel, 2002).

❑ Stock of total orgP-SW was invariant for all treatments. This might be due to the more stable forms of organic P in the soils, like phytate (Condron et al., 2005) and easily mineralizable forms in applied products.

❑ Moreover, added of composts may have no or little influence on the amount of phytate in soils (Requejo and Eichler-Löbermann, 2014).

Statistics parameters of soil P stocks dynamics

P forms	Intercept	Slope	*P value*	R^2
InorgP	1764	0.82	<0.0001	0.55
PorgP-SW	601	0.02	0.44	0.005
TotP-HF	2358	0.88	<0.0001	0.65

Conclusions

❑ Application of composted GWS in soils based in C led to an highly positive cumulated P budget.

❑ Variations in inorgP and totP-HF stocks reflected differences in P budget.

❑ Long-term application of urban composts had no significant effect on soil orgP-SW stock.

❑ Stability of soil orgP-SW in 0P indicated that soil organic P contributed little or not at all to crop phosphate nutrition.