Changes in phosphorus pools in grazed grassland soils after 15 years of equilibrium fertilization

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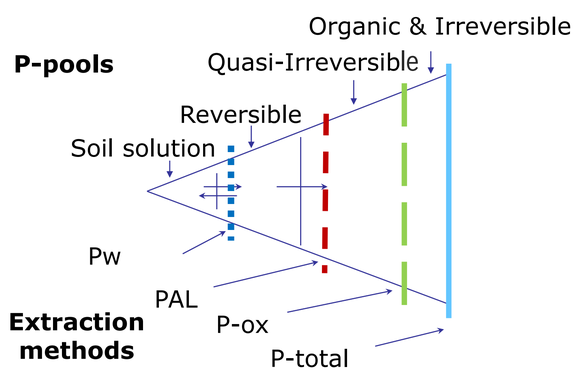
Background

A responsible use of P is necessary to reduce both the environmental impact of agriculture and to limit the use of this scarce resource. In the Netherlands, the aim is to reach a balance between P export by the crop and P fertilization by 2015 (equilibrium fertilization). Farmers fear that this will lead to a decrease in plant available phosphorus and thus to losses of crop yield and crop quality.

Objectives

- To show the consequences of the long term effects of equilibrium fertilization on plant available P in the soil.
- To explain changes in plant available P by changes in the various soil P pools (see figure).



Field Experiments

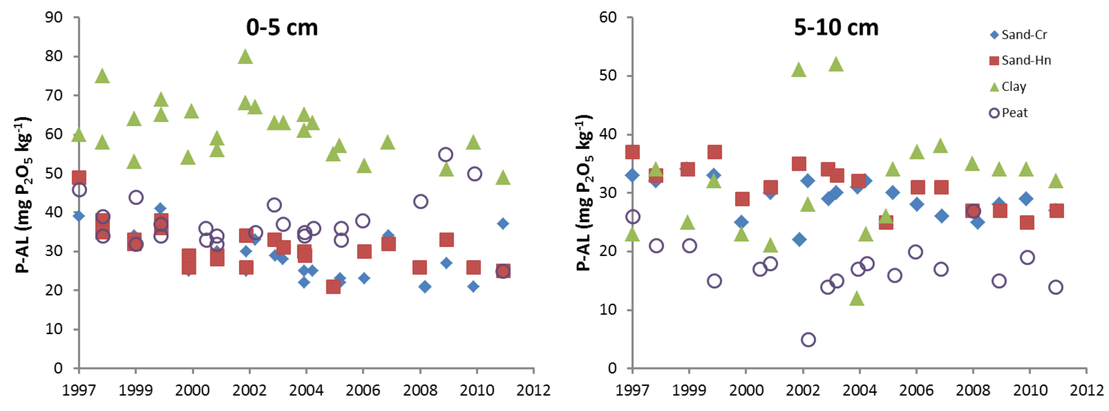
The fate of phosphorus was studied for 15 year at 4 experimental dairy farms on the major Dutch soil types (2 sandy soils, 1 clay soil, 1 peat soil). Each location had 6 treatments with a yearly P surplus of 0, 9 and 18 kg P ha^{-1} yr^{-1} and 180 and 300 kg N ha^{-1} yr^{-1}.

The treatments were grazed and mown. P balances were constructed based on measured yield and uptake. Soil samples were collected annually in autumn at a depth of 0-5cm, 5-10 cm, 10-20 cm and 20-30 cm depth.

Results

Plant available P (P-AL) at equilibrium fertilization

P-AL values varied strongly in time but generally decreased in both the 0-5 cm layer and the 5-10 cm layer at the N180-P0 treatment. In the deeper soil layers (10-20 cm, 20-30 cm) the changes in P-AL were negligible.



Annual trends in P-pools

Statistical analysis (REML) showed a decline in plant available P (Pw, P-AL) in the upper soil layers at the sandy sites and a small (not significant) increase at the clay and peat site (see Figure 1). No significant changes were found below 10 cm depth.

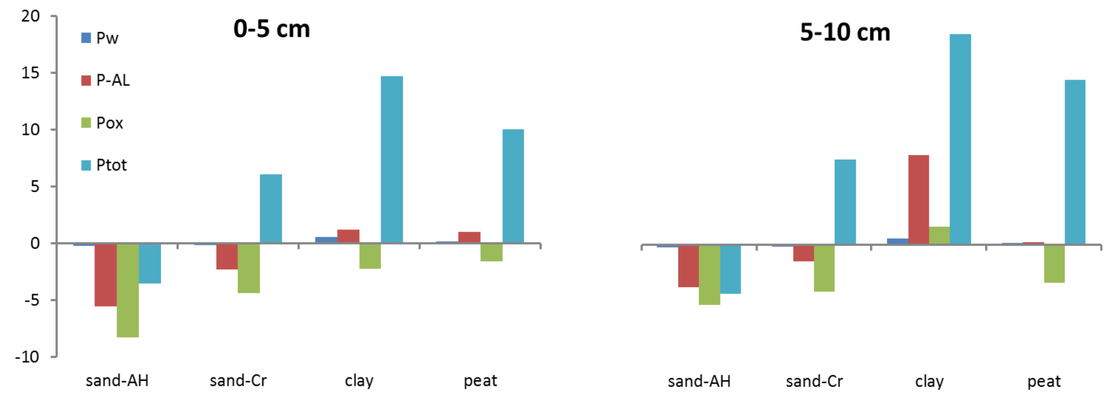


Figure 1. Annual change in mineral P-pools and total-P (kg ha^{-1} yr^{-1}) for the four soil layers

Mineral P (P_{ox}) declined significantly in all soil layers. A strong correlation existed between the change in plant available P and mineral P (P_{ox}). The loss in P_{ox} was higher than in P-AL. The total loss of P_{ox} ranged between 8 and 27 kg ha^{-1} yr^{-1}. Total-P generally increased in the topsoil but no significant changes were found below 10 cm depth.

Discussion

At all sites we found a decline in mineral P (P_{ox}), which was substantially higher than leaching losses (< 5 kg ha^{-1} yr^{-1}). The fate of mineral P is not clear. Measurements of P_{org} at part of the treatments point to an substantial accumulation of organic P (Fig. 2). However, uncertainties in these trends are too large to construct a closed balance.

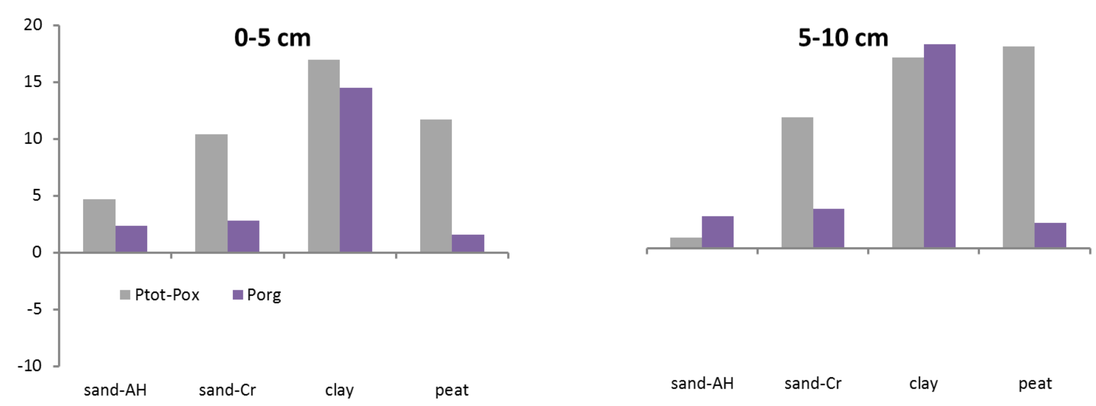


Figure 2. Annual change in total-P -P_{ox}(kg ha^{-1} yr^{-1}) and organic P for the four soil layers

Conclusions

- Equilibrium fertilization on permanent grassland led to a decline in plant available P on sandy soils and was stable or slightly increased at the clay and peat soil but these changes were generally not significant,
- Mineral P (P_{ox}) declined at all sites and this decline was larger (2-3 kg ha^{-1} yr^{-1}) than the decline in plant available forms,
- There is evidence for accumulation of organic P in the topsoil (plant residues, manure), which might explain the loss in mineral P.

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