Gross P Mineralization and Microbial P Uptake in Forage Soils Along a Gradient of Available Inorganic P

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Introduction

Soil phosphorus availability is generally assumed to be governed by physico-chemical processes, but biological processes including organic P (P_o) mineralization can make important contributions to plant-available P (Bünemann et al., 2012). Mineralized P_o may be especially important in soils where solution and labile P_i are low.

Isotopic dilution techniques have been developed to measure P_o mineralization under steady state conditions (Oehl et al., 2001_a; 2001_b). This is done by pairing a short-term Isotopic Exchange Kinetics (IEK) batch experiment, with a longer incubation experiment to separate the physico-chemical and biological processes that govern the amount of isotopically exchangeable P_i in a soil system.

Research Objective

To assess gross Po mineralization and microbial P uptake in four calcareous forage fields soils along a gradient of Olsen soil test P (STP) concentrations.

Methods

Soils from two organic and two conventional forage fields in Ontario, Canada, providing a gradient of STP concentrations were selected (Tab. 1) (*n* = 4 soil samples per field x 4 = 16)..

Two main experimental components:

1) Isotopic Exchange Kinetics (IEK) experiment: Measured ^{31}P and ^{33}P in solution at 1, 4, 10, 40, 60 and 80 minutes after ^{33}P addition. Parameters of isotopic exchange were determined and used to extrapolate *E*-values ($E_{extrapolated}$).
2) 7-day Incubation experiment: Measured ^{31}P and ^{33}P in soil solution and microbial biomass, determined *E*-values due to both physico-chemical and biological processes ($E_{measured}$)

***E*-value** – amount of isotopically exchangeable P in a system in a given time period ($E_t = P_{H2O}/r_t/R$), where R is amount of radioactivity added initially and r_t is the amount remaining at time *t*.

Gross P_o mineralization = $E_{measured} - E_{extrapolated}$

Tab. 1: Soil properties of the sampled fields.

Soil Description (Field #)	Location (County)	Management Type	Soil Fertility Amendments	Total C ($g\ C\ kg^{-1}$)	pH	Olsen STP ($mg\ kg^{-1}$)	P_{H2O} ($mg\ kg^{-1}$)
1	Perth	organic	manure	22.6^a	7.4^a	2.8^a	0.03^a
2	Bruce	organic	manure	25.2^a	7.2^a	5.5^{ab}	0.07^a
3	Perth	conventional	manure and fertilizer	23.6^a	7.3^a	6.8^b	0.10^a
4	Bruce	conventional	manure and fertilizer	25.9^a	7.5^a	11.2^c	0.24^b

Fig. 1: Labelling and weighing out soil for the incubation experiment.

Results

Gross P_o mineralization accounted for a mean of 35% of isotopically exchangeable P across all four field soils (Tab. 2)

After 8 days, > 20% of the ^{33}P label was found in the microbial biomass P pool in 11/16 soils.

Microbial ^{33}P uptake was most rapid for soils with the lowest available P_i (Fig. 2).

As microbial P concentrations were constant, the data suggests accelerated P cycling (turnover) at the lowest solution P concentrations < 0.1 mg P kg^{-1}.

Gross P_o mineralisation was positively related to water soluble P_i concentrations (Fig. 3); however, this relationship deserves further study, as 3/16 soil samples with low solution P_i concentrations may have been underestimated due to very rapid microbial P uptake.

Tab. 2. Mean extrapolated (E_{ext}) and measured (E_{meas}) isotopically exchangeable P (*E*) values determined for the four field soils. Gross organic P (P_o) mineralization (min) is calculated by difference.

Soil	E_{ext} ($mg\ kg^{-1}$)	E_{meas} ($mg\ kg^{-1}$)	Gross P_o min. ($mg\ kg^{-1}$)
1	12.8^a	23.7^a	10.9^a
2	17.5^a	24.7^a	7.2^a
3	19.8^{ab}	30.4^a	10.2^a
4	28.9^b	42.6^b	14.1^a
Average	**19.8**	**30.3**	**10.5**

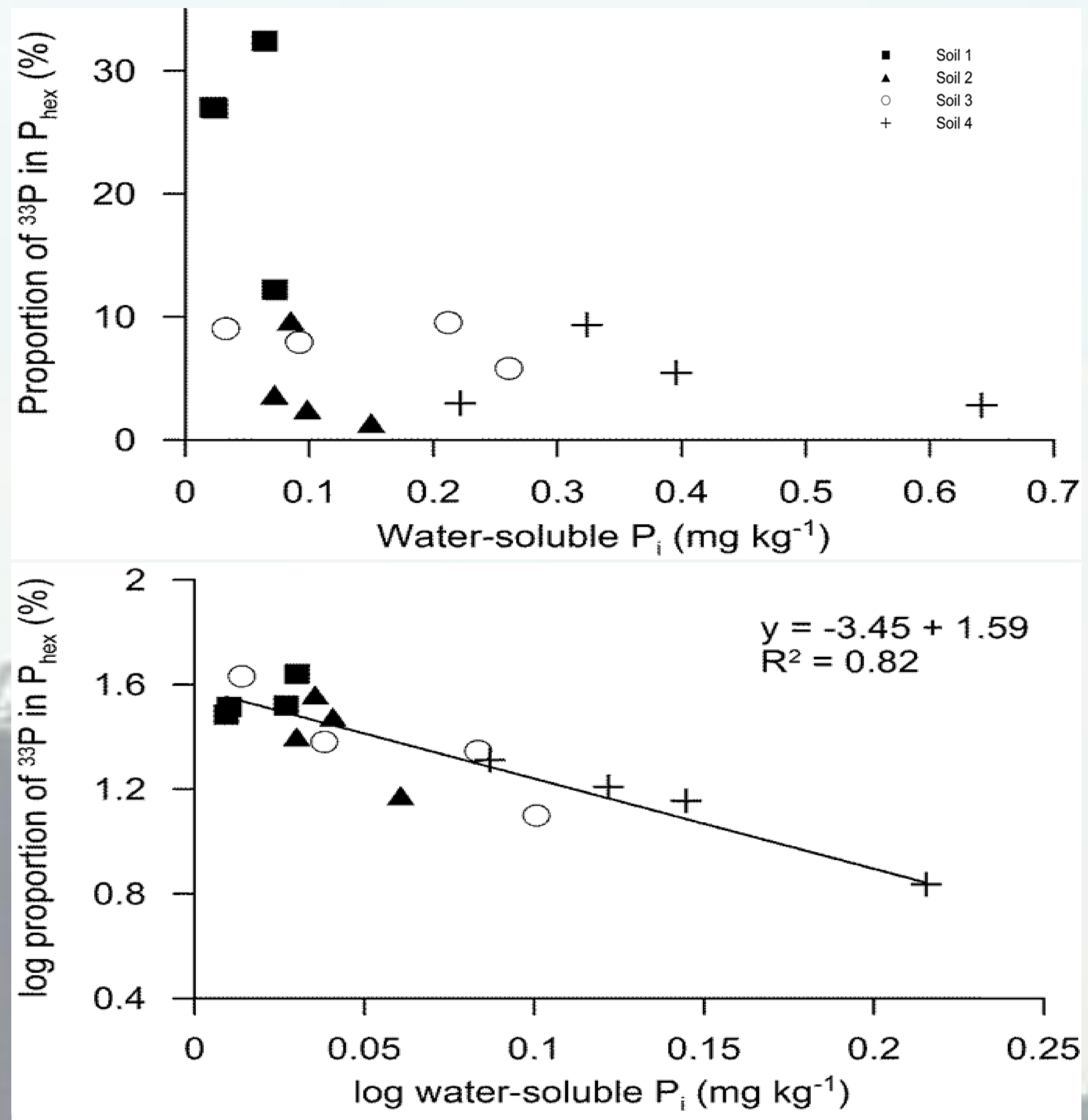

Fig. 2. Proportion of ^{33}P label added found in the microbial bioimass P pool (P_{hex}) one (top) and eight (bottom) days after soil labelling.

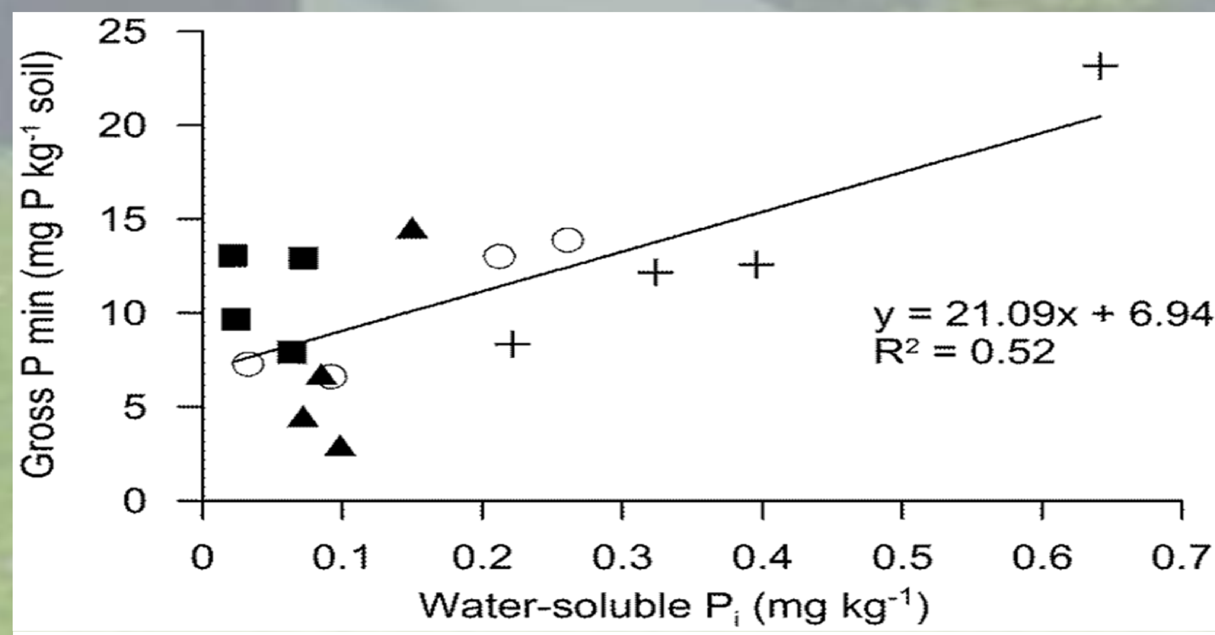

Fig. 3: Gross organic P mineralization (min) after eight days of soil labelling vs. soil water soluble P concentration.

Conclusions

Gross P_o mineralization accounts for a significant amount of isotopically-exchangeable P in forage soils.

Rapid uptake of ^{33}P into microbial biomass P pool indicates important P cycling occurs under steady-state conditions. The data suggest microbial P turnover is accelerated under low conditions of low solution P_i concentrations.

Methodological challenges including the use of high P-fixing soils with low water soluble P_i concentrations need to be further addressed when using these methods.

References

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