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Phosphorus forms determined by ^{31}P-NMR as affected by phosphorus fertilization in a grassland soil

Dalel ABDI[1,2*], Barbara J. CADE-MENUN[3], Noura ZIADI[1], Yichao SHI[1], and Gilles BÉLANGER[1]

[1]Agriculture and Agri-Food Canada, Soils and Crops Research and Development Centre, Québec, QC, Canada.
[2]Department of Soils and Agri-Food Engineering, Université Laval, Québec, QC, Canada. *dalel.abdi.1@ulaval.ca
[3]Agriculture and Agri-Food Canada, Semiarid Prairie Agricultural Research Centre, Swift Current, SK, Canada.

Introduction

- Different techniques can be used to determine the forms and concentrations of soil **phosphorus** (**P**) to better understand P transformations under grassland production.
- The preferred technique to characterize soil P forms is **^{31}P nuclear magnetic resonance** (**^{31}P-NMR**) spectroscopy.

Objective

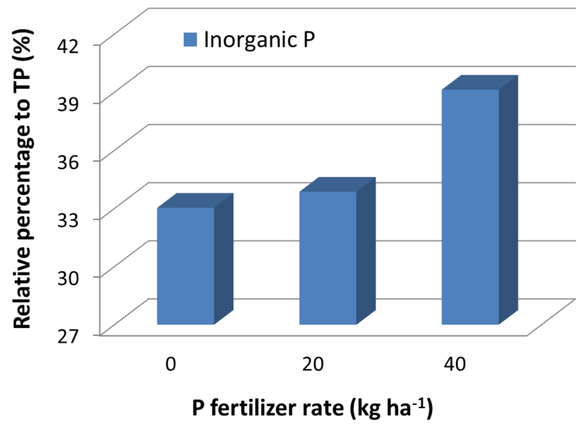
- To assess the effects of P fertilization on soil P forms in grassland soil using ^{31}P-NMR.

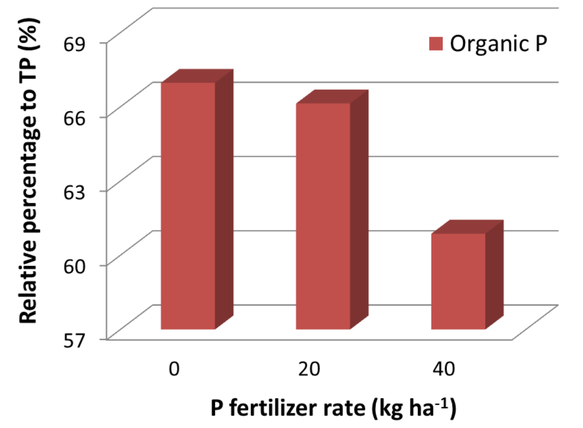
Materials and Methods

- Experiment at the Harlaka Experimental Farm of Agriculture and Agri-Food Canada near **Québec City**.
- The soil is a Kamouraska clay (fine, mixed, frigid, Typic Humaquept).
- Three P rates (**0, 20, and 40 kg P ha^{-1}**) have been applied to a previously established timothy sward each year since 2010, with three replicates.
- Soil samples (**0 - 10 cm**) were collected in the fall of 2013.
- Soil available P was analysed by the Mehlich-3 method (**Mehlich-3 P**; Mehlich, 1984).
- P forms were determined using solution ^{31}P-NMR spectroscopy (Cade-Menun and Preston, 1996).
- P forms were identified by their chemical shifts (ppm) relative to an external orthophosphoric acid standard, and the orthophosphate peak was standardized to 6 ppm for each sample.
- Peak area were computed by integration on spectra processed with 7 Hz and 1 Hz line brodening, using NUTS software (Acorn NMR, Livermore CA, 2000 edition).
- Analyses of variance for centred log-ratio transformed data (Abdi et al., 2014) for Mehlich-3 P concentrations and the percentage and concentration of ^{31}P-NMR P forms were conducted to test the effects of P fertilization.

Results

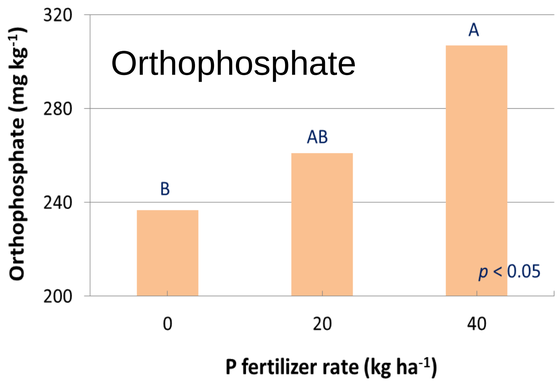
P forms as percentage of total P (TP)

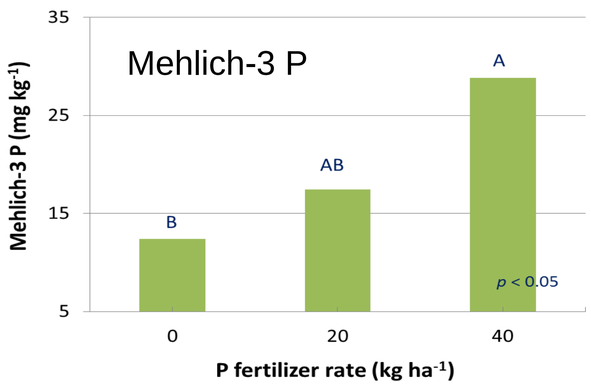


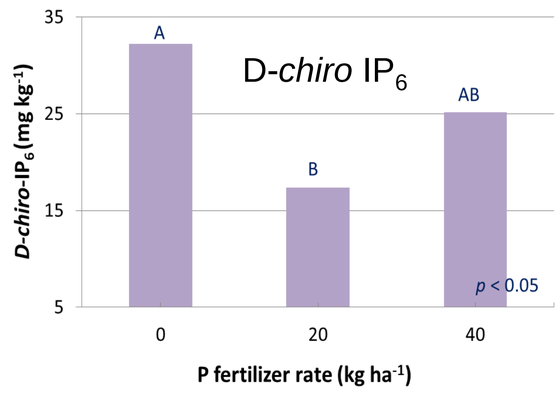


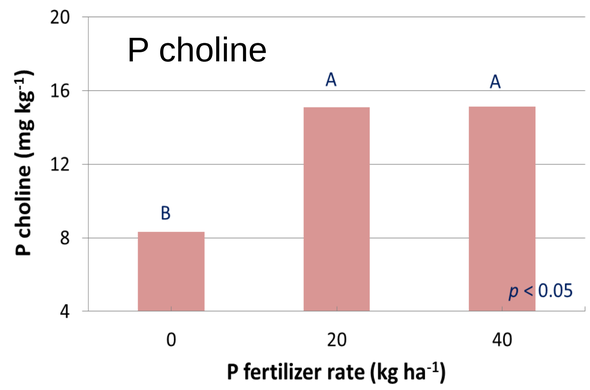
- Percentage of inorganic P forms increased with P fertilization, however, organic P decreased.

Concentrations of P species and Mehlich-3 P









- P fertilizer significantly increased the concentrations of orthophosphate, Mehlich-3 P, and P choline.
- Application of 20 kg P ha^{-1} significantly decreased *D-chiro* IP$_6$.
- Pyrophosphate, polyphosphate, phosphonate, *myo*-IP$_6$, *scyllo*-IP$_6$, *neo*-IP$_6$, nucleotide, α- and β-glycerophosphate, and DNA were not significantly changed by P fertilization (data not shown).

Conclusions

- ❑ P fertilization changed orthophosphate, P choline and *D-chiro*-IP$_6$ concentrations at the 0-10 cm depth of grassland soil.
- ❑ P fertilization increased inorganic soluble P (orthophosphate and Mehlich-3 P) at the soil surface (0-10 cm), potentially increasing P loss.

References

- *Abdi, D., Cade-Menun, B.J., Ziadi, N., and Parent, L.É. 2014.* J. Env. Qual. 43: 1431. - *Cade-Menun, B.J., and Preston, C.M. 1996*. Soil Sci.161:770. – *Mehlich, A. 1984.* Commun. Soil Sci. Plant Anal. 15:1409.

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