Spatial Variability of Soil Phosphorus Under Two Contrasting Grassland systems in Eastern Canada

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Abstract. *Phosphorus (P) is an essential nutrient for grasslands. When applied in excess, P tends to accumulate at the soil surface causing P stratification, increasing P loss through runoff and soil erosion. Thus, sustainable P management is based on spatial variability of soil P under intensive grassland fields, to reduce P losses, and protect environment. This study aimed to investigate field-scale variability of soil P indices [referred to as P_{M3} and $(P/Al)_{M3}$] in two contrasting grassland fields for sustainable P recommendations in grassland management. Two fields were selected, a young grassland (YG; 2 years; 2.35 ha), and an old grassland (OG; 10 years under permanent pasture; 2.47 ha). Both fields were moderately well-drained humo-ferric podzols. Organic manure was applied in both fields. Soil samples were collected in 16-m by 16-m triangular grids at two depths (0–0.05 and 0.05–0.2 m), and were analyzed for available P and other soil properties by the Mehlich-3 method (M3). Data were analyzed using descriptive statistics and geostatistics. At 0–0.05 m, average soil P_{M3} and $(P/Al)_{M3}$ values were 52 mg kg^{-1} and 3% respectively under YG, compared to 125 mg kg^{-1} and 7% respectively for OG. At 0.05–0.2 m, average P_{M3} and $(P/Al)_{M3}$ values were 55 mg kg^{-1} and 3% respectively for YG, and 75 mg kg^{-1} and 4% respectively for OG. P stratification was observed in OG, owing to long-term manure application. Variability of soil P indices was high (CV > 50%). Moderate spatial structure (25–75%) was observed for P indices at both fields. Consequently, a soil sampling strategy focusing on the 0–5 cm layer should be recommended for sustainable P recommendations, due to risk of soil P stratification, comparatively to the current soil sampling strategy (0–17.5 cm) used for permanent grasslands in Eastern Canada.*

Keywords. *Soil P indices, P extracted Mehlich-3 (P_{M3}); organic manure, geostatistics*

Introduction

Phosphorus (P) is an essential nutrient for grasslands. When applied in excess, P tends to accumulate at the soil surface causing P stratification, increasing P loss through runoff and erosion. Canadian grassland fields were intensively fertilized with organic manures which contain high P concentrations (CRAAQ 2010). Thus, sustainable P management is based on spatial variability of soil P under intensive grassland fields to reduce P losses, and protect environment. Few studies have examined the spatial variability of soil available P in grassland fields in Eastern

Canada. The specific objectives of this study were 1) to investigate field-scale variability of soil P indices [referred to as P_{M3} and $(P/Al)_{M3}$] and other selected soil physicochemical properties (soil pH_{water}, total carbon, Al_{M3}, Ca_{M3}, Fe_{M3}) and 2) to study the relationship between soil P indices and selected soil physicochemical properties for two contrasting grasslands. This information can be used to provide soil sampling guidelines for effective and sustainable grassland management.

Materials and methods

The study was conducted in the Chaudiere-Appalaches region, Quebec, Canada. Two fields were selected, a young grassland (YG; 2 years; 2.35 ha), and an old grassland (OG; 10 years under permanent pasture; 2.47 ha). Both fields were moderately well-drained Humo-Ferric Podzol. Organic manure was applied in both fields. Soil samples were collected in 16-m by 16-m triangular grids at two depths (0–0.05 and 0.05–0.2 m), and were analyzed for available P and other soil properties by the Mehlich-3 method (M3). Descriptive statistics were carried out using SAS Software version 9.4 (SAS Institute 2010). Pearson correlation analysis was completed to establish relationships between soil P indices and the soil physicochemical properties using SAS. Geostatistics data were performed for each of the soil layers using the GS+ version 9 software to perform all the geostatistical computations and model validations.

Results and discussion

At 0–0.05 m, average soil P_{M3} and $(P/Al)_{M3}$ values were 52 mg kg^{-1} and 3% respectively under YG, compared to 125 mg kg^{-1} and 7% respectively for OG. At 0.05–0.2 m, average P_{M3} and $(P/Al)_{M3}$ values were 55 mg kg^{-1} and 3% respectively for YG, and 75 mg kg^{-1} and 4% respectively for OG. P stratification was observed in OG, owing to long-term manure application (Table 1). variability of soil P indices was high (CV > 50%). Moderate spatial structure (25–75%) was observed for P indices at both sites (Data not showed). Soil P variability and spatial dependence were lower in OG (31–52%) than in YG (63–71%), caused by soil extrinsic factors, such as P-rich manure applications. Thus, repeated applications of organic fertilizers increased soil P buildup in permanent grasslands while decreasing soil P variability and spatial dependence. Consequently, a soil sampling strategy focusing on the 0–5 cm layer in permanent grasslands should be recommended for more sustainable P recommendations, due to risk of soil P stratification, comparatively to the current soil sampling strategy (0–17.5 cm) used for grasslands in Eastern Canada.

Table 1. Descriptive statistics of the soil P indices for two soil layers (0–0.05 m and 0.05–0.2 m) in the YG and OG fields

		------0–0.05 m-----			----0.05–0.2 m---		
	Unit	n	Mean	CV (%)	n	Mean	CV (%)
Young grassland							
P_{M3}	mg kg^{-1}	151	52	63	151	55	65
$(P/Al)_{M3}$	(%)	151	3	79	151	3	81
Old grassland							
P_{M3}	mg kg^{-1}	149	125	46	149	75	60
$(P/Al)_{M3}$	(%)	149	7	52	149	4	64

Conclusion

Repeated applications of organic fertilizers increased soil P buildup in permanent grasslands while decreasing soil P variability and spatial dependence. Consequently, a soil sampling strategy focusing on the 0–5 cm layer in permanent grasslands should be recommended for more sustainable P recommendations.

References

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