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Near-infrared reflectance spectroscopy for soil organic phosphorus

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Introduction

- Organic phosphorus (**OP**) is abundant in soil and is an essential source of phosphorus for plants. To date, however, there is no direct method to quantify the total concentration of OP in soils.
- OP can only be estimated indirectly by ignition (Saunders and Williams, 1955) or extraction (Hedley et al., 1982; Tiessen and Moir, 2008).
- Near-infrared reflectance spectroscopy (**NIRS**) is a direct, rapid, inexpensive, and accurate analysis technique for a wide variety of materials and it is increasingly used in soil science.

Objective

- To examine the potential of NIRS to predict soil organic P.

Materials and Methods

- Soil samples (**N = 360**) were taken from an experimental site near Indian Head, SK, Canada, from **short-term** (**ST**, 8 years) and **long-term** (**LT**, 31 years) **no-till** plots of a field pea–spring wheat rotation receiving P fertilizer annually (0, 11, 22, 33, or 45 kg P_2O_5 ha^{-1}).
- Samples were collected in 2008 and 2009 at three soil depths : 0-7.5, 7.5-15, and 15-30 cm.
- Soil OP was determined by the ignition method (Saunders and Williams, 1955).
- Samples were scanned in the visible-near-infrared region using a NIRSystems 6500 Instrument (Foss, Silver Spring, MD) with a quarter cup (≈ 25 mL).
- Modified partial least squares regression method was used to develop NIRS equations using 80% of the samples for calibration and 20% for validation.
- Predictive ability of NIRS was evaluated using the coefficient of determination of validation (**R^2**) and the ratio of standard error of prediction to standard deviation [**RPD = SD / SEP(C)**] according to the guidelines proposed by Malley et al. (2004).
- Calibration equations were considered to be :
  - **excellent** : $R^2 > 0.95$ and RPD > 4.00;
  - **successful** : $0.90 \le R^2 \le 0.95$ and $3.00 \le RPD \le 4.00$;
  - **moderately successful** : $0.80 \le R^2 < 0.90$ and $2.25 \le RPD < 3.00$;
  - **moderately useful** : $0.70 \le R^2 < 0.80$ and $1.75 \le RPD < 2.25$;
  - **less reliable** : $R^2 < 0.70$ and RPD < 1.75.

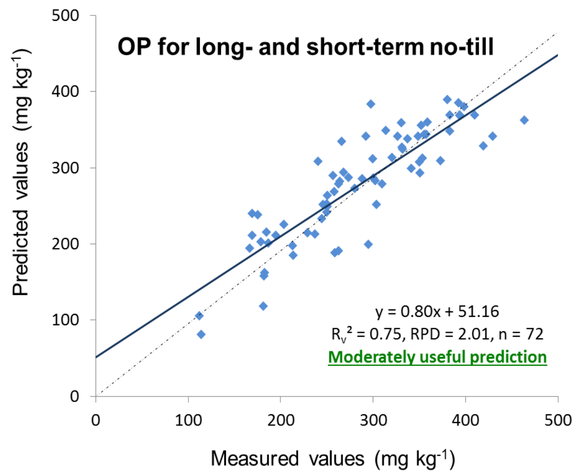
Descriptive statistics for the soil organic P

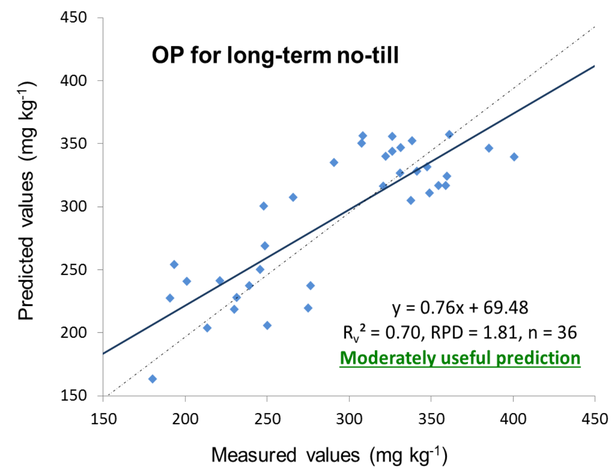
	N	Min	Max	Mean	SD	CV (%)
		mg kg^{-1}				
LT + ST no-till	360	16.2	492.7	274.9	84.7	30.8
LT no-till	180	72.6	406.1	269.1	71.4	26.5
ST no-till	180	16.2	492.7	280.6	96.0	34.2

LT : long-term; **ST** : short-term; **SD** : standard deviation; **CV** : coefficient of variation

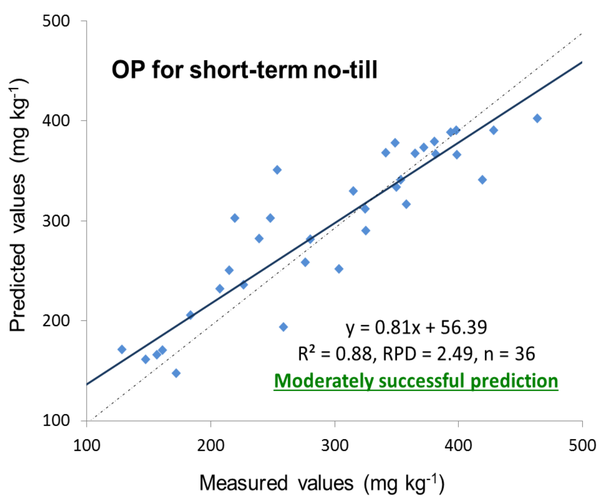
Results and Discussion

NIRS predicted *vs.* measured values of soil OP in the validation sets





NIRS predictions of OP are **moderately useful** ($0.70 \le R^2 < 0.80$ and $1.75 \le RPD < 2.25$) for total sample set and for long-term no-till set.



NIRS prediction of OP is considered **moderately successful** ($0.80 \le R^2 < 0.90$ and $2.25 \le RPD < 3.00$) for short-term no-till sample set.

The NIRS predictive ability of OP appears to be related to the relationship with soil organic matter ($R^2 = 0.52$, $P < 0.001$) and to the dispersion of OP in the soil.

Conclusions

- ❑ The NIRS prediction of soil organic phosphorus was classified moderately useful to moderately successful.
- ❑ NIRS prediction model should be validated with a greater number of samples of more diverse soils. Further studies are needed to evaluate the potential of NIRS for predicting the chemical forms of soil OP.

References

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