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Prediction of volumetric water content in conservation agriculture

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Introduction

- The lack of accurate data on soil hydraulic properties is an obstacle to the use of water and solute transport models
- Pedotransfer functions (PTFs) represent a solution to cope with data scarcity
- PTFs relate easily measurable soil properties to properties more difficult to access such as water retention curve
- They were mostly developed for soils under conventional tillage systems
- The ability of PTFs to predict water retention in conservation agriculture is unknown

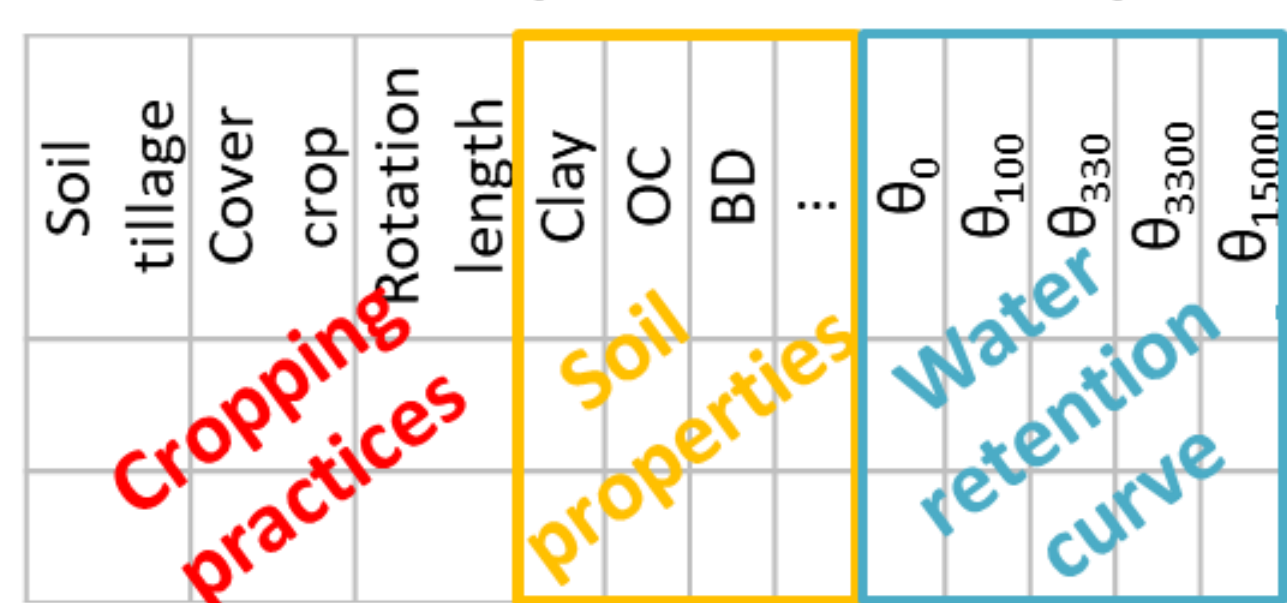
Objectives

- Assess the quality of prediction of soil water retention of different published PTFs for soils managed with conservation agriculture practices
- Develop specific PTFs for soils under conservation agriculture

Materials and Methods

- Evaluation of 29 existing class-PTFs, continuous-PTFs and tree-PTFs using a dataset describing cropping practices, soil properties and water retention curves under conservation agriculture

Dataset (170 individuals)



θ observed



θ predicted

Statistical criteria used to assess the quality of prediction

$$RMSEP = \sqrt{\frac{1}{N} \sum_{i=1}^N [\hat{y}_i - y_i]^2}$$

RMSEP: Root Mean Square Error of Prediction

$$MEP = \frac{1}{N} \sum_{i=1}^N [\hat{y}_i - y_i]$$

MEP: Mean Error of Prediction

$$EF = 1 - \frac{\sum_{i=1}^N [\hat{y}_i - y_i]^2}{\sum_{i=1}^N [y_i - \bar{y}]^2}$$

EF: Efficiency

\hat{y} ; y : predicted & observed values, \bar{y} : mean of observed values, N : number of values

- Development of new PTFs predicting soil water content (θ) at field capacity (θ_{FC} at -100 or -330 cm) and at wilting point (θ_{WP} at -15000 cm), as a function of soil properties and cropping practices, using a regression tree method (recursive binary partitioning with rpart package in R)

- Quality of prediction of the new PTF was estimated by cross-validation considering spatio-temporal correlations

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Results

1. Quality of prediction for $\theta_{FC_{100}}$ (2 out of 26 functions are shown)

BEST CLASS AND CONTINUOUS FUNCTION	RMSEP	MEP	EF
Class: texture FAO (stratification) [1]	0,049	-0,03	-0,23
Continuous: $a + b \times \text{clay} + c \times \text{sand} + d \times \text{BD}$ (stratification) [2]	0,057	-0,046	-0,67

- Among all PTFs, RMSEP ranged from 0,034 cm³/cm³ to 0,192 cm³/cm³
- Almost every PTF tends to underestimate $\theta_{FC_{100}}$ (MEP<0)
- One function led to a correct EF but it requires both θ_{WP} and $\theta_{FC_{330}}$



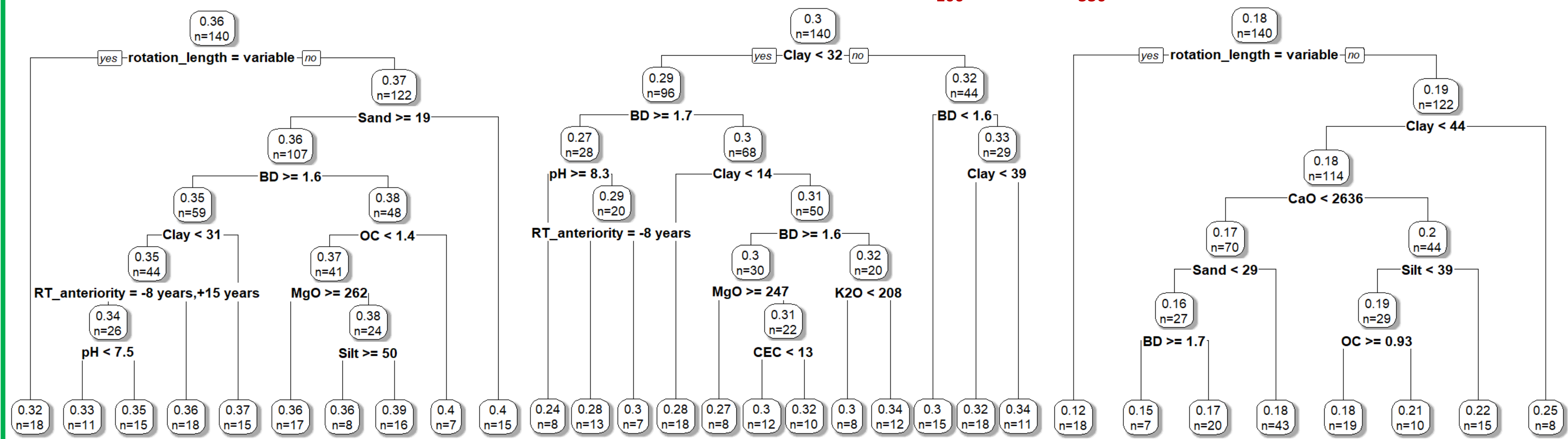
Field under conservation agriculture practices

2. Quality of prediction for θ_{WP} (2 out of 29 functions are shown)

BEST CLASS AND CONTINUOUS FUNCTION	RMSEP	MEP	EF
Class: texture FAO and BD [3]	0,042	0,002	0,18
Continuous: $a + b \times \text{clay} + c \times \text{sand}$ [2]	0,034	0,003	0,45

- RMSEP ranged from 0,034 cm³/cm³ to 0,051 cm³/cm³
- Error represents a higher proportion of water content than for $\theta_{FC_{100}}$ prediction
- 2/3 of the PTFs underestimated θ_{WP}
- EF were globally better than for $\theta_{FC_{100}}$ prediction

3. Regression trees to predict volumetric water content at field capacity ($\theta_{FC_{100}}$ and $\theta_{FC_{330}}$) and wilting point (θ_{WP})



- Length of rotation is the first predictor splitting the dataset in $\theta_{FC_{100}}$ and θ_{WP} trees
- Anteriority of reduced/no tillage appears in $\theta_{FC_{100}}$ and $\theta_{FC_{330}}$ trees

4. Quality of prediction of the developed regression trees

Cross-validation	$\theta_{FC_{100}}$	$\theta_{FC_{330}}$	θ_{WP}
RMSEP	0,036	0,041	0,041
MEP	0,002	0,003	0,001
EF	-0,08	-0,24	0,03

- The $\theta_{FC_{100}}$ tree has a better predictive quality than published PTFs: smaller RMSEP and MEP. However, EF remains low
- The θ_{WP} tree performed equally or even worse, as compared to published PTFs

Conclusions & Perspectives

- Existing PTFs did not have a good quality of prediction of our water retention dataset
- New tree-PTF has a better ability to predict soil volumetric water content at field capacity ($\theta_{FC_{100}}$)
- Variables describing cropping practices were found to be important in order to predict soil water retention in conservation agriculture
- Their role in the development of PTFs needs further investigation

