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Prediction of soil water retention under 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

(i) Assess the quality of prediction of soil water retention of different published PTFs for soils managed with conservation agriculture practices.
(ii) 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.
- Development of new PTFs predicting soil water content (θ) at field capacity (θ_FC at -100 to -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.

Results

1. Quality of prediction for θ_FC330 (2 out of 26 functions are shown)

<table>
<thead>
<tr>
<th>BEST CLASS AND CONTINUOUS FUNCTION</th>
<th>RMSEP</th>
<th>MEP</th>
<th>EF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class: texture FAO (stratification) [1]</td>
<td>0.049</td>
<td>-0.03</td>
<td>-0.23</td>
</tr>
<tr>
<td>Continuous: a + b × clay + c × sand + d × BD (stratification) [2]</td>
<td>0.057</td>
<td>-0.046</td>
<td>-0.67</td>
</tr>
</tbody>
</table>

- Among all PTFs, RMSEP ranged from 0.034 cm^3/cm^3 to 0.192 cm^3/cm^3.
- Almost every PTF tends to underestimate θ_FC330 (MEP<0).
- One function led to a correct EF but it requires both θ_WP and θ_FC330.

2. Quality of prediction for θ_WP (2 out of 29 functions are shown)

<table>
<thead>
<tr>
<th>BEST CLASS AND CONTINUOUS FUNCTION</th>
<th>RMSEP</th>
<th>MEP</th>
<th>EF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class: texture FAO and BD [3]</td>
<td>0.042</td>
<td>0.002</td>
<td>0.18</td>
</tr>
<tr>
<td>Continuous: a + b × clay + c × sand [2]</td>
<td>0.034</td>
<td>0.003</td>
<td>0.45</td>
</tr>
</tbody>
</table>

- RMSEP ranged from 0.034 cm^3/cm^3 to 0.051 cm^3/cm^3.
- Error represents a higher proportion of water content than for θ_FC100 prediction.
- 2/3 of the PTFs underestimated θ_WP.
- EF were globally better than for θ_FC100 prediction.

3. Regression trees to predict volumetric water content at field capacity (θ_FC100 and θ_FC330) and wilting point (θ_WP)

- Length of rotation is the first predictor splitting the dataset in θ_FC100 and θ_FC330 trees.
- Anteriority of reduced/no tillage appears in θ_FC100 and θ_FC330 trees.

4. Quality of prediction of the developed regression trees

<table>
<thead>
<tr>
<th>Cross-validation θ_FC100</th>
<th>θ_FC330</th>
<th>θ_WP</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMSEP</td>
<td>0.036</td>
<td>0.041</td>
</tr>
<tr>
<td>MEP</td>
<td>0.002</td>
<td>0.003</td>
</tr>
<tr>
<td>EF</td>
<td>-0.08</td>
<td>-0.24</td>
</tr>
</tbody>
</table>

- The θ_FC100 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 (θ_FC100).
- 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.

References


Acknowledgements

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