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Calibration and Evaluation of the STICS Intercrop Model for Two Cereal-Legume Mixtures

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Background

• Intercropping, i.e. multiple species grown simultaneously on the same field, used as a way of ecological intensification

• Especially mixtures of leguminous and non-leguminous crops could reduce inputs and potential environmental damage through N losses

• Intercropping increases system complexity

➢ The aim of this study was to calibrate and evaluate the improved STICS-Intercrop model (Vezy et al., 2020) by simulating two types of cereal-legume mixtures (winter and spring intercrops)

Materials and Methods

• French data sets comprised of 4 years of winter wheat (Triticum turgidum L.) and pea (Pisum sativum L.) (Bedoussac, 2009; Kammoun, 2015), and 4 years of spring barley (Hordeum vulgare L.) and pea (Corre-Hellou, 2005) including different N levels and plant densities (Table 1)

• 3-step Approach: 1) Calibration of species and cultivar parameters with sole crop data ; 2) Calibration of two intercrops parameters ; 3) Evaluation for intercrop data, in order to determine the validity domain.

• Step 1 of calibration followed the order: phenology, leaf area, biomass, nitrogen uptake/fixation, and grain yield

• The species and cultivar parameters calibrated in step 1 are used again for intercrop simulations in step 2

Table 1: Description of the observed field data.

<table>
<thead>
<tr>
<th>Location</th>
<th>Winter Wheat</th>
<th>Winter Pea</th>
<th>Spring Barley</th>
<th>Spring Pea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auzeville, France</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Angers, France</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Results and Discussion

• Largest source of error was winter pea (nRMSE=40.0 %)
• All other crops had a nRMSE<17.0 %
• Simulated winter pea reached max LAI too early, possibly a result of limited observed phenology data → further research needed

Figure 1: Comparison of simulated observed grain yield for sole crop winter wheat, winter pea, spring barley, and spring pea.

Figure 2: Comparison of simulated and observed partial land equivalent ratio (LER) for intercropped winter wheat/winter pea and spring barley/spring pea.

• Largest source of error was winter pea (nRMSE=80.9 %)
• High nRMSE for all other crops (37.4 to 60.3 %)
• Winter wheat crop height increased too quickly in simulations, causing overestimation of biomass and grain yield → further revision of height simulation formalisms needed to avoid bias

Conclusion

• Based on the sole crop calibration, some intercrop situations could be correctly simulated
• Further analysis of the model’s simulation of interspecific competition is necessary to better capture the large variation in observed data and to improve model accuracy

➢ With these future improvements, the STICS intercrop model can be a useful tool for better understanding the biological functions of intercropping systems to and assist in optimizing their management

Sources


Kammoun B. 2014. Analyse des interactions genotype x environnement x conduite culturale de peuplement bi-specifique de cultures associées de blé dur et de legumineuses à graines a des fins de (LER) for intercropped winter wheat/winter pea and spring barley/spring pea.

Vezy R et al. (2020) Implementation of new formalisms in STICS for intercropping modeling. ICROPM, Montpellier, France.