Intercomparison of models for simulating timothy yield in northern countries

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Background

- Forage-based livestock and dairy production are the economic backbone of agriculture in many northern countries.

- In northern Europe and eastern Canada, forage grasses for silage are commonly grown for 2-4 years or longer in rotations with cereal crops and harvested 2-3 times per year.

- In those regions, timothy (*Phleum pratense* L.) is one of the most widely grown forage grass species.

- Models that simulate the growth and nutritive value have been developed for timothy, but the performance of different models has not been compared so far.
Research questions

• How can current timothy models predict timothy yields of the first and second cut in northern areas of Europe and Canada where timothy is widely grown?

• Are the models able to predict the timothy yield response to climatic factors and changes in management (e.g. changes in cutting times or N application rates)?

• How do models perform with cultivar-specific vs. non-cultivar specific (generic) calibrations?

• What is the magnitude of uncertainty associated to the yield predictions by different models?
Model comparison setup

• Three models:
  – BASGRA (The BASic GRAssland model, based on LINGRA)
  – CATIMO (CAonian TIMothy MOdel)
  – STICS (Simulateur mulTldisciplinaire pour les Cultures Standard)

• 7 study sites

<table>
<thead>
<tr>
<th>Country and site name</th>
<th>Treatments (calibration+test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td></td>
</tr>
<tr>
<td>1. Fredericton</td>
<td>6 (4+2) (different N levels)</td>
</tr>
<tr>
<td>2. Lacombe</td>
<td>2 (2+0)</td>
</tr>
<tr>
<td>3. Quebec</td>
<td>9 (6+3) (different N levels)</td>
</tr>
<tr>
<td>Finland</td>
<td></td>
</tr>
<tr>
<td>4. Maaninka</td>
<td>2 (2+0)</td>
</tr>
<tr>
<td>5. Rovaniemi</td>
<td>6 (4+2) (different N levels)</td>
</tr>
<tr>
<td>Norway</td>
<td></td>
</tr>
<tr>
<td>6. Saerheim</td>
<td>6 (4+2) (early and late cut)</td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
</tr>
<tr>
<td>7. Umeå</td>
<td>2 (2+0)</td>
</tr>
</tbody>
</table>

Altogether ~1500 observations of dry-matter yield (also for leaf and stem fractions), crop height, leaf area index and specific leaf area.
Calibrations

• Model users were free to use preferred calibration method
  – BASGRA and CATIMO applied Bayesian calibration
  – STICS was calibrated using the integrated optimization tool (simplex algorithm)

• Data from 24 treatments were used for calibration and the remaining 9 treatments were used to assess model performance

• Two different calibrations
  – Cultivar-specific calibration
  – Generic calibration applying data from all sites and cultivars

<table>
<thead>
<tr>
<th>Study site</th>
<th>Cultivar</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fredericton, Canada</td>
<td>Champ</td>
<td>1991-1993</td>
</tr>
<tr>
<td>Lacombe, Canada</td>
<td>Climax</td>
<td>2004-2005</td>
</tr>
<tr>
<td>Quebec, Canada</td>
<td>Champ</td>
<td>1999-2001</td>
</tr>
<tr>
<td>Maaninka, Finland</td>
<td>Tammisto II</td>
<td>2006-2007</td>
</tr>
<tr>
<td>Rovaniemi, Finland</td>
<td>Iki</td>
<td>1999-2001</td>
</tr>
<tr>
<td>Særheim, Norway</td>
<td>Grinstad</td>
<td>2000-2002</td>
</tr>
<tr>
<td>Umeå, Sweden</td>
<td>Jonatan</td>
<td>1995-1996</td>
</tr>
</tbody>
</table>
Simulated and observed time course of dry-matter accumulation and leaf area index

Example: Særheim, Norway, year 2000

Dry matter yield

Leaf area index
Model performance for the 1\textsuperscript{st} and 2\textsuperscript{nd} cuts

Simulated and observed maximum yields of the 1\textsuperscript{st} and 2\textsuperscript{nd} cut of each treatment using cultivar-specific calibration
Cultivar-specific vs. generic calibration

Arrows depict treatments used to assess model performance (not included in calibration).
Yield responses to N levels

Fredericton, year 1993, Cultivar-specific calibration

![Graph showing yield responses to nitrogen levels]
Uncertainty related to model predictions
Discussion

• All models generally managed to estimate the DM yields satisfactorily and none of them worked clearly better than the others at all sites.

• Cultivar-specific calibration provided better simulation accuracy than the generic calibration. Calibration effect on simulated yields varied among sites and treatments.

• Models differed in their ability to simulate a response to nitrogen fertilization.

• Uncertainties in simulated yield estimates in models are still quite wide and they are related to deficiencies in models process descriptions, uncertainties in model parameters and input data.
Next steps

• MACSUR2 LiveM task 1.2 - grassland quality modelling
  – Model survey of how current grass growth models simulate the nutritive value of forage grasses is currently going on
  • Related workshop to be held in connection with EGF 2016 in Trondheim (Norway) in September
    – Contact panu.korhonen@luke.fi if you want to join in or need more information!
    – Hopefully leads to model comparison paper

• Results will be used to improve models:
  – CATIMO: Regrowth functions will be updated soon
  – BASGRA: Ongoing work to improve N responses
  – STICS: Planned upgrades to better simulation of plant reserve dynamics for improved regrowth and multiannual simulations
Thank you!