Yield gap analysis of cereals in Europe

Supported by local knowledge

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Cereal yield gaps in Europe

- **Background**
  - Global Yield Gap Atlas
  - Benchmarking Atlas

- Cereal yield gaps
  - Yield gap protocol
  - Results so far

- Outlook

- Questions
Background of yield gap analysis

- Challenge to keep production on track with demand
- Identify regions with unlocked yield capacity
- Identify regional causes of yield gaps
- Develop options to reduce yield gaps
Production ecological principles

Yield gap

Potential

Water limited

Water and nutrient limited

Actual

Defining factors
- Radiation
- Carbon dioxide
- Temperature
- Crop features

Limiting factors
- Water
- Nutrients

Reducing factors
- Weeds
- Pests and diseases
- Pollutants

Crop Yield

eg. Van Ittersum & Rabbinge, 1997
Earlier yield gap studies

Regional and local approaches
- Inconsistent concepts and methods
- models, experiments, best management practices
- local relevance, but difficult to compare

Global and continental approaches
- Consistent
- Generic crop growth models
- Coarse, lacking local detail and hence less agronomic relevance

*Mueller et al., 2012*
GYGA approach

- Bottom-up
  - local data for weather, cropping systems and soils
  - involving local scientists
  - upscaling to national, continental and global levels

- Standard protocols

- Transparency
  - data available at www.yieldgap.org
Dissemination of results
Cereal yield gaps in Europe

- Background
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Yield gap analysis, step by step

1. Climate zones
2. Harvested areas
3. Weather station buffer zones
4. Soil types and cropping systems
5. Crop model simulations
6. Actual yields
7. Yield gaps
Selected climate zones for wheat

Selected zones:
>5% of national harvested area
Selected weather station buffer zones
Selected areas - wheat
Select dominant soil map units

Soil map units

3 dominant soil map units

Harvested areas
Crop model simulations

- Potential and water-limited yield

- Simulation runs are combinations of
  - 3 to 4 crops
  - 3 to 40 weather buffer zones per crop
  - 3 soil map units x 5 soil type units
  - 13 to 25 years

- Crop models
  - WOFOST for all countries
  - Local model (optional)
Cereal yield gaps in Europe

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Published results

www.yieldgap.org
Rainfed wheat - water-limited yield

Weather station VILLARRUBIA DE SANTIAGO, Rainfed wheat
Water limited yield (Yw): 3.8 tons per harvested ha.
Rainfed wheat cropping intensity: 1.00. Annual water limited yield: 3.5 tons per year.
Harvested area inside weather station buffer zone: 10215 ha.

Simulation run results: (used model WOFOST)

<table>
<thead>
<tr>
<th>Year</th>
<th>Cropping system</th>
<th>Weight</th>
<th>Sowing date</th>
<th>Crop cycle</th>
<th>Yw</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>Single_winter wheat</td>
<td>100</td>
<td>AUTUMN SOWN</td>
<td>1</td>
<td>3.3</td>
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<tr>
<td>2012</td>
<td>Single_winter wheat</td>
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<td>AUTUMN SOWN</td>
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<tr>
<td>2010</td>
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<td>AUTUMN SOWN</td>
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<td>2009</td>
<td>Single_winter wheat</td>
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<td>AUTUMN SOWN</td>
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<td>2008</td>
<td>Single_winter wheat</td>
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<tr>
<td>2007</td>
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<tr>
<td>2006</td>
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<td>AUTUMN SOWN</td>
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<tr>
<td>2005</td>
<td>Single_winter wheat</td>
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<td>AUTUMN SOWN</td>
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<td>0.5</td>
</tr>
<tr>
<td>2004</td>
<td>Single_winter wheat</td>
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<td>AUTUMN SOWN</td>
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<td>6.7</td>
</tr>
<tr>
<td>2003</td>
<td>Single_winter wheat</td>
<td>100</td>
<td>AUTUMN SOWN</td>
<td>1</td>
<td>1.8</td>
</tr>
<tr>
<td>2002</td>
<td>Single_winter wheat</td>
<td>100</td>
<td>AUTUMN SOWN</td>
<td>1</td>
<td>4.3</td>
</tr>
<tr>
<td>2001</td>
<td>Single_winter wheat</td>
<td>100</td>
<td>AUTUMN SOWN</td>
<td>1</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Legend: ○ all classes ○ current classes
- 2.4 - 3.2
- 3.2 - 4.0
- 4.0 - 4.8
- 4.8 - 5.6
- 5.6 - 6.4
- 6.4 - 7.2
- 7.2 - 8.0
- 8.0 - 8.8
- 8.8 - 9.6
- 9.6 - 10.4
- 11.2 - 12.0
Rainfed wheat - water-limited yield
Rainfed wheat - water-limited yield
Actual yield – rainfed wheat
rainfed wheat – yield gap
Local approach

- Country agronomist
- Additional data
- Reality check
Local approach

- Country agronomist - bias
- Border effects
- Is the assessment per country really ‘standard’ ?
- Time consuming
- Rigorous selection: leaves valuable information unused
## GYGA compared to a grid approach (CGMS)

<table>
<thead>
<tr>
<th></th>
<th>GYGA</th>
<th>Boogaard et al., 2013 (CGMS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meteo</strong></td>
<td>Source: WMO / additional stations / NASA</td>
<td>WMO / additional stations</td>
</tr>
<tr>
<td></td>
<td>Spatial: Sampled point in climate zone</td>
<td>Grid: 25 km x 25 km</td>
</tr>
<tr>
<td></td>
<td>Temporal: 13-23 years of daily data</td>
<td>16 years of daily data</td>
</tr>
<tr>
<td></td>
<td>Data: Actual / different parameters</td>
<td>Derived / Consistent</td>
</tr>
<tr>
<td><strong>Soils</strong></td>
<td>Source: European soil map (JRC)</td>
<td>European soil map (JRC)</td>
</tr>
<tr>
<td></td>
<td>Spatial: 1 km x 1 km</td>
<td>1 km x 1 km</td>
</tr>
<tr>
<td></td>
<td>Temporal: -</td>
<td>All soil map units</td>
</tr>
<tr>
<td></td>
<td>Data: 3 dominant soil map units</td>
<td>All soil map units</td>
</tr>
<tr>
<td><strong>Crop calendar</strong></td>
<td>Source: AgroPheno + additional sources</td>
<td>AgroPheno</td>
</tr>
<tr>
<td></td>
<td>Spatial: Point -&gt; Weather station zone</td>
<td>Point -&gt; Grid 25 km x 25 km</td>
</tr>
<tr>
<td></td>
<td>Temporal: Later than 1990</td>
<td>16 year</td>
</tr>
<tr>
<td><strong>Actual yield</strong></td>
<td>Source: National statistics</td>
<td>FADN</td>
</tr>
<tr>
<td></td>
<td>Spatial: NUTS2 – NUTS3</td>
<td>FADN-regions</td>
</tr>
<tr>
<td></td>
<td>Temporal: 5 to 10 year</td>
<td>16 year</td>
</tr>
<tr>
<td><strong>Crop simulation</strong></td>
<td>Model: WOFOST + others</td>
<td>WOFOST</td>
</tr>
<tr>
<td></td>
<td>Calibration: Boons-Prins/ASEMARS + local data</td>
<td>Boons-Prins/ASEMARS</td>
</tr>
<tr>
<td></td>
<td>Spatial: Weather station -&gt; climate zone</td>
<td>Grid: 25 km x 25 km</td>
</tr>
<tr>
<td></td>
<td>Temporal: 13-23 year</td>
<td>16 year</td>
</tr>
</tbody>
</table>
Comparison CGMS – GYGA: Potential yield

Boogaard et al., 2013

Crop Growth Monitoring System
- 25 x 25 km grid
- Interpolated weather per grid cell
- Model inputs per grid cell

Global Yield Gap Atlas
- Selected zones
- Actual weather per station zone
- Model inputs per zone
### Comparison CGMS – GYGA: Potential yield

<table>
<thead>
<tr>
<th>Method</th>
<th>CGMS</th>
<th>GYGA</th>
<th>GYGA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meteo</td>
<td>grid</td>
<td>grid</td>
<td>zone</td>
</tr>
<tr>
<td>Schleswig</td>
<td>9.0</td>
<td>9.9</td>
<td></td>
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<tr>
<td>Neuruppin</td>
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<td>8.0</td>
<td></td>
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<tr>
<td>Dresden</td>
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<td>7.8</td>
<td></td>
</tr>
<tr>
<td>Mannheim</td>
<td>8.8</td>
<td>7.8</td>
<td></td>
</tr>
</tbody>
</table>
Cereal yield gaps in Europe - outlook

- Continue ‘standard’ GYGA-work on Europe
  - Global Yield Gap Atlas
  - Benchmarking Atlas

- MACSUR-2 cross cutting activity (XC 9)

- Methods
  - Look for improvements
  - Compare GYGA to CGMS
  - Uncertainty analysis
  - Using empirical data to estimate attainable yield
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