GLOBAL YIELD GAP ATLAS; CEREALS IN EUROPE

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Introduction

The increasing global demand for food requires a sustainable intensification of crop production in low-yielding areas. Actions to improve crop production in these regions call for accurate spatially explicit identification of yield gaps, i.e., the difference between potential or water-limited yield and actual yield. Several global and local studies have already addressed yield gaps (Van Ittersum et al., 2013). Global studies generally rely on generic crop models or statistical methods combined with a grid-based approach of information on climate, soils, and crop calendars. Although using a consistent method, they are less suitable for local yield gap assessment. Moreover, local studies exploit knowledge of location-specific conditions and management, but are less comparable across locations due to different methods. To overcome the inconsistency of local studies and shortcomings of global studies, the Global Yield Gap Atlas (GYGA) project proposes a consistent bottom-up approach to estimate yield gaps. This paper outlines the implementation of this approach for estimating yield gaps of cereals across Europe.

Materials and Methods

For each country, a climate zonation (Van Wart et al., 2013) is overlaid with a crop area map (You et al., 2000). Within climate zones with important crop areas, weather stations are selected with at least 15 years of daily data. For each of the 3 dominant soil types within a 100 km buffer zone around the weather stations, the potential and water-limited yields are simulated with the WOFOST (Boogaard et al., 1998) crop model, using location-specific knowledge on crop systems. Data from variety trials or other experiments, approaching potential or water-limited yields, are used for validation and calibration of the model. Actual yields are taken from sub-national statistics. Yields and yield gaps are scaled up to climate zones and subsequently to countries. The GYGA website (www.yieldgap.org) presents all the details on methods and standard protocols.

Results and Discussion

The contrast in climate zones is fairly limited within the territory of Poland, Germany and the Netherlands. Therefore, the simulated potential yields of winter wheat (not shown) only vary from 9.2 t ha\(^{-1}\), in areas with a relatively warm and short growing season, to 11.4 t ha\(^{-1}\), in areas with a cooler and longer growing season. These differences in potential yields are also reflected in the national averages (Table 1). The simulated water-limited yield varied from 7.6 to 11.0 t ha\(^{-1}\) year\(^{-1}\) between climate zones (Figure 1). Wheat production under rainfed conditions is driven by precipitation...
Figure 1. Water-limited yield (t ha⁻¹), at standard commercial moisture content, of winter wheat for climate zones in Poland, Germany and the Netherlands (www.yieldgap.org).

and soil characteristics. On the one hand, soils with a coarse texture, occurring for instance in North Germany, are more susceptible to dry spells. On the other hand, soils with high ground water tables, occurring for instance in the Netherlands, are less sensitive to drought.

The average actual farmer yields increase in the order Poland<Germany<Netherlands, representing differences in nutrient inputs and crop protection. The resulting yield gaps are approximately 50% for Poland and 20% for Germany and the Netherlands. A gap of 20% is hypothesized to be a practical ceiling for average national yields, considering other aspects, such as profitability (Van Ittersum et al., 2013). We are currently working towards European coverage of this analysis, thereby identifying those regions with prospective production increases.

Table 1. Average national potential yield (YP), water-limited yield (YW), actual yield (YA) and yield gaps (YW-YA) for winter wheat (standard commercial moisture content).

<table>
<thead>
<tr>
<th></th>
<th>YP (t ha⁻¹)</th>
<th>YW (t ha⁻¹)</th>
<th>YA (t ha⁻¹)</th>
<th>YW-YA (t ha⁻¹)</th>
<th>YW-YA (% of YW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poland</td>
<td>9.8</td>
<td>8.4</td>
<td>3.9</td>
<td>4.5</td>
<td>53</td>
</tr>
<tr>
<td>Germany</td>
<td>10.0</td>
<td>8.7</td>
<td>7.2</td>
<td>1.5</td>
<td>17</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>11.0</td>
<td>11.0</td>
<td>8.4</td>
<td>2.6</td>
<td>23</td>
</tr>
</tbody>
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References